Population-Environment Dynamics: Transitions in Global Change

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PREFACE

This monograph, is a compendium of the individual works of seventeen students enrolled in a newly cross-listed course NR 545 (EIH 575). The focus of this course, like prior years, is captured in its title Population-Environment Dynamics: Toward building a Theory. The course began with an examination of alternative theoretical constructs useful in studying the interaction between human populations and the environment. Also, at the beginning of the course, each participant was asked to select a topic of inquiry and a geographical setting for their study. This selection then became their major focus for the entire semester. Students participating formally in the course this fall had a delightful mixture of backgrounds and interests. Schools and colleges represented included the School of Natural Resources and Environment, School of Public Health, School of Business Administration, College of Engineering, College of Architecture and Urban Planning, and College of Literature Sciences and Arts. One undergraduate, fourteen masters and four Ph D students participated formally. Others sat in from time to time, including participants from previous years seminars. Disciplines represented included biology, economics, sociology, architecture, anthropology, mathematics, law, engineering, urban planning, public health, forestry and natural resources. Participants included colleagues from the Continents of North America, Europe, Asia, and Africa. In addition, several U. S. students had spent considerable time living and working in countries such as Russia, Benin, Costa Rica, India, Thailand and Nepal.

A very important element in the seminar was the use of data sources which recently have become available in machine-readable form. These data sources permitted the students to quickly gain exposure in handling longitudinal datasets, especially those which were not amenable to modeling with linear functions. As a consequence, part of the course required mastery of non-linear curve fitting techniques. The most useful and user friendly dataset provided participants was The World Resources Institute Data System (1994-95). Another tool used in the course was state-of-the-art PC-based Geographic Information Systems. The GIS package selected as most helpful, was ATLAS GIS version 3.0. The digital maps, used as separators of monograph chapters, help to unify monograph content as they depict, taken together, a spatial view of population-environment dynamics. New to this term was the availability of the Digital Chart of the World. Dr. Sandra Lach Arlinghaus, adjunct professor in The School of Natural Resources and Environment, provided instruction in curve fitting, GIS and ongoing individualized support to all participants.

A new feature of this terms course was the use of outside reviewers. These reviewers, all faculty in major teaching institutions, provided an additional level of academic feedback to participants. Papers included in this monograph had completed this review process by the time of publication. Remaining papers will be published at a later date.

The success of the course resulted largely from the enthusiasm of the participants. As in previous years, extra sessions were held near the end of the semester, which often extended beyond scheduled meeting times. Feedback from fellow participants was provided in these sessions. In addition, each student was asked to develop a brief synopsis of how their study related to the other participants in the class. These thoughtful remarks are presented as the main body of the concluding chapter. This monograph was published during the winter term in the academic year 1995-96.

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INTRODUCTION

This volume is a collection of separate but related studies focusing on the relationship between human populations and the environment. The effort consists of this introduction followed by seventeen chapters each written by a seminar participant which investigates a different aspect and geographic setting of the population-environment dynamic. A concluding chapter provides comments written by each participant relating their work to those of the others.

In this introduction we present a synopsis of the common framework, which we call a family of transitions. In addition to the common framework, this introductory chapter presents the abstracts for each ensuing chapter. Readers of the monograph reporting last year's work should note that the material in the following section on a family of transitions is repeated here for background and therefore can be skipped.

1. A FAMILY OF TRANSITIONS

One way of viewing the complex dynamic relationships between population and the environment is to visualize them as a family of transitions. That is, not only is there a demographic and epidemiologic transition but also a deforestation, toxicity, agricultural, energy and urbanization transition as well as many others. In this chapter it is argued that for each transition there is a critical period when society is especially vulnerable. During that period, rates of change are high, societal adaptive capacity is limited, in part, due to this rapid change, and there is a greater likelihood that key relationships in the dynamic become severely imbalanced. The trajectory society takes through a transition varies, depending upon many factors operating at local and national levels. Transitions not only are occurring in many different sectors but also at different scales, both temporal and spatial. At times, a society experiences several transitions simultaneously, which can raise social vulnerability because of how they amplify each other.

1.1 TYPES OF TRANSITIONS

The Demographic Transition

Let us begin with a review of the ideas behind the widely accepted demographic transition. At the onset of this transition, births and deaths are both high and are in relative equilibrium with each other. Historically, births exceed deaths by small amounts so total population rises only very gradually. Occasionally, famine or an epidemic causes a downturn in total population but in general, changes in rates are low. During the transition, however, death rates drop dramatically, usually due to a change in the health condition of the population. This change in health is caused by many, often interrelating factors. After some time lag, the birth rate begins to drop and generally declines until it is in approximate balance with the death rate again.

The Epidemiological Transition

The term epidemiologic transition was coined to describe the changing source of mortality and morbidity from infectious diseases occurring primarily in the younger age groups to degenerative diseases in older age groups. As with the demographic transition, there is considerable volatility during the transition. At the onset, infectious diseases begin their decline usually due to extensions of health care and sanitation by the national or local government. Single vector programs such as malaria control and immunization programs are often the first implemented because they are capable of ready extension and do not require as heavy a commitment to education and other sustained infrastructure - especially in rural areas. These single vector programs are then followed by broader-based health care which demand heavier investment in infrastructure. But an entirely successful move through this transition does not always happen. At times, other sectors in transition overpower the health care delivery system.

The Agricultural Transition

For several hundred years, worldwide agricultural production has been rising in relative harmony with population. Overall, increases in production have kept up with and even outpaced growth in population. The two factors that have been responsible for these increases are 1) extensions of land under cultivation and 2) improvements in productivity. At times changes have been dramatic. Formulating an agricultural transition reflects the condition that, in general, sources of increase in production shift from extending land to intensifying production on land already under cultivation.

The Forestry Transition

At the onset of the forestry transition generally a large percentage of a region is under forest cover. Rapid deforestation occurs during the transition and finally forest cover stabilizes at a lower level determined by many factors such as the local region's needs, the state of the local and national economy, climate and soil characteristics. In most settings this transition will end in a steady state equilibrium balancing growth and harvest. Again, how society handles the vulnerable transition period often determines in a profound way the quality of life for the region.

The Toxicity Transition

The toxicity transition can be considered a composite of many transitions: global atmospheric, local air pollution, surface water, ground water and solid waste to name a few. Again, there are at least two sets of factors operating in tandem. The transition begins with low levels of industrial or agricultural production and correspondingly low levels of toxins. As production and population increase, toxic byproducts increase to levels which eventually become unacceptable to the general public. This in turn, causes a public demand for pollution abatement. After an environmentally costly time lag, remediation steps are taken which helps to bring pollution under control.

The Urbanization Transition

The urbanization transition is driven by the dual forces of rural to urban migration and central city population growth. The early stages of the transition are characterized by rapid growth of urban population; however, in later stages, growth declines and may reverse. Rural to urban migration is a product of many forces - both "pull" and "push". In terms of the population-environment dynamic, the urbanization transition often acts as an amplifier as it interacts with other transitions.

The Fossil Fuel Transition

The fossil fuel transition is a special case of the energy transition. Historically, many energy transitions have already occurred in different regions and time periods. Significant transformations began in the sixteenth century brought about by sail and later, by steam power. Today, we are now in the most universal and perhaps critical energy transition: fossil fuels. Studying this transition is especially instructive because the record on different societies' passage through the vulnerable period is varied and appears to be heavily influenced by public policy.

1.2 GENERAL CHARACTERISTICS OF TRANSITIONS

Similarity of Trajectory Across Sectors

We have attempted to show in the seven example sectors discussed earlier that the notion of transitions apply across all sectors of investigation. Each class of transition, whether it be demographic, toxicity, forestry, agriculture, urbanization, energy or epidemiological have similar patterns. It is this perception that has caused us to posit the existence of a family of transitions possessing some common attributes useful in analysis. The first common attribute of all transitions is their trajectory. They all begin in reasonable stability, then move to the volatile transition period where change is rapid, and finally return again to relative balance. Analytically, these are clearly nonlinear systems but ones which have properties that lend themselves to well-understood mathematical functions.

Applicability of Transitions Across Scales

The second attribute has to do with scale. One of the most interesting and at the same time vexing aspects of studying population-environment dynamics is that many phenomena manifest themselves at all levels of geographic and temporal scale. For example, data depict one demographic transition for an entire continent, a different one for a country within that continent and still other different transitions at the regional level. Local conditions may delay or advance the onset and or completion of the transition in relation to the larger body. Thus, moving through the demographic transition can take more or less time as the scale changes. This same variation seems to exist in all other population-environment transitions that have been investigated. True, national or regional-level determinants often set the stage for the local dynamic, but in the end it is these local conditions which determine the timing, magnitude and specific trajectory of the overall transition.

One can think of our world, seeming to be chaotic, but instead consisting of a multitude of well defined transitions in many sectors, each with its own local characteristic. Different transitions begin at different times and places, but ebb and flow in an overlapping way, sometimes reinforcing one another and at other times dampening their dynamic. As adjustment occurs, occasionally useful niches are created which are then exploited by stressed elements of the ecosystem. Unfortunately, at other times, different sectors interact with each other in a harmful way to broaden and extend the susceptible period.

Societal Vulnerability

During transitions there seems to be a special vulnerability borne by society. Ample evidence indicates that key relationships are most likely to become out of balance during the transition. A primary cause of this vulnerability is the rapidity of change during the high velocity portion of the transition. Adaptive capacity is impeded because there is little time for systems to adjust and often there are limited feedback mechanisms operating which otherwise could help this process. Another contribution to social vulnerability during a transition is the amplifying effects created by transitions occurring simultaneously in several sectors. Rapid rates of change in several sectors could more easily overpower the available infrastructure which leads us to the next source of vulnerability during transitions: capital availability. Capital or investment capacity can either amplify or reduce societal vulnerability during a transition. If there are financial resources available to deal with the effects of rapid change, remediation is easier to implement. Africa which is trying to deal with a difficult demographic transition has almost no capital available for its use and will therefore undergo great hardship. The Soviet Union and Eastern Europe are struggling to find financial resources to deal with their flawed toxicity transition. Another dimension of transitions which affects societal vulnerability is the degree of interconnectedness. How closely is the local village connected to the regional and national economy? How much does what happens in one location determine what happens in another? There is no question that interconnectedness is increasing worldwide. We also know that under some circumstances linkage creates dependencies which in turn, increase vulnerability. However, it can work in the opposite direction as well. These very same links to a larger domain can also act as a safety net. If there are connections, resources can be brought to the stressed area more easily to mitigate the local adversity. The final and perhaps most important dimension of transitions affecting vulnerability is feedback.

Analytic Properties of Transitions

We have seen that many characteristics of transitions are common across all sectors and geographic scales. The question then, is whether there are analytic techniques which might be useful in describing this family of transitions. If so, these techniques may be helpful in portraying transitions in a way that facilitates comparison and thereby increases our understanding. In this quest we are especially interested in techniques and functions which reduce complexity and at the same time provide a reasonably accurate portrayal of reality

Functions which are candidates for consideration include exponential, exponential to the limit L, logistic, Gompertz, and the power function. Bounded functions which fit data more precisely but cannot be used for predictive purposes may also be helpful in uncovering patterns.

1.3 POLICY IMPLICATIONS OF TRANSITION THEORY

But what does it gain us to fit an exponential or logistic or for that matter any function to transition data? The answer lies in our ability to gain insights by relating different transitions to each other. First, consider the transitions within a given sector and at a given scale. We know there are transitions in a sector which some societies have already experienced while others have yet to endure. If the nature of these experiences can be captured in general form, it is more likely that knowledge can be transferred to other settings where a transition is first starting. Of course, each civilization or local culture has its own unique characteristics but any one emerging transition may be comparable to one or more of those which have occurred before because conditions are similar.

Second, there may be useful comparisons across different scales. We already surmise that a national-level transition, perhaps now in process, is actually comprised of a myriad of local transitions also in process or which have recently occurred. But there may be other locales in the region for which the transition has yet to happened. If similar patterns emerge because of similar local conditions, a useful prediction could be made about the nature of the passage through the transitions yet to appear.

Third, there may be insights gained simply by the process of fitting a function to historical data. Different mathematical functions often have very specific underlying characteristics which can provide useful ideas.

The next potential use of transition theory is to facilitate analysis across sectors. There is, of course, no good reason to expect the trajectory of, say, a forestry or agricultural transition to mimic an epidemiologic transition. However, for any society at a given time, there may be similarities in the rates of change across sectors. Developed economies have slower rates of change in their agriculture sector than developing economies when conditions are favorable. Rural based cultures may be expected to have urbanization transitions which are steeper than non-rural cultures. In short, it is worth testing to see if patterns can be empirically determined which would be helpful in predicting the shape of future transitions, given a stated level of intervention.

We have already mentioned the special societal vulnerability associated with several sectors being in rapid transition simultaneously. From a modeling perspective this simultaneity a very difficult condition to describe and analyze, which may be why less progress has been made in this area to date. However, being able to portray these multiple transitions with specific functions could be helpful. There is no question that each transition interacts with the other. And to the analyst this means that a reliable model must be structured as a set of simultaneous relationships. Describing transitions as functions facilitates this manipulation.

Another potential benefit of transition theory lies in the identification of lead indicators. If success is achieved in fitting transition data to an appropriate function, then for a given condition and point in time, the future trajectory can be predicted more accurately. Identifying lead indicators is facilitated because with an orderly function, only one, or at most, two parameters need to be determined to define the trajectory. This advantage is even more evident when several functions are considered simultaneously.

Finally and perhaps most importantly, transition theory may permit more informed public and private intervention. At one level we find ourselves believing that the trajectory of a transition is somehow fixed by an immutable law of nature. But at another level we know that this is not the case. Public and private policy can make a difference as we have seen from some of the cases discussed in this book. Rates of change can be influenced by policy redirection and consequent resource allocation. To the extent that we can link historical rate differentials with historical policy implementation, a better determination can be made about which intervention mix works best in dealing with problems facing society today.

ABSTRACTS

Aishton

The Komi Republic is an autonomous region located in northeastern Europe and is part of the Russian Federation. Komi is a region about the size of New England and is composed of 20 districts, governed in a hierarchical system from the Moscow government seat. Komi is a region of vast natural resources which includes natural gas, oil, wood products and precious metals. The emphasis of the paper focuses on strategies that will effectively influence a change in the administration of environmental policy in the Komi Republic. It is unreasonable and ineffective to regulate environmental policy, with little or no allowance for variation, directly from the Russian Federation seat in Moscow. The primary reason for the ineffectiveness emanates from the large land area and tremendous ecosystem diversity which exists in the Russian Federation. The Komi Republic also exhibits significant ecosystem diversity. This paper assert that the Komi Republic should formulate, administrate and enforce its own environmental policy. This contention is supported by the interpretation of quantitative data collected from many sources including the World Resource Database. Transition dynamics calculated from data compiled about the Soviet Union graphically illustrate anomalous behavior in the years leading up to its collapse in

1991. Environmentally-related data similarly compiled for Komi will likely display similar trends which portend a serious threat. Mathematical projections of environmentally related health issues such as hepatitis and upper respiratory problems in Komi represent increasing trends to which officials must pay attention. Dynamics involving the Komi government, International Corporations, the Russian Federation and environmental organizations truly reveal a complicated political situation. Drawing from the ecosystem diversity, transition dynamics of the Soviet Union, health projections in the Komi Republic and complicated political dynamics a case is built and presented which logically justifies the need to formulate a specialized and localized environmental policy in the Komi Republic.

Birkelund

The nexus between trade and the environment is only just beginning to receive attention. As global cooperation and international trade agreements become more common and more powerful, trade policies are starting to have a profound effect on the natural environment. The tropical timber trade in Indonesia and Malaysia serves as a prime example of how trade can interact with the environment. As a whole, this paper illustrates how international and domestic trade policies can worsen or alleviate pressures on resource consumption and become a major policy factor in population-environment transitions.

Both Indonesia and Malaysia are countries naturally endowed with tropical forests. At the same time, they are also both subject to the high population pressures and have not yet completed their demographic transitions. As a result, population pressures are magnifying the effects of trade on the environment in this area. By taking into account the dynamics between timber exports, deforestation, and population trends, government policies can work towards achieving sustainable methods of managing their forests.

More specifically, the governments in these countries need to focus on enforcing logging regulations, reforesting depleted forests, lifting export restrictions, and reducing the growth of their populations. As the tropical forests are often considered a "global resource", the international community should contribute financial support to this endeavor. Furthermore, the international trade community provides the appropriate medium for establishing sustainable forestry practices world-wide. The International Trade and Timber Organization is an example of the current efforts to promote global regulations on forest exploitation. In conclusion, it is imperative for Indonesia and Malaysia to deal with their forestry transitions in the near future if they wish to stop their tropical forests from being completely degraded. Additional research is needed to refine the relationship between the timber and trade. The tropical timber trade will be a critical factor in determining the final state of the tropical forests in this region.

Cheatham

With a population approaching one billion, the need for fertility reduction measures in India has never been greater. It can no longer be assumed that simply meeting latent demand is a sufficient means of reducing birth rates; the government must adopt policies that provide couples with economic incentives to reduce family size. One such measure would be to encourage private firms to increase female representation in their work forces; when women are employed in gainful wage-labor, the opportunity costs associated with multiple pregnancies are greatly increased. By employing women at a lower wage than men, the individual firm can increase its profits by cutting its costs of production; in this way, private industry can provide a social good (reduced fertility) by engaging in normal profit-maximizing behaviors. It is the role of government to provide potential employers with sufficient incentive to overcome strong cultural predilections opposing the employment of women.

Cunningham

While it is almost without doubt that global warming is occurring due to human activities, its full effects on humans and the environment are not known. The South Sahel region of West Africa (made up of Northern Benin, Burkina Faso and Southern Niger) is highly susceptible to the negative effects of global warming because of the tight linkages between the people of the region and the environment. Possible effects of global warming are investigated in terms of transition theory including, but not limited to,: increased impoverishment of the soil and subsequent decreases in agricultural production, increased rates of infectious and nutritional disease, and increased birth and death rates. No Regrets policies should be implemented by the South Sahel governments to benefit their societies now while at the same time protecting them against the possible effects of global warming in the future.

Frank

This study looks at the linkage of population growth and urbanization. Generally speaking, population growth and increasing urbanization seem correlated. Their causal relationship though is complex and urbanization factors differ from place to place. In comparing urbanization trends for 42 countries, the study identifies three different stages and pattern of urbanization. National urbanization trends however cannot be extrapolated to the local level. Despite overall increasing urbanization, individual cities may still decline. A major interest of the study is in the spatial dimension of urban growth. Urban shape and form is the physical manifestation of urban growth. Cities grow in different fashions. Urban form and shape is dependent on parameters such as size, growth rate, topography, available technology etc. It is the authors hypothesis that the time at which urban growth occurs will be greatly influence the shape and form of the urban area. Furthermore, it is assumed that there are more and less sustainable and harmonious pattern of growth. An attempt is made to devise a morphology of urban growth pattern to assist policy development regarding urbanization.

Gupta

Although the demographic transition India is undergoing is well known, with references to its population problem being quite frequent, the other transitions India is undergoing are less well known. Several of these key transitions, such as the agricultural, urbanization and forestry transitions are exist in a feedback loop exacerbating demographic problems. Policy decisions in India have historically paid only lip service, or altogether ignored pressures created by these transitions, however India is currently going through a critical phase as these transitions are experiencing rapid rates of change. A beneficial effect has been, the acknowledgment of economic and structural maladies by the authorities. Consequently a New Economic Policy has been adopted by the government entailing a fundamental shift in economic and social thinking. In this paper this economic policy is analyzed and its possible effects on other transitions are discussed.

Han

There is a vast, untapped field of natural gas in the world. It grows in size every year, instead of diminishing. And it can be found in every single country on earth. This resource is, naturally, the landfill. Technologies are currently being developed and improved upon to harness this energy that flows in the form of methane gas. This process of energy recovery reduces odors, health risks, smog, acid rain, and ozone depletion while increasing income to the local community. It is an ideal situation if the opportunity is exists. This paper attempts to derive several methods that may be used to determine just that, that is, does the opportunity exist? Problems and concerns with developing a landfill in the United States are examined along with possible solutions that may then be extrapolated to apply to various sections of the world. The major contributing factors are construction and operation, economics, social impact, and global feasibility. Transition theory is applied to the last section as an important tool that may assist policy-makers in deciding where and when a energy reclamation system may be constructed. This is a new technology and may eventually be discovered to be an excellent local solution to a wide range of global problems.

Landweber

This paper focuses on two epidemiological transitions in Thailand, one already past and one yet to come. Through governmental attention and infrastructure improvements, Thailand has faced its epidemiological problems directly, making great strides in reducing mortality for infectious diseases that mainly strike at the younger population. The successful accomplishment of that goal marked the end of the first transition, which is best illustrated by examining the war on malaria. However, Thailand now has an even greater problem: AIDS. Though the epidemic is only beginning to be felt in Thailand, predictions for the future point toward high death rates, particularly among the younger generations. This threatens to create a second epidemiological transition that would wipe out the progress made by the first, bringing with it catastrophic results for the nation as a whole.

Lombard

This paper traces the successes and failures of improved cookstove diffusion in India, Kenya and China. Taking completely different approaches to cookstove dissemination, these countries together offer a short-list of necessary elements in effective cookstove programming. The Indian government took a radical top-down approach to cookstove diffusion, heavily subsidizing hand-made clay stoves throughout rural India, resulting in the abandonment of millions of ill-constructed, low-quality stoves. Kenya, by contrast, aided by development organizations, employed a gradual, cyclical refinement process to stove design and dissemination strategy. Finally, by providing technical support and marketing for improved stove production, but allowing local energy offices and entrepreneurs to handle all aspects of stove production, the Chinese central government masterminded the most successful cookstove program to date. Although failures at diffusing cookstoves were plentiful in the 1980s, the last ten years indicate that cookstove projects can remedy past mistakes and provide fuel-efficient technology to large numbers of interested consumers.

Nabalamba

In Africa, more than anywhere else, political and economic choices made by the state have had important implications on how people and the environment interact. This paper will attempt to draw lessons in population and environment dynamics from the experience of two countries--Uganda and Tanzania- that adopted contrary economic and ideological paths after their independence and the implications of these decisions on national population growth and urbanization trends. The paper will discuss development theories that influenced national leaders on the population question. Data presented will show a direct relationship between the rate of urbanization and the fast deteriorating urban environment. I will argue that the degenerating environment is a consequence of national and urban population growth, and infrastructure deficiencies resulting from the inability of developing economies such as Uganda and Tanzania to sustain the growth. The paper will conclude with some policy suggestions intended to interrupt what is increasingly become a crisis situation.

OConnell

The country of Costa Rica is recognized internationally as a leader in conservation programs to preserve biodiversity. The current government of Costa Rica plans to continue this emphasis on conservation by being the first nation in the world to fully embrace sustainable development and development by implementing policy and institutional changes in accordance with Agenda 21 of the United Nations Conference on Environment and Development. Past and current rates of deforestation, and variables contributing to deforestation are analyzed in the context of the Costa Rican model of sustainable development. Deforestation increased during the social and economic transformation in the decades following the 1940's, and peaked during the 1970's. A national park system was instituted to protect the remaining forests, and today, approximately 25 percent of Costa Rica's land is protected. However, deforestation continues outside of the protected areas, and Costa Rica's current rate of deforestation may be one of the highest in the Western Hemisphere if the protected land is not included in calculation of the deforestation rate. If current trends continue, Costa Rica's forests will be exclusively located in national parks and protected areas.

Perry

This chapter examines the effects of increased urban growth on the natural environment in Kenya. First, the author looks at what stage of the demographic transition Kenya is, making generalizations about population growth. Then, specifically growth in urban areas is examined, including the phenomenon or urban-rural migration. Once a correlation between population growth and growth in the urban population is established, the chapter moves on to the larger issue of how the natural system in Kenya is being affected. The chapter seeks to answer the questions: what is the relationship between population growth and growth in cities; what effects do larger urban areas and an increasingly urban population have on the environment; and what policies will be effective in improving environmental quality as well as improving economic development.

Preston

Deforestation is increasing recognized as the number one threat to mountain ecosystems. Despite the fact that the causal relationships between deforestation and human populations is still largely unknown and debated, policy makers continue to move forward with piece meal strategies to combat the problem. The situation in Sikkim, India is no exception. Sikkim is in the midst of a forestry transition yet very little data has been collected about the actual amount of forest cover, the rate of deforestation or the causes of deforestation. However, using comparative case analyses, this study has determined that while deforestation in Sikkim is occurring at a more rapid pace than in other areas of the Himalayas, deforestation is also at a much earlier stage. Given that deforestation is only in the beginning stages, there is great potential for Sikkim as a country to reverse these trends before they reach the levels of destruction that have been reached in other areas. The first step in reducing deforestation is to understand the factors that contribute to it. This study examines the variety of contributing demographic factors as a means of illustrating the interrelationships of factors causing deforestation. One aspect of the problem treated in isolation will not be effective. Instead, policy makers need to understand the complexity of the problem and then develop comprehensive policies which address the full range of issues in an integrated comprehensive strategic plan. This study outlines policy recommendations which could enable Sikkim to reverse its deforestation trend and emerge as a leading example of a sustainable mountain ecosystem and economy.

Rowe

Nepal is a mountainous region with a number of Himalayan rivers flowing throughout the country, and there is no doubt that harnessing some of these waters will assist in improving the socio-economic well-being of Nepals people. It is a country where more than half the population lives at or just above the starvation level, a fact that has a significant impact on the environmental degradation. Its one abundant resource is water and its potential for hydroelectric power is great. However, there is an ongoing debate over small and large dam projects to be implemented. Large dam projects are intended to bring in revenue to the country, and small dams are designed to enhance rural development. It is Nepals task then, to recognize the trade-off that exist in implementing these different types of dams. With dam projects, the positive and negative effects are influenced by and vary greatly depending on the environmental, social and political context within a country or region. Potential dam construction will have a strong impact in many sectors, most directly effecting the agriculture, forestry and energy sectors. An examination of these sectors, and Nepals geography, environmental condition, and social and political status leads to the conclusion that large dams pose too much of a risk for Nepal.

Torng

The Intermodal Surface Transportation Efficiency Act of 1991, ISTEA, designated $21 billion to extend the interstate highway system. Subsequently, a 158,000-mile national highway system has been proposed much of the extension of which will be built in metropolitan fringe areas. Empirical urban development reveals that transportation and land use affect each other interactively. Existing studies have discussed the aggregate effects of interstate highway systems on demographic and socio-economic evolution. This research explores the intensity of interstate highway effects on suburbanization by examining the directional effects on growth and migration of population in the suburbs. Oklahoma City, Oklahoma, is selected for longitudinal analysis over three decades of interstate highway and suburban growth from 1960 to

1990. A major transition in the influence of spatial effects on suburbanization between 1970 and 1980 is detected. The directional effect of highway systems on encouraging urban to rural migration is fading (i.e., spatial correlation effect). Meanwhile, the expansion of urban areas is taking place evenly in all directions surrounding the existing urban areas (i.e., spatial neighboring effect).

Tracy

The paper focuses on the possibility the existence of a sustainable building material transition. It uses thinking similar to traditional transition theory. It also attempts to describe the effects of the timing of other transitions on the sustainable building material transition. In addition, the text makes recommendations on how to facilitate such a transition.

It is of importance that this paper deal with the issues of resource use in the building industry. Specifically, this paper will deal with the topic of renewable and nonrenewable resources as they apply to the materials used for the structure of buildings. Of interest are the choices people in the United States make with regard to the way they build in the context of the environment as a whole. Of particular interest is the comparison of the impact of traditionally popular methods/materials of construction and "Green" or "Sustainable" methods/materials of construction.

CHAPTER 1

THE KOMI REPUBLIC

RICHARD W. AISHTON

The Komi Republic is located in the northeastern corner of the European part of the Russian Federation. Its global position is approximately 590 north latitude to the Arctic circle and is on the west side of the Ural Mountains from 660 to 480 E longitude. (Refer to Map #1 in Appendix) Komi measures approximately 416,800 square kilometers, approximately the size of New England, with a population of nearly 1,250,000 people. The capital city of Komi, Syktyvkar, has a population of about 225,000 inhabitants. It is nearly 200 years old, which is young by Russian standards. Komi possesses its own cultural origins which researchers determined to originate in the Vwym River valley. The culture is closely related to Eskimo culture due to its northerly location. Aside from Russian language Komi also has its own language, of Finno-Ugric origin which is in the Uralic language family. Komi was one of Stalins favorite gulag locations and, in fact, there are well over 1,000 gulags located in the Komi Republic, some of which are still active as prisons.

The Komi Republic is considered a part of Russia's Northern Economic Region which is noted for its forest products, mining and fishing industries and the production of metals such as aluminum. Major natural gas and oil industries located in Ukhta create an interesting dynamic between Komi, Moscow , International or Multi-national Oil Corporations and environmental organizations. Komi industries stratify the Republic as follows: north - coal mining and fishing; central - oil and natural gas; south - wood products.

The Komi capital of Syktyvkar is situated at the confluence of the Syssola and Vwychegda Rivers. The surface and ground water resources surrounding Syktyvkar that are needed to satisfy industrial, agricultural and municipal demands are becoming incrementally less sufficient. These two rivers along with the huge Pechora River are already significantly polluted by nutrients or industrial wastes. In 1994, a major break in an oil pipeline severely polluted the Pechora and several other streams in the Pechora watershed.

Wildlife resources have been heavily depleted by industrial development and pollutants, as well as by decreases in critical habitat associated with widespread replacement of primary forests with secondary forests and draining of marshes. Fish resources have been degraded because of deteriorated conditions for reproduction by pollution of water bodies and major and minor spills. Within the boundary of the Komi Republic lies a natural reserve called a zapovednik. This reserve, the Pechoro-Illych, is located in the central taiga and was designated as a biosphere reserve by the former Soviet Government. The Pechoro-Illych, preserved strictly for pure research, is nearly 1.5 million acres of untouched wilderness.

The Need for Environmental Standards

The opening section of this paper provided a general description of the Komi Republic. This section begins to build a case which supports the development of specialized environmental policy for the Komi Republic. The paper relies on both historical data taken from literature and the World Resource Database (WRD) and current information gathered on site in Komi to justify my contention for restructuring the Komi Republic's environmental policy.

Case I

Since the breakup of the Soviet Union in 1991 Komi has developed complex political and environmental interrelationships with the Moscow government seat. Although such circumstances are not uncommon in the Russian Federation, Komi and Moscow display some unique dynamics. The Komi Republic is rich in natural resources, which include vast natural gas and oil resources and the largest pulp and paper complex in Europe. The potential for exploitation of these resources by foreign investors is a genuine concern. I foresee a complicated situation. For example, companies in Komi may decide to enter into to contractual agreements with foreign investors for hard currency. Moscow could decide to challenge these contracts on the basis of land and resource "rights" granted under the former Communist regime. A dispute would likely develop between a Komi company, Moscow and foreign investor. This dispute process would all but ignore a very important consideration, not only in Komi, but throughout Russia: the environment. Environmental remediation in Komi is at a standstill, as it is in the rest of the Russian Federation. The cause of this standstill appears to be a chicken-egg relationship. How does one address environmental problems without a stable economy and why should one not immediately undertake environmental remediation since, without it there may be a drastic, negative impact on the economy? I suggest a strategy that incrementally addresses both, simultaneously. The general plan begins with the following narrative:

Russia has a land area of 16,995,800 square kilometers, nearly twice that of the United States. Its southern borders are located near 500 N latitude and the northern borders are above the Arctic circle (66.70N lat.). With this degree of geographical diversity one uniform set of environmental laws seems inadequate, yet this is exactly what one finds in the Russian judiciary system. Refer to the map of forest biomes of the Russian Federation in the appendix.(Map #2). The variation of ecosystems present in each of the different biomes virtually orders a policy structure that considers this variability and addresses it with an appropriate policy for each biome. The pure size of the Russian Federation creates a substantial logistical problem for discussing the implementation of specialized environmental policy. However, the Komi Republic is a more manageable model with which to defend the notion of a new, more specialized environmental policy that will enable local and regional economies to strengthen along with the development and refinement of a new environmental policy.

I contend that the optimal method of addressing these problems is to allow each geopolitical region (such as the Komi Republic) to have the power and freedom to undertake necessary strategies specific to their geographical location, since each area will have a different set of problems. The ultimate goal will be to allow the Komi Republic to structure its own environmental policy, with Moscow supplying only general guidelines. Each geopolitical region will have more extensive knowledge of their own area. Since the judicial branch of the Russian Federation is ineffective an alternative resolution strategy is appropriate. The use of consensus-building strategies will afford Komi the decision-makers the opportunity to arrive at a mutually beneficial implementation plan that will address both economic and environmental needs.

Refer to Map #3 and biome chart in the appendix to further understand the contention for specialized environmental policy structure. The map delineating the biomes in Komi illustrates the ecosystem differentiation. Six different biomes are located in Komi, including two variations of tundra. Particular management practices or other external effects from human interaction will have a different impact on each particular biome. Ecosystem management principles recognize the need to develop impact assessment for the biotic variation similar to that found among the different biomes in Komi. It is evident that management strategies developed for tundra regions vary from other areas lacking the permafrost which defines the Arctic tundra. Therefore, it is imperative that the Komi Republic adopt an environmental policy which allows for the variation dictated by these different biomes.

Komi not only is constrained by the general environmental standards issued from Moscow but is also constrained by the hierarchy of political structure. The organizational chart (Chart I in Appendix) portrays the continued trend in one set of standards for environmental regulation from the former Soviet Union to the Russian Federation, of which the Komi Republic is a part. The organizational chart also points out another weakness in the current system of management. The map of Komi, which shows the 20 regions, (Map #4 in appendix) and the organizational chart are used to help explain the next contention. Each of the 20 districts in Komi has an identical structure from the economic ministry down through the organization. Therefore, each of the seven departments under the jurisdiction of the Economic Minister is also in direct contact with the Economic Minister in Moscow and, as the chart demonstrates, the Komi Economic Minister can be bypassed by directives received at the district level directly from Moscow. The potential for duplication or confusion is very high. In addition, the enforcement network and fine system for the Federation is antiquated and ineffective. The Komi district map also delineates another weakness of their system. Each individual district employ only three inspectors and they each have a specific area of assignment, which makes a very inefficient system. For example, if one inspector is a fisheries expert and happens to find a forestry-related violation he must contact the forestry specialist in his district to evaluate and deliver the penalty, usually a fine.. The system of fines is antiquated and has not kept up with inflation. An accidental spill of to 1000 to 10,000 gallons of oil into a waterway of any type carries a fine of 100,000 rubles - $20.00. Environmental incentives are non-existent with such a system.

The Constitution of the Republic of Komi states the following: Article 64, subsection (e), the use of natural resources; protection of environment and maintenance of ecological safety; especially protected nature reserves; protection of monuments of history and culture are common jurisdiction of the Russian Federation and the Republic of Komi. In order to establish a positive trend with environmental remediation there is need for significant policy modifications that will allow the Komi Republic to formulate, modify and enforce its own environmental policy.

Case II

The collapse of the Soviet Union in 1991 signaled a change in world order and precipitated a wealth of speculation about the future of the Russian Federation and the other Republics of the Former Soviet Union (FSU). Within the former Soviet system are also found a number of republics called Autonomous Republics. They were established under the Stalin regime but nothing changed except these republics were allowed to call themselves autonomous. From Stalins perplexing ideal of maintaining ethnic diversity originated this autonomous designation. Each republic still operated as required under the Soviet system. The Komi Republic is one of these so-called Autonomous Republics and is the subject of this paper.

The death of Constantin Chernyenko in March of 1985 and the subsequent appointment of Mikhail Sergeevich Gorbachev as the secretary general of the Communist Party of the Soviet Union (CPSU) marks the beginning of a period of significant change in the Soviet Union. The methodology of ideological reform under Gorbachev was not dissimilar to previous changes in Soviet thinking. Gorbachev took on the task of uskornie (acceleration) of scientific-technical progress. Launching reform of this type displaced developed socialism rather than destroying it outright, consequently developed socialism was allowed a foothold by those unwilling to change. Nevertheless, as we know, Gorbachev was able to displace or counterbalance the ideology of developed socialism with his uskornie of technical, social and economic reform. Ultimately these were part of perestroika (restructuring).

It is productive to address the specific nature of the dynamics between the rapidly eroding Soviet Union and current problems in the Russian Federation and the Komi Republic. I propose to use transition theory as outlined in Chapter 14 of (Drake) , Towards Building a Theory of Population-Environment Dynamics,(Ness, Drake, Breslin, 1992) as an evaluative mechanism. We know that the collapse of the USSR occurred in 1991 and by using several indicators I surmise that the transitions will point to SOMETHING imminent during the years approaching 1991. Since we already know what happened then the focal point is available. Can the transitions be used as a predictive mechanism? I hypothesize that transition theory will illustrate trends with which to make general predictions that substantiate the fall of the USSR. If similar transitional trends are evident utilizing environmental-related data specific to Komi then I theorize an environmental abnormality exists. This abnormality must then be addressed through appropriate scientific investigation. Decisions based on these data may lead to policy modifications. This paper includes a more detailed narrative of the factors that led to the breakup of the Soviet Union. Clearly, the transitions would not actually predict the breakup but the could illustrate, with different indicators, that something would happen within a few years or less. By combining supporting data and transitions a correlation will appear that is mutually supportive. In order to explain this presumption a number of transitions have been prepared from different subject areas. If all of these areas indicate a change or continued trend in a direction that implies impending problems then it seems clear that transitions could be used as a significant correlative factor in an overall predictive mechanism. The next part of this paper will explore the idea of transitions and their usefulness in more detail.

What led to the breakup of the Soviet Union?

The election of Gorbachev as secretary general of the CPSU in March of 1985 testified to the Politburos recognition that the country was in a very serious long-term crisis which would eventually jeopardize its standing as a great power alongside the United States. Gorbachev was the candidate of those who wanted change. He realized that change could no longer be postponed. Gorbachev intensified the goals of Yuri Andropov, his patron and mentor, to reduce party corruption and investigate non-labor income, that is, Gorbachev lobbied against people who received earnings not acquired in officially recognized employment. He also sharply restricted the sale of alcoholic drinks and banned their consumption on official occasions. This was the first part of perestroika. Gorbachev also launched glasnost (publicity) which was supposed to indicate less secrecy and eliminate censuring of the press. The catalyst for perestroika and glasnost occurred in April of 1986 - Chernobyl. Foreigners were indignant that they should learn of an explosion affecting public health around the world from a non-Soviet source (the Swedes were supposedly the first to call attention to the increased atmospheric levels of radiation).

Gorbachev may have been the architect of the breakup of the USSR but it surely was in a more reactive role than a proactive one. Once he loosened the grip of the former Soviet system he and the socialist government were overwhelmed. Shortly after Chernobyl Gorbachev held a meeting with a delegation of writers and told them to print the truth. They responded with attacks on censorship and on environmental pollution. Books including Solzhenitsyns Gulag Archipelago were published and the realities of Stalins regime were revealed in their entirety. Sakharov was released from exile in Gorky and immediately made his presence known, even to Gorbachev, who ordered his release.

Gathering momentum toward freedom throughout 1987 and 1988 the Baltic countries (Latvia, Lithuania and Estonia) started with sharp commentary about environmental issues and quickly moved toward the freedom lost in 1940 as part of the Nazi-Soviet Pact. On March 11,

1990. Lithuania proclaimed independence and the Latvian and Estonian Supreme Soviets followed suit soon thereafter.

August 19, 1991, a small of group of opponents within the party attempted to take over the government in a coup attempt. The attempt occurred a day before the Treaty of 9 + 1 was to be signed. The 9 + 1 describes a treaty with the 9 remaining republics (those republics which had no plans for complete independence) plus Moscow. The treaty would allow for broader de-centralization of power and would virtually exclude much of the former Communist Politburo. The Politburo was composed of men who made their livelihood from the Communist Party's abuse of power. They would not relinquish this power and their elite lifestyle without attempting a takeover. This failed coup attempt left Boris Yeltsin in a position of power and effectively neutralized Gorbachev. The failed attempt marked the official end of the USSR.

The Economic Facts Behind the Collapse of the Soviet Union

When Gorbachev and his advisors took power in 1985 a national systemic crisis confronted them. It was a crisis of effectiveness. The Soviet Union was an economic disaster. Its performance in almost every sphere but the military was below not only world standards, but the standards set by its own leadership. Official party reports were completely inaccurate.. The party-state administration was highly bureaucratized, penetrated by a corporatist spirit, and thoroughly corrupted by Mafia-like informal associations. With regard to the economy, in a speech given at the Plenum of the Central Committee in

February 1988, Gorbachev summed up the state of affairs with a remarkable statement: In the 20 years previous to his accession to power, the Soviet national income, with the exception of production of alcohol, did not increase in real terms at all. The combination of the trends of Soviet economic and technological stagnation with the explosive growth in the capitalist world was potentially, and in part actually, calamitous to the Soviet Union and to the domestic and international aspirations of its ruling circles. During the mid-1980s the Soviet Union was falling behind major capitalist nations in key comparative economic indicators. Most important, the technological gap between the Soviet Union and advanced capitalist countries was widening with increased momentum. The Soviet Union produced, for example, twice as much steel as the United States, with a GNP half the size of the United States, and still encountered chronic shortages of steel. The explanation for this anomaly is quite simple: The Soviet Union wastes steel by engaging in an unnecessary and unproductive enterprise. The amount of steel in Soviet capital and consumer goods is comparatively exorbitant. (This record of enormous waste is also true of lumber and other primary products, most notably the wasteful consumption of electricity and oil.) Such practices, when combined with the invasion of Afghanistan in 1979, served to further deteriorate an already huge imbalance between the military-industrial complex and the foreign/domestic economic situation.

The transitions found on the following page are graphic representations which, when combined with the narrative of the events leading up to the collapse of the USSR, make a clear representation of the factors contributing to that collapse. The figures which comprise the analytical base for the transitions were taken primarily from the World Resource Database (WRD). The transitions portray parallel information which, in stable relationships, generally follow a parallel path, when A goes up B goes up and when A goes down B goes down. The interesting behavior of the transitions occurs when the two parallel relationships either converge or diverge. Something must have happened to cause this behavior. Therefore, the transitions indicate some type of aberrant nature and underlying causality and, when combined with other factors, act as a reliable indicator or support predictive mechanisms. My examples focus specifically on the Soviet Union leading up to 1991. The curves primarily, but not exclusively, demonstrate economic trends. Those indicators graphically evince diverging or converging curves which, under stable conditions, display parallel behavior. I theorize that creating similar transitions, but with the use of environmental data from Komi, will illustrate behavior similar to the transitions from the Soviet data leading to the collapse in 1991. If the transitions from Komi do show similar dynamics then I contend that there are environmental problems which require further scientific analysis.

The following six relationships graphically delineate trends which illustrate a change in the norm: 1) external debt vs current borrowing; 2) total labor force vs agricultural labor force; 3) energy production vs energy consumption; 4) energy exports vs energy imports; 5) roundwood imports vs roundwood exports. (6) crude birth and death rates:

(Information taken from the World Resource Database - WRD)

Figure #1

Figure #1 illustrates an increasingly diverging trend in external debt versus current borrowing from a point in time between 1987 and 1988. This trend continues and as the graph indicates the trend demonstrates a more pronounced divergence from 1990 toward 1991. I consider this an indication of the increasing devaluation of the ruble on the world market. In addition, the high debt makes the Soviet Union a poor risk to lenders, which causes the current borrowing trend to decrease.

(Information taken from the World Resource Database - WRD)

Figure #2

Figure #2 graphically represents the relationship between total labor force and agricultural labor force. I speculate that this graph explains the movement of the labor force from agricultural areas to the military-industrial complexes. Agriculture is a labor intensive industry in the Soviet Union and the loss of this work force will necessitate the need for food importing.

(Information taken from the World Resource Database - WRD)

Figure #3

Figure #3 shows the relationship with the energy production versus energy consumption in the Soviet Union. Notice the sharp drop in both production and consumption beginning about 1989. A projection of this graph shows an intersection of the energy curves, which indicates the need for conservation measures or indicate the need for energy purchases from another source.

(Information taken from the World Resource Database - WRD)

Figure #4

Figure #4 corresponds with Figure #3 regarding energy usage. The energy production and consumption figures predicted an intersection. Measures were taken to correct this trend. Energy exports were severely cut back. Imports were reduced, again most likely due to the poor buying power of the ruble on the world market.

(Information taken from the World Resource Database - WRD)

Figure #5

Figure #5 above is another transition curve which also solidifies the fact that Soviet Union is in a critical economic situation. The roundwood imports have been reduced and the projection line indicates that the imports will continue to decline. This transition again provides a graphic illustration indicating an economic downturn.

(Information taken from the World Resource Database - WRD)

Figure #6

Figure #6 has been projected manually simply to illustrate the significant trend in the crude birth and crude death rates. 1990 appears to be at the beginning of a transition which graphically represents a serious situation for the people of the new Republics formed from the Soviet Union.

The previous six transitions (Figures #1 - #6) were created by data which, when displayed graphically, delineated negative trends. The transitions did not predict anything specific but when viewed together they made a compelling argument that something negative occurred or was beginning to occur. By combining these graphic observations with existing history the transitions are consistent with what we now know about the collapse of the Soviet Union. It is my theory that if environmental data gathered in the Komi Republic displays negative characteristics similar to transitions in figures #1- #6 then further, quantitative investigations are appropriate, and I theorize that these investigations will conclude that Komi's environmental situation has not stabilized but continues to deteriorate. Therefore, the Komi Republic has need to address this situation through environmental remediation as outlined by a specific environmental policy.

Two questions arise when reviewing the transition dynamics: (1)

Why didn't some officials within the government of the Soviet Union recognize what was happening? (2) How will the FSU finance remediation of environmental problems and reverse the serious downward trend of economic indicators? Part of the explanation for both of these questions follows: According to official statistics (which were later found to be false), Boris Gosteev, the minister of finance, reported in October 1985, that the Soviet Union had generated a budget surplus of 4.1 billion rubles. Belatedly in 1988, he corrected himself to reveal that on the contrary, the 1985 budget had not run a surplus but a deficit of 37 billion rubles, or about $59 billion. Gosteev anticipated that in 1989 there would be a budget deficit of 35 billion rubles or about $56 billion; the previous figures reflect an exchange rate of $1.60 = 1 ruble. Figure #7 below illustrates the REAL, world-market value of the ruble during the time period from 1989 to the present. (Breakup of the USSR occurred in 1991).

(Compiled from yearly trips to Russia by the Richard W. Aishton)

Figure #7

Referring to Figure #7, Gosteev's deficit figures are far beyond 37 billion rubles since the real market value of the ruble far in excess of his exchange rate of $1.60 = 1 ruble.

The Former Soviet Union (FSU) has broken into a fragmented economic disarray. The Russian Federation is the main player with whom this paper is concerned because my interest relates to the Komi Republic, which resides within the boundaries of the Russian Federation, yet to a degree has some freedom beyond Russia. This is a complex relationship that has a unique dynamic, which will be explored. Hedley Bull argues the point of anarchy and how it is incompatible with society in the international trade arena. I understand where this could be loosely applied to the Moscow - Komi situation, or any other place in the Russian Federation. Russia needs to become a permanent, reliable fixture on the international market yet its history also does not allow it completely sever with the past practices quite yet. The old Communist elite are now entrenched in the new capitalism yet still do not fully understand how to separate from the anarchist/socialist model under which they lived and thrived. Presently the situation has changed in the FSU, but has it really? According to my interpretation of Double-Edged Diplomacy (Putnam, 1992), Russia may not be very far from its usual situation in world trade. For most countries involved in international relations, whether it is trade or dispute resolution the politicians or decision-makers were involved in a two-level game. The decision-makers are required to make decisions based on what constituents at home desire (aka. domestic table) and another set of decisions and rules are needed to deal with what politicians and businessmen from foreign countries are asserting (aka the international table). Question: Does Moscow actually care about domestic policy or is it too busy trying to get into the international arena where Russia can stand to make political and economic gains? According to my theory based on proposals discussed in

Double-Edged Diplomacy (Putnam, 1992), Russian Federation government officials face decisions on an international level that conflict with domestic interests. These officials make decisions based on improving economic gains and consequently they ignore domestic problems, which include the terrible environmental conditions. A more free press in Russia and greater world media attention creates a forum in which government officials are more exposed to criticism. President Boris Yeltsins heart condition has jeopardized his political future. Current acting President Viktor Chernomyrdin, a former businessman, must now devise a strategy in which to address both the economic and environmental conditions in the Russian Federation.

Case III

The economic situation for the average Russian citizen is still bleak but another specter looms in the shadows of the Russian country - environmental degradation. In the wake of Soviet Communism the Soviet Union has left a legacy of inconceivable and potentially irreversible environmental damage. In land area, the Soviet Union was the largest country in the world. In population in 1990 it ranked third, after China and India. For decades it was the leading producer of oil and steel, the owner of a quarter of the planets forest reserves and an equal portion of its fresh water. Yet it beggared itself by endangering the health of its population - especially its children and its labor force - the productivity of its soil and the purity of its air and water. The simply unbelievable environmental legacy left to the people of Russia defies the imagination. Not only are five regions - the Urals, East and

West Siberia, Central and North Russia - on the brink of ecological disaster, but, where air quality was monitored, it is theoretically impossible to live in every seventh city. There is 20 times as much nitrous oxide as the normal international standard in the air of Gorky (Nizhny-Novgorod), Smolensk and Omsk; 33 times as much sulfur dioxide as the normal international standard in Nikel; 183 times as much methyl mercaptan as the normal international standard in Volzhsky, 289 times in Arkhangelisk, 478 times in Novodvinsk; the benzopyrene content in Novokunetsks air is 598 times above the maximum permissible by international standards. The air in Novokuznetsk, in fact, ranked on as the fifth most polluted in the USSR. Most of these cities are in a Catch-22 situation whereby the large industry is such an integral part of the economic structure of the city that closing the factory down to retrofit it with proper pollution control systems would disrupt the flow of funds for the municipal budget, throwing the city into economic chaos.

Stalins desire to demonstrate Soviet superiority led to the acceleration of industrialization while leaving behind all other aspects of development including health and environmental safeguards. The United States followed a similar developmental strategy but in the early 1960s the US had the benefit of people like Rachel Carson (Silent Spring, 1961) who had a democratic forum in which to raise questions that initiated scientific research. Decisions based on this research insured proper stewardship of the earth. Unfortunately, the Communist society was interested only in being superior, at all costs. The price the

Russians and other Republics of the FSU have paid is far beyond the benefits. Health minister, Aleksei Yablakov, has completed a two-year study which shows a bewildering array of ominous health trends including increases in anemia, tuberculosis, infectious hepatitis and acute upper respiratory tract infections which are linked to the intensity of pesticide use, water pollution and suspended particulate matter well in excess of established international norms. The graphic representation below illustrates the trend of infectious hepatitis.

(Compiled from data in Ecocide, Murray Feshbach, 1992.)

(Figure #8)

Figure #8 projects the trend in the occurrence of hepatitis. Hepatitis (which includes both hepatitis A & hepatitis B) is commonly used as a reliable indicator for water quality. Figure #8 illustrates an increasing trend which projects continued poor quality water for the Russian Federation. This trend demonstrates the need to formulate a program designed to remediate the poor quality of water in Russia. It also adds another component to the overall environmental picture of Russia.

The environmental situation in the FSU is serious, and with the addition of nuclear waste problems the situation is grave. The eventuality for all of the indiscriminate use of nuclear technology is a somber future for the citizens of the former republics of the USSR. As many as 120 civilian underground explosions have been carried out in the

USSR over the past four decades and about 1,000 more under military operations. There are 54 civilian nuclear power plants in the former USSR, operated in ways that would be considered less-than-safe by International standards. There are many radioactive waste sites, even in densely populated areas: 636 in Moscow; 200 in Omsk and 1,400 in St. Petersburg. These commonplace sources take a toll in morbidity, as do the dramatic events, such as the nuclear accident at Chernobyl in 1986. Over 650,000 people were exposed to radiation at Chernobyl and a 1992 commission found 1,700 cases of thyroid cancer (200 of them children) believed to have resulted from that accident. Currently, the average life expectancy in men in the Former Soviet Union is lower than the pension age. Compare the following graphic projection, which further delineates future trends in birth and death rates in Russia.

(Information taken from the World Resource Database - WRD)

Figure #9

(Information taken from the World Resource Database - WRD)

Figure #10

When one compares the previous two curves (Figures #9 & #10) the differences in the projections do not appear to be serious since the deaths project a range of deaths from 4000 to 5500 (using linear or exponential methods) in the year 2030. The births projected to the year

2030 are estimated reach approximately 5800 to nearly 6000. The erratic nature of the births curve is a concern.. The births have displayed this behavior since 1950 and would appear to be normally eccentric in the Russian Federation (and FSU) population. I submit, however, that this erratic nature is a product of decades of environmental problems and will be more susceptible to increasing spikes and valleys as the concentrations of pollutants increases.

The Komi problem described earlier in this paper is duplicated all over the Former Soviet Union. In this particular instance there are clear data projections and a definite potential program to reverse the environmental destruction that so defines the legacy of the FSU. The Komi Republic has some unique features that make it both attractive and practical to begin a new environmental program. The remoteness of its location make it necessary to govern more independently. Its remoteness has also contributed to the fact that less environmental damage has occurred there than in other regions of the FSU.

Komi is the site of the cleanest water in Europe (located in the Pechoro-Illych Biosphere), which is something worth saving. The mighty Pechora River is the last stronghold of virgin Atlantic salmon fisheries. The city of Ukhta is the focal point of the oil and natural gas extraction coming out of the Siberian oil fields. The largest pulp and paper complex in Europe is located 10 miles from the capital city of Syktyvkar. This paragraph illustrates the conflicts and potential for conflicts among environmentalists and capitalists in the Republic. Since the people have long been oppressed it is only natural to ignore the environment for economic gain which

would make them at least comfortable. The Komi people realize that the land exists for future generations. They have a very active Green Party in Komi and have a published newspaper called Cheesta Pechora. (Literally translated this means clean Pechora) Officials in the Troitsko-Pechorsk district (see map #2 and attachment in appendix) have taken measures to further protect the Pechoro-Illychsky biosphere which is located within the area of this district. A one-half kilometer wide buffer zone has been delineated on the ground around the entire perimeter of the biosphere to insure protection against encroachment from logging. Legal pressure is limited, but the citizens of the district apply public pressure to maintain the pristine conditions of the biosphere and in this district the pressure has had a positive effect. However, long-term, legal solutions to the environmental problems seem less positive since policies and laws originate within the government and the bureaucratic snarl that pervades the legacy of the Communist Party.

The Komi Republic has taken a positive initiative by developing a project name of Eckom. The project, infused in the educational system, is teaching children at all grade levels about the dangers of improper ecosystem management. But without significant policy modifications or changes even this worthwhile project may be rendered useless.

The following two graphic projections pertain specifically to the Komi Republic. The curves confirm that Komi also appears to be consistent with data from the Russian Federation and FSU. In both instances the curves indicate trends that require further attention and more sufficient quantitative analysis. The first set of curves (Figure #10) relates the frequency of upper respiratory infections in the Komi Republic which are presumably linked to air pollutants from pulp and paper complexes, coal mining facilities and other industrial complexes with insufficient or non-existent pollution abatement equipment.

(Information from the Komi Government - Tentakov, 1995) Figure #11

Although the death rate does not appear to seriously accelerating it nevertheless indicates an increasing trend. Trends such as this are not considered serious but when combined with other data a complete picture is constructed which indicates serious long-term, health problems. Poor health is directly proportional to poor environmental conditions.

(Information from the Komi Government - Tentakov, 1995) Figure #12

As one can see there is an increasing trend in both curves. Unless remediation strategies are implemented this trend will continue and may begin to accelerate. The ecosystem variation dictates a varied environmental management program. However, the only method to initiate such a program is to bring about a change in policy at the government level. With mathematical projections illustrating negative trends it seems logical to explore other relationships to determine if similar trends are evident. When more data becomes available for the Komi Republic transition dynamics will be applied as it was for the Soviet Collapse. If these transitions display similar behavior to those transitions explored in the collapse and quantitative data support the transitions' behavior then there is a need to implement timely and fundamental policy changes are necessary. The legacy of the CPSU (Communist Party of the Soviet Union) still maintains a hold on the bureaucratic process. It will be a difficult task to persuade the Russian government to allow Komi and other regions in Russia to develop a new set of specific environmental laws and regulations, with an active and efficient enforcement arm. By utilizing the processes described in this paper along with additional quantitative data perhaps changes in the environmental policy structure can be realized.

The following summarizes desirable policy recommendations for the Komi Republic based on the interpretation of data acquired during research:

1. The Russian Federation has such a huge land area and such ecosystem diversity it is not reasonable to try to administrate environmental policy with one general guideline. Therefore, it is incumbent upon the Russian Federation to consider modifying the structure of policy administration. The Federation could model their policy similar to the United States. Moscow would supply general guidelines as a baseline with which to work. The environmental policy structure would be decentralized and the responsibility for the development of specific

environmental standards would be the task of the administrative apparatus located in the seats of government at the Republics level.

2. The development of the enforcement section of the judicial system in the Federation Government will be slow. Therefore, I recommend that at the Republics level a task force is assembled, with appropriate distribution among government officials, technical experts, environmentalist and industry representatives. This task force can begin to formulate a workable plan to allow for environmental remediation and still maintain functional economic standards. What is the incentive for this type of consensus-building? Agreements which originate from this type of consensus process would be "grandfathered" out of new laws enacted by the Moscow government at a later date. Of course there would be limits to this exemption.

3. The Komi Republic needs to adopt specialized regulations which reflect the ecosystem diversity in the Republic. A "biome environmental policy" should be considered as one alternative. Technical assistance for such a policy is easily obtainable from the Ural Division of the Russian Academy of Sciences in Syktyvkar.

4. Refer to the organization chart of the Komi government (In the Appendix). The minister of natural resources must have direct contact with Moscow. The current organization creates the potential for confusion and redundancy.

5. Each of the 20 districts in Komi must have the freedom to form planning boards and to adopt local ordinances which are, in turn, recognized and aided by the Komi and Moscow governments. Local

enforcement will be successful only if backed up by government policy.

6. The number of inspectors in each of the districts must be increased. The geographic size of the districts and poor road systems create inefficiency. A larger number of inspectors will alleviate some of the inefficiency problems. The inspectors should be required to have a strong scientific and environmental background with practical experience and university backgrounds preferable. And they should be paid accordingly. Their work will have a significant effect on the overall environmental policy and remediation process.

The Komi Republic is a unique area in the Russian Federation. Due to its vast wealth of natural resources it has enjoyed relative prosperity compared to other areas of the Russian Federation and the FSU. The Komi people and the Russians who live in Komi share the common goal of maintaining Komi as a sustainable society. Poor economic conditions and environmental degradation threaten this sustainability unless properly addressed. By combining the ideas outlined in this paper with other innovative ideas from the Komi residents it is likely that Komi will succeed. This success, however, is a function of environmental policy and decision-making strategies. Komi and Russia are quickly approaching a critical period when poor decision-making could cause their serious environmental situation to accelerate towards disaster. If they act quickly it not too late for resolution.

APPENDIX

Attachment: Maps #1 and #2.

APPENDIX

Attachment with Biome Map (#3)

Areas and delineations for the forest biomes of the Komi Republic

Biome	Percentage of Area	Square Kilometers
Mountain Tundra	10.2	42513.6
Arctic Tundra	2.4	10003.2
Wooded Tundra	6.4	26675.2
Northern Taiga	40	166720
Central Taiga	38	158384

Southern Taiga	3	12504
	100	416,800

APPENDIX

Attachment with Komi District Map (#4)

and flow chart

region	name of region	area 1000 sq km	population 1000's of people	administrative center	population 1000's of people
1	Syktyvkar	0.7	242.6	Syktyvkar	226.3
2	Vorkuta	24.2	209.7	Vorkuta	113.5
3	Vuktill	22.5	26.3	Vuktill	18.8
4	Inta	30.1	68.4	Inta	59.9
5	Pechora	28.9	92.4	Pechora	64.8
6	Sosnogorsk	19.4	62.1	Cosnogorsk	31.2
7	Usinsk	30.6	70.9	Usinsk	53.2
8	Ukhta	10.3	140.8	Uhkta	110.9
9	Ijem	18.4	24.3	Ijma	4.1
10	Knyajpogost	24.6	36.7	Emva	18.9
11	Koigorod	10.4	12.2	Koigorodok	3.1

12	Kortker	19.7	27.7	Kortkeros	4.8
13	Preloz	13.2	29.4	Obyachevo	5.8
14	Syktyvdin	7.4	28.2	Vwilgort	11.2
15	Sissola	6.2	19.3	Vizinga	7.5
16	Troitsko-Pechorsk	40.7	25.3	Troitsko-Pechorsk	10.8
17	Udorsk	35.8	31.8	Koslan	4.2
18	Ust-Vweem	4.8	40.6	Aikino	3.8
19	Ust-Kulom	26.4	39.7	Ust-Kulom	5.7
20	Ust-Tselem	42.5	17.3	Ust-Tsulma	5.4
	Total	416.8	1245.7		

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CHAPTER TWO

JAMES M. BIRKELUND

TRADING AWAY FORESTS: INDONESIA AND MALAYSIA

Introduction

International trade is no longer solely an issue for economists. As nations become more integrated in a global market, there is a growing consensus that trade has a powerful effect on all areas of society and the environment. Recent developments in the international political arena have only just started to take into account the environmental ramifications of trade policies.

Although international trade by itself is not a direct cause for environmental degradation, it can profoundly affect patterns of natural resource consumption. In the case of Indonesia and Malaysia, the tropical timber trade has been an influential factor in determining how these countries manage their forests. Not only are the forests being logged for international interests, but the process of logging opens the way for other factors causing forest depletion and environmental degradation in Indonesia and Malaysia.

The Importance of Tropical Forests

The tropical forests in the Indo-Malaysian region contain some of the world's highest levels of biological diversity. Indonesia alone is estimated to contain 25 percent of the world's fish species, 17 percent of the bird species, 16 percent of the reptile and amphibian species, 12 percent of the mammal species, and 10 percent of the flowering plant species (Ministry of Forestry, 1993). Consequently, there is a strong global environmental movement to protect the forests and maintain the ecological systems that support these diverse life forms. There is also a growing concern that tropical forests should be preserved because they act as natural consumers of carbon dioxide and help prevent global warming. At the local level, the forests play other important roles in preventing soil erosion, protecting watersheds, and maintaining micro-climatic conditions.

Economically, the Indo-Malaysian region contains an especially valuable source of tropical timber from the dipterocarp tree species. The dipterocarp produce hardwood with a high commercial value, and the trees grow tall and straight making them easy to cut into long durable planks. The forests in Indonesia and Malaysia contain high percentages of the dipterocarp trees.

The Dynamics between Commercial Logging and The Forests

The demand for timber on the international trade market provides a direct incentive to log trees for profit. As a result of logging, there is also a high level of secondary damage to the surrounding vegetation. Within any forest there are numerous trees that have no commercial value either because they are too small or because they belong to unprofitable species. The potential for the forest to regenerate after logging depends heavily on the methods of logging extraction and the extent of vegetation left to regenerate itself. Industrial timber companies generally use heavy machinery to take out valuable trees and to establish roads for transporting equipment into the remote areas of the forests. A fair amount of vegetation is destroyed just in the process of getting the logging equipment to the location of the trees. Once there, companies pay little attention to the felling techniques used to cut the trees and as a consequence large trees often fall on and harm the surrounding vegetation. Studies conducted by the International Timber and Trade Organization (ITTO) estimate that 60 percent of vegetation not directly logged is severely damaged or destroyed as the result of logging practices (Collins et al., 1991).

Another effect of industrial logging practices is to provide locals with the means to enter otherwise remote areas of the forests. Once the logging companies have left an area, settlers often use the roads to go in and stake land which has already been cleared of trees for agricultural purposes. Settlers also clear additional land beyond the areas exploited for timber. Thus, the logging practices can be seen in conjunction with agriculture as the first step in permanently removing trees in many of these areas which do not have a chance to recover once the logging companies have moved on.

Historical Background

Before the timber trade, the Southeast Pacific was almost completely covered with tropical rainforests. With few exceptions, the large-scale deforestation of Malaysia and Indonesia did not begin until the 1960's and early 1970's respectively. At this time, multinationals from the United States, Europe, and Japan invested heavily in this region and traded timber back to their home countries. Initially, the governments in both the home and host countries encouraged foreign investment in these tropical forests. As shown in Graph #1 and Graph #2, large-scale logging and the export of unprocessed timber (roundwoods) rose steeply during the 1960s and 1970s.

GRAPH #1

GRAPH #2

Commercial logging and the timber trade was beginning to provide a steady income for Malaysia and Indonesia. Oil remained the most profitable export good, but following the Oil Crisis in 1973 both countries started looking for ways to increase their foreign export earnings. Along with utilizing natural gas deposits, these countries targeted the timber industry for development. The governments in Indonesia and Malaysia began charging more for the forest concessions they gave to logging companies. In addition, they also increased the percentage of domestic firms that received these concessions. By the late 1970s, Indonesia had started to restrict foreign investment to promote the growth of their domestic timber industry. Realizing additional profits could be retained by exporting processed timber instead of roundwood, Indonesia banned the export of logs in 1980. This resulted in a domestic increase in the production of sawnwood and panel forest products (Graph #1). In response to international pressures, Indonesia lifted its ban on raw log exports in 1992 (export data after 1991 is unavailable). In Malaysia, the government also attempted to restrict log exports by raising tariffs in the 1980s. However, unlike Indonesia, the Sabah and Sarawak regions of Malaysia continued to rely on the export of unprocessed timber and the overall roundwood exports in Malaysia have steadily increased to the present time (Graph #2). Although attempts to restrict log exports were not as successful in Malaysia as compared with Indonesia, the Asian bloc of countries increased secondary timber production steadily from the 1960s to the 1990s. While the percentage of roundwood and sawnwood exports fluctuated, the percentage of wood-based panels skyrocketed from 41 percent in the 1961 to 90 percent in 1990 (Table 1).

TABLE #1

Exports of Timber Products as a Percentage of Production in Tropical Countries (%)

	1961	1970	1980	1990		
All Tropical Countries						
Industrial Roundwood			15.6	27.1	18.2	11.1
Sawnwood		15.3	17.3	16.2	12.0	
Wood-based Panels			34.0	33.0	32.5	69.4
Tropical Africa						
Industrial Roundwood			23.8	23.3	16.3	9.5
Sawnwood		32.1	28.5	12.7	12.3	
Wood-based Panels			34.0	33.0	28.6	21.9
Tropical Central and South America						
Industrial Roundwood			1.6	1	0.2	0.2

Sawnwood		14.7	13.6	6.9	3.9	
Wood-based Panels			34.0	33	15.3	19.4
	1961	1970	1980	1990		
Tropical Asia and Oceania						
Industrial Roundwood			22.2	44.2	33.4	20.4
Sawnwood		11.9	18.5	24.5	117.5	
Wood-based Panels			40.5	39.9	49.4	89.7

Source: FAO (1992) in Barbier et al. (1994).

Despite the variations in the unprocessed versus processed timber exports, the international trade of timber products as a whole has steadily increased from the 1960s to the present day.

Economics- The Driving Factor

As shown in Map #1, the distribution of tropical rainforests is found primarily in South America, Africa, India, and Asia. The regional view of Indonesia and Malaysia shows that both these countries are heavily endowed with tropical rainforests. Following David Ricardo's basic economic theory of comparative advantage, Indonesia and Malaysia would be well advised to sell tropical forests (which they have in abundance) on the international market in exchange for other goods and services. Modern economics has since expanded on the theory of comparative advantage, but there remains an underlying economic incentive for countries in the tropical areas to trade timber.

While in practice the tropical hardwoods exported from all of the developing countries only account for 3 percent of the total wood removal from these countries, in certain areas such as Malaysia, it is estimated that 68 percent of all wood removal enters into the world trade market (Collins et al., 1991). More specifically, of the 25 million cubic meters (mn cu m) of tropical hardwood logs exported worldwide in 1986, 19 mn cu m came from the Sabah and Sarawak regions of Malaysia; seventy percent of the world trade in sawn hardwood came from SE Asia; and Indonesia is now the world's largest tropical plywood producer (Ibid., 1991).

Another worldwide study compiled by Barbier et al. (1994) measures the amount of forested land in tropical countries and the percent of area being deforested annually (see Table 2).

TABLE #2

Tropical Forest Resources: Status and Changes in thousands of hectares

			Area	% of Area			
			Deforested		Deforested		
	Land	Forest Area		Annually		Annually	
	Area	1990	1981-90	1981-90			
Latin America							
Brazil	845,651	347,000	3,200	0.92			
Peru	128,000	73,000	300	0.41			
Bolivia	108,439	55,500	60	0.11			
Venezuela		88,205	42,000	150	0.36		
Colombia		103,870	41,400	350	0.85		
Guyana	19,685	19,300	3	0.02			
Suriname		15,600	15,200	3	0.02		
Ecuador	27,684	12,300	60	0.49			
Africa							
Zaire	226,760	103,800	200	0.19			
Congo	34,150	21,100	22	0.10			
Gabon	25,767	20,300	15	0.07			
Cameroon		46,540	17,100	80	0.47		
Central African Republic				62,298	3,600	5	0.14
Equatorial Guinea			2,805	1,200	3	0.25	
Asia							
Indonesia		181,157	108,600	1,315	1.21		
Malaysia		32,855	18,400	255	1.39		
Philippines		29,817	6,500	110	1.69		

Source: Schmidt (1990) in Barbier et al.
(1994).

Asia as a region suffered from the highest rate of deforestation throughout the 1980s with Indonesia, Malaysia, and the Philippines having the highest rates per country. To some extent these percentage statistics are more meaningful when there is a large total area of tropical forests in the country. And indeed, Indonesia is second only to Brazil with a total of 109 million hectares (mn ha) of rain forests. Combined with Indonesia's 1.21 percent rate of deforestation this results in a loss of 1,315,000 ha of rainforests every year (Barbier et al., 1994). In order to understand why Indonesia and Malaysia are being so heavily deforested, it is necessary to look at the importance of forest products to their national economies.

In 1989, the industrial forest sector in Indonesia and Malaysia accounted for 3-6 percent of the total gross domestic product, and forest based exports accounted for between 10 and 16 percent of the total exchange value of all exports. In comparison, the industrial forest sector in most countries with tropical forests was less important and averaged below 2 percent of the total gross domestic product of these countries (Barbier, et al., 1994). An explanation for the heavy logging in Indonesia and Malaysia is the presence of the valuable dipterocarp species of tree. Furthermore, this region has the highest density of tropical forests in the world (see Map #2), and it is relatively easy for companies to realize profits and reduce transportation costs when trees are located close to each other. Both of these factors combine to make Indonesia and Malaysia the two leading countries in exports of forestry goods by a large margin over most other tropical countries, many of whom are net importers of tropical forest goods (Table 3).

TABLE #3

Forestry Products in Selected Countries- Thousands of US Dollars

	Imports	Exports	Net Exports
Tropical Africa			
Cameroon	35,412	99,833	64,421
Central African Rep.	468	29,994	29,526
Congo	4,500	106,087	101,587
Ivory Coast	27,200	236,147	208,947
Gabon	3,655	136,774	133,119

Kenya	23,594	4,054	-19,540	
Liberia	1,942	78,264	76,322	
Madagascar		8,546	534	-8,012
Malawi	8,085	1993	-6,065	
Nigeria	33,083	1,680	-31,403	
Tanzania		15,700	1,539	-14,161
Zaire	3,666	17,032	13,366	
Zimbabwe		5,765	4,169	-1,596

Tropical Central and South America

Costa Rica		40,020	21,895	-18,125
Cuba	193,411	1,847	-191,564	
El Salvador		21,800	2,725	-19,075
Guatemala		69,410	18,326	-51,084
Honduras		137,921	31,061	-106,860
Mexico	403,605	13,884	-389,721	
Nicaragua		10,566	2,569	-7,997
Panama	76,979	3,988	-72,991	
Bolivia	4,060	22,160	18,100	
Brazil	299,402	1,750,981		1,451,579
Columbia		104,056	20,060	-83,996
Ecuador	157,834	24,373	-133,461	
Paraguay		13,055	24,971	11,916
Peru	104,914	2,558	-102,356	

Tropical Asia and Oceania			
Hong Kong		1,752,273	705,535	-1,046,738
India	290,967	16,337	-274,630
Indonesia		330,157	3,069,199	2,739,042
Laos	200	10,251	10,051
Malaysia		483,372	3,040,884	2,557,512
Myanmar	4,721	148,084	143,363
Philippines		173,662	123,119	-50,543
Singapore		747,548	663,302	-84,246
Thailand		1,002,371	101,551	-900,820
Fiji	7,804	22,775	14,971
Papua New Guinea		5,504	115,500	109,996

Source: FAO (1992) in Barbier et al. (1994).

Indonesia is now the leading exporter of processed tropical hardwoods. In 1992 Indonesia's timber industry was worth 4.6 billion US dollars; much of this went to directly employing 2.5 mn people in the timber industry as well as 1.2 mn people in complementary or related businesses (Ministry of Forestry, 1993). By 1983, Malaysia accounted for 58% of the total global export of tropical timber (Cronau, 1993), and in 1988, timber overtook petroleum as Malaysias main export commodity, valued at 3.6 billion dollars (Davis and Henley, 1990). Both Indonesia and Malaysia are prime examples of countries that rely heavily on timber exports to support their national economies.

Exports and Deforestation

The qualitative relationship between exports and deforestation is captured in Graph # 3.

GRAPH #3

While this only includes roundwoods, there is a strong correlation between the increase in roundwood exports and the decrease in forested area from 1961 to 1979. The notable drop of exports in the early 1980s corresponds with the sudden ban on raw log exports in Indonesia and, to a lesser extent, on the higher export tariffs on raw logs in Malaysia. The total exports of forestry products, including panel wood and sawnwood, has continued to increase steadily throughout the 1980s to the present. Therefore, while the data on exported sawnwood and panel wood is not available, the relationship between deforestation and exports is very strong if all forest products are considered.

It should be noted that a direct quantitative relationship between the exported amount of wood (in cu m) and the associated deforestation of land (in ha) has not been calculated. This is a very difficult relationship to establish for several reasons. As mentioned in the section on the dynamics between commercial logging and the forests, not only are trees removed for direct use, but approximately 60 percent of the surrounding vegetation is destroyed. Secondly, logging operations are seen as part of the process enabling local people to gain access to closed forests and destroy additional forests for agriculture. And, finally, because of the wide practice of illegal logging, the true number of exported logs is likely to be much higher than the officially reported measurements. Logging rules are commonly disregarded and illegal exports are common. For example, between 1986 and 1990, the Primary Industries Minister Lim Keng Yaik of Malaysia reported that four states exceeded their logging quotas by as much as 300 percent (Lumpur and Tsuruoka, 1991). According to a study conducted in Indonesia by Skephi, a non-government environmental organization, "timber transportation documents are commonly reused two to five times, which would mean that unreported logging in some areas may range from 100 to 400 percent over the volume of reported logging" (US Embassy, 1994). Because of the wide range of associated uncertainties, it is not possible to calculate a quantitative relationship between exports and deforestation in Graph # 3.

Even with missing data, the overall growth of roundwood exports is best characterized by a linear trend that, if it continues, would reach over 40,000 cubic meters by the year 2010 (see Graph #4).

GRAPH #4

This worst case scenario would have devastating effects on the remaining tropical forests in this region. Furthermore, even if roundwood exports remain at current levels, the tropical forests will still continue to disappear at an alarming rate. Domestic and international trade policies will be the critical factor in determining whether forest exports increase or decrease in the upcoming years.

Forests in Transition

Having established some relationships between exports and deforestation, it is useful to think of the interaction between the two in terms of a forestry transition. William Drake describes the concept of transitions in Towards Building a Theory of Population-Environment Dynamics: A Family of Transitions (1993). To paraphrase briefly, the idea behind transitions is that societies are especially vulnerable to change in critical time periods which depend in part on the state of the population in these societies. Moreover, government policies can act to alleviate the problems associated with these critical time periods. When a sector, such as the forestry sector, enters a transition period it undergoes rapid change before returning to a stable state; the forestry sector in Indonesia and Malaysia is doing just that. According to Drake, if we can recognize transitions, we can proscribe policies to help reduce the negative aspects of the transition and influence the final equilibrium state.

Applied to this paper, the theory of transitions explicitly recognizes that there is a dynamic relationship between deforestation and the tropical timber trade. This relationship started in the 1960s and is continuing today. Judging from the continued rates of deforestation and forest exports in Graph #4, the forestry transition is far from over. In regards to population trends, Indonesia and Malaysia reached their peak growth rates in the mid 1970s and mid 1960s respectively (see Graphs #5 and #6).

Since then population growth rates have declined and are expected to continue declining into the 21st century. However, because the birth rates and death rates in these countries have both fallen at relatively the same speed (see Graphs #7 and #8), the total population in these countries continues to rise rapidly.

GRAPH #5

GRAPH #6

GRAPH #7

GRAPH #8

Thus, the population transition is not yet over and is expected to continue into the 21st century. Modernization provides an indirect link between population changes and increased timber exports. As modern medicine acted to promote the decline in death rates / birth rates, the modern market system acted to promote improvements in the economy, trade, and technology (all three are necessary to exploit timber resources). Commercial logging in Malaysia began in the 1950s about ten years before population growth rates reached a maximum, and commercial logging began in Indonesia in the 1960s about ten years before its maximum population growth rate. The same technological and economical advances that spurred the logging industry also preceded the beginnings of the demographic transition. The direct link between the demographic and forestry transition is easily found by examining the dynamics between logging and deforestation. There are two major connections:

1.) As the total population rises, landless peasants become more numerous and it becomes more difficult to stop them from contributing to deforestation as they follow logging operations and convert forested land into fields for agriculture.

2.) As the total population rises, there is increased pressure on the national economy to sustain more people. In the short-term, this pressure can be partly alleviated by supplementing national incomes with an increase in the exports of forestry goods. This in turn increases deforestation.

The effects of the timber trade on deforestation began with Indonesias and Malaysias exposure to the Western capitalist market system. Furthermore, the exposure to Western medicine prompted the demographic transition which has magnified the problems between the timber trade and deforestation in these countries. In order to effectively get through the forestry transition, Indonesia and Malaysia need to concentrate on getting through their demographic transitions as well.

The Missing Element- Reforestation

Until deforestation begins to level-off and approach reforestation, the forestry transition will not reach a stable state and logging operations will continue to deplete the tropical forests in this region. At some point, the forestry transition will reach an equilibrium. Where this equilibrium is partly dependent on the ability of governments to implement reforestation management.

There is very little data on the reforestation of the tropical forests of Indonesia and Malaysia. Much of the available information is from the forestry departments of the governments and can be notoriously unreliable. In 1990, the worldwide extent of plantations in the tropical areas was estimated at 43.9 mn ha, or less than two percent of the total forested area of 1,715 mn ha (Barbier, 1994). According to the World Resources Database (1994-1995), Indonesia and Malaysia respectively had 8,750,000 and 116,000 ha of plantations in 1990 and were adding to plantations at a rate of 474,000 ha a year in Indonesia and 9,000 ha a year in Malaysia. Considering the average annual deforestation rate in the 1980s was 1,315,000 ha in Indonesia and 255,000 ha in Malaysia (see Table 2), the rate of reforestation to deforestation is less than 25 percent in Indonesia and less than 10 percent in Malaysia. The forestry transition will not be complete until the rate of reforestation equals the rate of deforestation.

One drawback to reforested plantations is they often consist of only one species of tree. Sometimes this is not even an indigenous species. For example, the Eucalyptus tree from Australia is a fast-growing valuable timber that is often chosen to replace native trees. Plantations do little to preserve the biological diversity of the traditional forests and can destroy the soil and water table as well. It is therefore highly desirable for these countries to focus not only on reforestation, but also on preserving the integrity of the original forests. Indonesia and Malaysia should attempt to move their logging efforts from areas of primary growth to reforested areas of secondary growth.

Domestic Policies

In the 1983 United Nations Conference on Trade and Development, the International Tropical Timber Organization (ITTO) was created to address the problems between trade and tropical forests. Indonesia and Malaysia are both members of ITTO and have committed to the goal of sustainably managing all tropical forests by the Target Year 2000. This leaves the domestic governments with the task of balancing the short-term interests of the economy and logging companies against the long-term interests of the future economy and environmentalists. The governments in Indonesia and Malaysia would like to improve the economic efficiency of the forestry sector without increasing the raw material growth of inputs or over-cutting the tropical forests. In the past, one strategy pursued to promote this goal is to add economic value to their forests by restricting roundwood exports and processing lumber into secondary products before exporting it on the international trade market.

There are several problems with the strategy to export processed lumber. While on the one hand it may be effective at adding monetary value to wood products before selling them, it also requires the countries to restrict trade on raw log exports. Initially it might be expected that by cutting out foreign sales of raw logs the deforestation rates might go down. However, as seen from the 1980 ban of log exports in Indonesia, deforestation rates were not reduced. Roundwood production remained steady while sawnwood and panel wood production rose rapidly (see Graph # 1). From an economic perspective, trade barriers decrease the market value of raw logs for the domestic wood processing industries. When the price of logs goes down, domestic companies can purchase greater numbers of logs and this could actually cause an increase deforestation. According to the World Bank, Indonesia's ban in log exports pushed the price of domestic logs to half the world level and resulted in over-cutting and over-investment in secondary wood production in Indonesia (Schwarz, 1992a). When a natural resource loses market value it becomes less valuable to protect as a long-term source of income. The second point made by economists is that because domestic industries are shielded from competition with foreign wood processing companies (foreigners cannot buy raw material from these countries), export restrictions cause inefficiencies. According to Marina Whitman, an international trade professor at the University of Michigan, international competition is essential for promoting the most efficient production of goods on a global level. Trade restriction have proven unreliable for decreasing deforestation and can hinder the development of efficient domestic industries. This runs contrary to the governments overall objective of increasing efficiency and maintaining the levels of raw material consumption.

Another problematic domestic issue is the abuse and corruption that undermine the enforcement of logging regulations. The governments in Indonesia and Malaysia are notorious for accepting bribes and showing preferential treatment to logging companies with personal connections to powerful officials. Enforcement of national logging rules is poor at best. As noted earlier, the illegal export of raw logs is also widespread. The governments need to make a firm commitment to stopping corruption and enforcing their own logging regulations.

Finally, the domestic policies for granting timber concessions to logging companies need to be reviewed. Typically the governments grant timber concessions to logging companies for relatively short periods of time -- approximately 20 years. This encourages companies to take as much as they can from the forest before they lose their timber concessions. It takes 35 to 40 years for dipterocarp trees to re-grow to commercially valuable sizes. Therefore, the companies are not expected to get a second harvest from any particular concession (Schwarz, 1991). There is little concern by business for the future productivity of their forest concessions.

International Policies

Until recently, the international political structures affecting deforestation in Indonesia and Malaysia were mainly due to market demand in other countries. Companies in industrial nations would purchase tropical timber for their own hardwood processing and subsequently sell products to consumers in industrialized nations. Although this continues to be the case, in the past two decades, a number of new political actors (international organizations) have started to put pressure on Malaysia to sustainably manage its tropical forests.

Internationally, the response to concerns over the global destruction of tropical forests have led some foreign countries, such as those in the European Union, to impose trade restrictions-- import tariffs or non-tariff barriers on tropical forest products. In 1986, the European Union imposed restrictions on the import of tropical wood. These restrictions required timber to be "certified" from "sustainable forests". Most of the logs exported from Indonesia and Malaysia can not meet these requirements (Tasker and Ai, 1994). If implemented on a global level, trade sanctions could theoretically limit the amount of forestry products exported from Indonesia and Malaysia and potentially reduce deforestation rates. However, as the demand for trees goes down, the forests become less "economically valuable", and much of the financial impetus for sustainable management disappears. According to Alastir Fraser, a Briton working with Indonesia's Ministry of Forestry, "It would be tragic if trade stopped. The forests would become less valuable and there would be less incentive to protect them" (Schwarz, 1992b). Foreign trade restrictions can distort the true economic value of the forests in to these countries. Instead of reducing deforestation, foreign trade restrictions in the long-term could decrease the economic incentives to preserve the forests. Admittedly, some policy makers are not convinced trade restrictions are a cause for environmental damage and would argue that Indonesia and Malaysia make more money from restricting log exports and selling secondary wood products instead.

However, even if trade restrictions were effective at reducing deforestation, the General Agreement on Tariffs and Trade (GATT) is slowly working to phase tariffs and other trade restrictions out of the global economy. In 1992, the lift in the ban on log exports in Indonesia was partly the result of pressure from the GATT. Thus, it would be difficult to coordinate a world-wide trading ban on forest products produced in this region. This would go against the predominantly free trade atmosphere currently advocated in international politics and the GATT.

In the place of trade restrictions, the GATT is promoting multinational trade agreements that involve all countries. In the

Uruguay Round of GATT negotiations, environmental issues have become increasingly important in discussions, although substantial global environmental regulations have not been established. As it relates to Indonesia and Malaysia, the obvious advantage of multinational agreements over unilateral trade restrictions is to take into account the views of both importing and exporting nations. This does not necessarily mean environmental protection. But, environmental solutions for reducing deforestation could be framed by GATT in an economically and socially beneficial system for both Indonesia and Malaysia with international support. This might entail international financial support to implement management programs that provide viable alternatives to using old growth forests. Management programs that focus on reforestation and intensification of land that has already been deforested. This would reduce the pressure to log old growth forests. ITTO is an example of an international organization that has encouraged developed nations to co-operate with developing nations with the common goal of promoting the sustainable management of tropical forests. The World Bank is currently looking at a proposal to employ a foreign company to help Malaysias government monitor logging operations. However, to really have an impact, international organizations need to make stronger commitments to support these countries in their attempts to curb the current problems of deforestation. GATT, ITTO, and the World Bank have not yet had a big effect on deforestation rates in Indonesia and Malaysia.

Conclusions

Although the international timber trade is undoubtedly an important part of the economies in Indonesia and Malaysia, it is difficult to quantify the exact relation between exports and forest deforestation. Given the limitations of data, the relationship of exports to the forestry transition is captured in Graph #3. There are two major areas affecting the forestry transition in these countries: the demand for exports and the lack of reforestation. In effect, if exports continue to increase or even remain at constant levels without improved rates of reforestation, the forests in Indonesia and Malaysia will rapidly disappear.

There are several domestic policies that should be advanced to reduce deforestation rates. Because of the geographical, environmental, demographical, and political similarities between Indonesia and Malaysia, both countries are in very analogous positions and should follow the same general strategies to prevent deforestation. First, they should remove any remaining restrictions on the export of raw logs. This will provide the economic conditions that favor the most efficient use of timber goods on a global level. While the domestic industries may lose money in the short-run, in the long-run the country will benefit from utilizing its resources more efficiently. If these countries continue to restrict timber exports, they will face retaliation measures from the international community and the GATT. Trade retaliation could harm the other important sectors of their economies including oil and natural gas exports. In addition, the domestic governments need to cut down on corruption and improve enforcement of the current logging regulations. This will involve a financial commitment to enforce logging rules and a moral commitment by government officials to decline bribes from powerful logging industries. And finally, the current terms of granting short-term forest concessions should be increased to provide an incentive for companies to start reforesting and sustainably managing the forests. Changing the policies for granting logging concessions is beneficial to all parties involved and should be relatively easy to implement. Finally, Indonesia and Malaysia both need to work on controlling population growth. If populations continue to increase rapidly, their will be pressures to use deforested land for agriculture instead of reforesting it for future timber production.

From the international level, countries need to move away from unilateral restrictions and work towards developing common forest management goals. ITTO is a step in the right direction, but negotiations could start to include mechanisms for enforcement as well. The GATT, while still a long-way from having an international enforcement arm, could provide this service sometime in the future. To be pro-active, the international community needs to provide more financial aid to these countries to help with the costs of sustainably managing forests. It is also possible to develop a set of internationally agreed upon forestry practices, whereby the demand for forestry exports could be reduced to what can be provided consistently over generations. The sooner this agreement is reached, the more tropical rainforests will be left when the forestry transition is over.

As a whole, this paper serves to reinforce the importance of the relationship between international trade and the forests of Indonesia and Malaysia. Hopefully future studies can provide additional data to support the general policies proscribed here and provide more specific guidelines for the domestic governments and international community. The relationship between trade and the environment is still an evolving study with many unanswered questions.

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CHAPTER THREE

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PRIVATE SECTOR SOLUTIONS TO FERTILITY REDUCTION IN INDIA

The Demographic Transition

The demographic transition is the very core of family planning theory, tracing the transition of a given society across time, from very high birth and death rates to very low ones, such that the post-transition gap between births and deaths is less than or equal to its level prior to the transition. Conceptually, the demographic transition begins in an environment in which households, in need of familial labor and heirs, must compensate for high levels of mortality by producing large numbers of children; as the provision of public health and sanitation technologies increases, mortality should greatly decrease, cutting death rates far below rates of birth. At this point in the transition, high birth rates are no longer being offset by high rates of death, and population will boom; the perceived value of having children will eventually change, and individual reproductive behaviors will adapt, lowering birth rates until the difference between birth and death rates is similar to, if not lower than, that which existed prior to the transition.

In the transition experienced by most industrialized nations, mortality fell slowly and haltingly, relying on innovation and invention to incrementally cut death rates; eventually, fertility followed this trend and, after two hundred years of transition (Demeny, 1989), Europe and the rest of the industrialized world eventually reached stable birth and death rates and a steady fertility rate at near replacement level. The experience of the developing world, however, has been quite different; not until after World War II, and the end of colonialism, did this region begin its transition. Medical and public health technologies first discovered during the European transition had since been perfected, and were grafted into the transition of the developing world, cutting death rates to levels enjoyed by the industrialized world in a quarter of the time (U.S. Census Bureau, 1991). Unfortunately, despite the infusion of large amounts of Western monetary and technological aid, birth rates have resisted most attempts at forced reduction, leaving a large gap between current birth and death rates.

As a result, population in much of the developing world today is growing almost without bound. As the sheer numbers of people within a given region reach and surpass levels that can be sustained by existing political, economic, or ecological systems, family planning becomes an issue of increasing importance. Unfortunately, many fertility-reducing programs, both past and present, have generally been of limited effectiveness; although a number of programs have been able to cut fertility rates to some extent, most of the developing world continues to face frighteningly high growth rates and above-replacement-level-fertility. One major limitation of past programs was a concentration on supply-side marketing; family planners assumed that there existed a latent demand for contraceptive technology and that fertility could be reduced by providing a supply of this technology. This is not to say that these programs have been failures; many have quite effectively reduced fertility, but in each case, birth rates have reached some lower threshold, beyond which they simply cannot pass.

Building a Theory on Fertility Reduction

Family planning practices that seek only to meet latent demand will always reach a limit to fertility reduction which they cannot breach; this lower limit is, in fact, indicative of a saturation of the natural (latent) demand market. Clearly, any family planning program that seeks to overcome limits to fertility reduction must be based not on meeting an existing, limited demand for contraceptive technology, but on the expansion of demand markets. Supply-side theories fail in family planning because they disregard the externalities that exist within a given households decision to reproduce: The social costs of high population, and therefore high fertility, are extremely high; yet, so long as large families are desirable, or profitable, to the individual household, the (individual) opportunity costs of high fertility will remain significantly below the (aggregate) social costs, and households will continue to produce large numbers of children. Thus, effective family planning programs can exist only where the household opportunity costs of high fertility are more reflective of its social costs. Significant reductions in fertility come about only where reduced fertility is perceived as beneficial to the individual household; in other words, family planning practices can only truly be accepted where they are seen as a desirable expansion of choice.

The increasing prevalence of fertility reduction theories of the type outlined above amongst demographers and family planners (Coale; Knodel, 1984; Cleland, 1987) has generated a growing body of policy-related variables that effect fertility rates; one variable with a pronounced effect on fertility is womens education. As women become increasingly educated, they begin to take on more of the skills required for wage-labor; the wages associated with female employment, because they would be lost to women rearing large numbers of children, provide a disincentive to high fertility by increasing the opportunity costs associated with large families. The scatter-point diagram on the following page seems to support this hypothesis, showing a clear negative correlation between fertility rates (1990) and the percentage of females aged twenty-five or older who have completed primary school (1989) over a wide range of countries.

Although the conceptual link between womens education and fertility makes intuitive sense and seems to be supported by empirical evidence, it reveals only one part of a more complex relationship. Womens education, in this case, acts as a proxy for the somewhat vague concept of the value of women; specifically, the average level of education attained by females within a particular society should act as a flag, indicating the degree to which women participate in that society, including the value that is placed on their labor. The level of acceptance of female education within a society should be correlated with that societys acceptance of female employment in the formal sector; in other words, womens ability to develop their own human capital, in the form of education, must be linked to the market demand for female human capital. Under these conditions, female education acts as a proximate measure of a given societys norms regarding the full participation of women in formal sector employment; this is part of what is meant by the value of women. The link between market demand for female labor and fertility provides the same conclusion as the link between female education and fertility, only in a more direct way: The possibility of losing the potential to earn a wage increases the opportunity costs associated with large families, and thus has a dampening effect on fertility.

Fertility Reduction in India

The theorization laid out above is heavily biased towards solving the population problems of the developing world. This concentration is characteristic of most theories in family planning and is by no means accidental; the population problems experienced in this part of the world are more severe than those affecting the industrialized nations, as are the consequences of ignoring them. In so saying, the key to understanding the difficulties of this region is in remembering that these problems are not unique to the nations of the developing world so much as they are characteristic of the stage of the demographic transition which most of these nations have reached.

The nation of India is suffering the effects of being trapped in the median stages of the demographic transition perhaps more than any other country in the developing world. India currently enjoys a death rate of 10.07 deaths per 1,000 population (CIA World Factbook, 1995), lower than that of both Europe and Russia (U.S. Census Bureau, 1991); yet, its birth rate remains unnecessarily high, at 27.78 births per 1,000 population (CIA, 1995). In a nation of almost 950 million people (CIA, 1995), a birth rate-death rate gap of over 17 births per 1,000 population produces a population increase of over 16 million in excess of replacement levels. A combination of strong political support on the national level for family planning programs and extensive Western aid has reduced Indias fertility rate to 3.4 births per woman (CIA, 1995), an enviably low level by developing world standards; unfortunately, in a nation as large as India, the population pressure of even this low a fertility rate is incredible. The age structure of the Indian population adds an air of urgency to efforts to reduce fertility; thirty-five percent of the population is under fifteen years of age, and fertility rates must be reduced before this cohort reaches reproductive age.

Unfortunately, there is little evidence to suggest that fertility rates in India will fall in the near future. With national family planning programs dating back to 1951, no other government in the world has placed as much of an emphasis on reducing family size than Indias; however, these programs have generally failed to see the results that they could have. Government family planning programs have ranged from offering incentives to couples for contraceptive use to forced male sterilization, yet none of these has brought about significant reductions in fertility, largely because the low social status of women has been consistently ignored. Indian households bear a strong preference for male children; the son in the traditional Indian household not only serves as heir and continuation of the family line, but also provides labor for the family and, according to Hindu tradition, must perform the parents sacred burial rites. A daughter, on the other hand, represents a net economic liability because of the financial pressures that her dowry places on her parents. The dichotomous relationship between the sexes creates a situation in which women are denied the property rights and control over economic resources that would increase their social value, relative to men.

A Free-Market Solution

In a society where womens roles are marginalized, the value of their labor tends to be underestimated. Where this is the case, the private sector has the ability to capitalize on this undervaluation by hiring women at a lower wage than that which is offered to men, thus capturing increased returns to production; the difference between actual female wages and the potential wage bill, had males been employed, generates a fiscal surplus that can be invested into capital expansion of the industry. Now, if it is true that increasing the employment opportunities available to women has a significant negative effect on fertility, this implies that private industry has the opportunity to affect positive social change in the course of normal profit-seeking operations. The situation at hand is beneficial to both society and industry alike.

Where a firm hires women to capture the lower wages associated with female labor, that firm can experience lower costs of production without reducing the market price of its goods, in this way increasing its returns to labor. As other firms recognize the scale effects of increasing their female work force, they will hire increasingly more females, boosting the rate of growth of the female labor force. The female labor force will grow increasingly until the environment of heightened demand begins to nudge the female wage upward; at this point, the growth rate of the female labor force will begin to decline. The growth rate of female participation in formal labor will incrementally decline as the female average wage increases; eventually, the female wage will rise to a point where employers are indifferent between the sexes, and the female participation rate will stabilize.

The increasing-then-decreasing rates of growth story is typical of models of innovations that lead to lowered costs of production; if the increased use of womens labor can be characterized as an innovation, the growth of the female labor force can be mapped out in another way, one which is complimentary to that which is outlined above. When a firm in a competitive market captures a lower wage bill due to the employment of an increased number of women, that firm will lower the asking price for its particular good, in an effort to expand its share of the market for its product. Once several firms in an industry expand their female labor force, they will be in direct competition with each other to capture the greatest savings to production that this innovation can offer. As more firms increase their female work force, the practice of hiring women will become more commonplace, and the original innovators will not see significantly greater returns to labor over their direct competitors. At this point, these firms will begin to look to other sources of economic growth, and the growth rate of the female labor force will begin to decrease. Once female-to-male employment ratios are equalized across the industry, the individual firm will have nothing more to gain from employing more women, and the industrys female labor force will stabilize.

Systems that experience growth rates that at first increase and then decrease to a steady state equilibrium of no growth can be replicated with the following generalized equation:

dY/dt = kY * (q - Y)/q (**partial derivative**)

Here, Y is the percentage of the national labor force that is female, q is an exogenously-generated upper boundary to growth, t is time, and k is the constant of proportionality. The variable k is referred to as the constant of proportionality because the derivative of Y at any point can be explained, at least partially, as some proportion k of the original function Y. That the partial derivative of Y is equal to some form of itself implies that this is an exponential function: de^t/dt = e^t * dt, and above, **dY** = kY * **dt** * (q - Y)/q. The second part of this equation, (q - Y)/q, is a forcing term, introduced to limit the growth of the exponential in this equation; this equation is attempting to predict the growth of a variable that is measured in percentages, and so we must necessarily impose an upper limit of one hundred percent, if not some even lower value. The forcing term (q - Y)/q dampens growth by interacting with Y; where Y is a small number, the term is very close to one, but as Y increases, the forcing term approaches zero. In short, this equation states that the female percentage of the labor force would grow exponentially over time (kY), if it were not for the existence of some exogenous limit to growth ({q - Y}/q); instead, it grows exponentially only up to a point, after which growth slows until the function stabilizes at a fixed value.

We can see that the equation laid out above is just another interpretation of the Verhulst equation:

$$Y'/Y = (k/q) * (q - Y), \qquad \text{-- 1}$$

where Y'is another form of notation for the first derivative of Y with respect to t.

We can approach a general form solution of the equation by integrating equation 1. We begin by multiplying through by Y

$$\mathbf{dY/dt} = Y * [k - \{(k/q) * Y\}], \qquad \text{-- 2}$$

and then separating variables

$$\mathbf{dY}/(Y * [k - \{(k/q) * Y\}] = \mathbf{dt}. \qquad \text{-- 3}$$

In order to simplify the integration process, we want to separate the left hand side of equation 3 into the form:

$$1/(Y * [k - \{(k/q) * Y\}] = A/Y + B/\{k - (k/q) * Y\},$$

where A and B are as yet unknown. To do this, we multiply both sides of the above equation by Y * [k - {(k/q) * Y}], to get:

$$(A * k) - [A * (k/q) * Y] + (B * Y) = 1.$$

Now, where Y = 0, A = (1/k), and where Y = 1, [(1/k) * k] - [(1/k) * (k/q)] + B = 1, which gives us the solution B = (1/q). Thus,

$$1/(Y * [k - \{(k/q) * Y\}] = (1/k)/Y + (1/q)/\{k - (k/q) * Y\}.$$

(This can be checked by multiplying the equation through by Y * [k - {(k/q) * Y}], which produces 1 - (Y/q) + (Y/q) = 1.)

We now have an equation of the form

$$[(1/k)/Y + (1/q)/\{k - (k/q)Y\}] * dY = dt. \qquad \text{-- 4}$$

Integrating with respect to t gives us

$$(1/k) * \ln Y - (1/k) * \ln[k - (k/q) * Y] = t + C, \qquad \text{-- 5}$$

where C is the constant of integration.

Multiplying both sides by k and consolidating the natural logs produces the following solution:

ln[Y/(k - {(k/q) * Y})] = k * (t + C), -- 6

which simplifies to...

Y = [k * e^(k * {t + C})]/[1 + {(k/q) * e^(k * {t + C})}] -- 7

This is the generalized form of the solution to the Verhulst equation above; it makes explicit the relationship between time and growth for this model.

Equation number seven is extremely useful in describing the growth of the female labor force in India, with some caveats; the most important of these considerations is that time is used as a proxy for attitudes towards womens labor. The hypothesis, as stated, is highly time-dependent; womens labor is used increasingly over time as more of the individual players in the labor market recognize its value. The use of time as a proxy for this phenomenon may be slightly misleading, but the malleability of time as a variable makes it a satisfactory measure of what is actually a rather nebulous concept. Time is a valid proximate of any incremental change because it is measured in ordinal numbers; that is, each number in a time series measures only its location within a sequence, and does not have any particular value attached to it. Thus, time will continue to be used in further transformations of the above equation, with the implicit assumption that it is a proxy for the changing intensity of use of womens labor.

The generalized solution form makes explicit the relationship between Y and t, q, and the two constants k and C; however, in order to generate solutions for specific data, k and C must be replaced with more definite values. Conventionally, the constant of integration, C, is used only in indefinite integration; where at least one explicit relationship between the variables is known, this is definite integration, and C is assumed to be equal to zero. If we use the most recent value for female labor force participation available from the World Resources Database and assume a specific upper limit to growth, we have values for Y and t, and q, respectively, and can assume C out of the equation, generating a new generalized form:

$$Y = [k * e^{(k * t)}]/[1 + \{(k/q) * e^{(k * t)}\}]. \qquad -- 8$$

Unfortunately, the argument of definite integration is not, by itself, the most robust justification for assuming away C; the transition from equations 4 to 5 is actually one of indefinite integration. This is because our explicit relationship between variables uses observed data from 1990; however, there is no reason to believe that any behavioral change occurred in 1990 to institute the growth that this equation describes. Our 1990 data does not constitute any initial conditions, but instead acts as a baseline for speculation as to the general applicability of this model.

Nineteen-ninety data is used as a baseline value only because it is the most recent available; this by no means implies that the process described above commenced at this date. We perform indefinite integration between equations 4 and 5 because the data we are using is clearly not the start of an historical example of the above process; were it actual historic data, it would be referred to as initial conditions, and definite integration could be performed. Instead, we use baseline values, plugging them into the variables in question to generate hypothetical scenarios as a means of testing the robustness of our model; we use indefinite integration to preserve the generalizability of the solution equation, allowing us to test the results of a variety of baseline assumptions. We are now placed in a position where we have specific data, yet we have performed indefinite integration and, as a result, we have the constant C in our equation. Yet, precisely because we do have specific data, we can still assume away C; we can do this because, in the following analysis, we treat each set of baseline values as if it were historical data, and we know that C is not included in the definite integration of historical values.

Baseline values play their most important role in the determination of definite values for the constant of proportionality, k. The World Resources Database provides the following baseline data: Females accounted for 48.318% of the population, yet only 25.191% of the labor force of India in 1990. Thus, Y = 0.25191 and, because 1990 is the baseline year in our iteration, time t = 0. If we assume that, once a demand increase has been generated, the percentage of women in the labor force will expand up to but not beyond their proportional representation in society, then we have set our upper limit to growth at q = 0.48318. We now have the tools necessary to generate an estimate of k; we begin with the general form solution,

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Y = [k * e^(k * t)]/[1 + {(k/q) * e^(k * t)}]            -- 8
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and include our baseline values, to generate the following:

0.25191 = [k * e^(k * 0)]/[1 + {(k/0.48318) * e^(k * 0)}]. -- 9

Replacing e^(k * 0) with 1 and multiplying the right hand side of the equation by (0.48318/0.48318) produces...

0.25191 = (0.48318 * k)/(0.48318 + k),

which provides us with a k-value of approximately 0.52630. Thus, the general form of our solution for this set of assumptions is:

Y = [0.5263 * e^(0.5263 * t)]/[1 + {(0.5263/q) * e^(0.5263 * t)}]. -- 10

The equation now provides an explicit relationship between the independent variable t, the policy variable q, and the dependent variable Y, subject to the baseline assumption that Y(0) = 0.25191, q = 0.48318. The following graph details the convergence of this equation on the upper boundary of Y = 0.48318. The accompanying table clarifies the growth pattern of the function, highlighting the fact that it infinitely approaches 0.48318 without actually reaching that value.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
%	25.10	31.19	36.41	40.40	43.20	45.04	46.20	46.92	47.35	47.61
L.F.	4	3	0	2	0	3	8	5	9	9
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
47.77	47.86	47.92	47.95	47.97	47.98	47.99	47.99	47.99	47.99	47.99
4	6	1	3	2	4	0	4	7	8	9

The upper limit to this equation was arbitrarily set at 0.48318, the percentage of the total population of India that was female in 1990; however, this percentage has been growing steadily, although marginally, over the past twenty years. This implies that our equation may be more reflective of the growth pattern it attempts to describe if the upper limit q of our equation were to be included as an increasing function of t instead of as an arbitrarily determined constant. In fact, the regression of this data over the years 1970 to 1990 produces the function $Y = (0.000026 * t) + 0.4823$, which grows at so slow a rate that it can be legitimately approximated by any constant function at or about $Y = 0.4823$.

Although it seems to be appropriate to estimate the upper boundary to growth with a constant function based on current estimates of female representation in the general population, the thinking behind this conclusion may be ignoring some rather serious considerations. India has a long cultural history of son-preference between children, which may bias contraceptive and child-rearing techniques; although these practices have become less prevalent in modern India, the proportion of females in Indian society in 1990 was still only 48.23%, less than the world rate of 49.68% and significantly below the 51.54% faced by the industrialized world (WRD, 1994). It may not be unrealistic to assume that some residual son-preference continues to exist within Indian culture, and that this is maintaining the proportion of females in society at an artificially low level; this sort of consideration is linked to the above model because the prevalence of son-preference amongst households is directly related to the value of women within a society. Now, where an increase in womens employment is brought about in a climate of son-preference, it seems safe to assume that the increased potential for future wage labor that this places upon a female child may compensate for any cultural predilection towards sons; in this way, the growth of the percentage of females in the labor force may increase the percentage of females in the general population, thus expanding the upper limit q used in the predictive model.

Any activity that reduces artificial constraints placed upon the size of the female population within a society is inarguably producing a public good; however, any points regarding the effects of this demographic change on the model may be moot. As the graph shows, our predictive function converges with its upper limit in only ten iterations (iterations here are denoted as years because this is the unit of measure that seems to make sense, although other units of time could be used); it seems unlikely that behavioral patterns that are as deeply ingrained as son-preference could be changed in as short a time as ten years.
Further, the delayed effects of changes in reproductive behaviors on the

labor pool ensure that any increase in the female population will occur long after the demand boom has passed, such that female employment rates are unlikely to be effected by an increase in the female population at this stage.

A more fundamental criticism of the model suggests that there is no reason to believe that the growth of the female labor force will be at all limited by the proportion of females in the general population; it is more likely that the female labor force will overshoot the proposed limit of percentage female representation in society. If an individual firm, in the course of expanding its labor force, recognizes lower costs to production by employing women instead of men, there is little to prevent that firm from further reducing costs by replacing as many currently employed men as possible with women. The only hindrance to this sort of mass replacement (if we can momentarily assume away contradictory cultural norms) would be a limited supply of sufficiently-educated women, and this constraint should weaken significantly once individual households begin to recognize the newly increased value of their daughters.

It is difficult to determine the extent of the predicted excess growth of the female labor force; it is easy to believe that employers themselves will generally be male and will not be replacing themselves, and so the female labor participation rate could never reach one hundred percent. In fact, most upper- and middle-management positions would be closed to women for this same reason; the most physically strenuous jobs, too, would almost certainly be denied to women. This implies that some significant percentage of employment positions within the economy exist which are simply unavailable to women; that is, the demand for female labor associated with this percentage is inelastically fixed at zero. In 1990, male representation in the work force exceeded male representation in society by approximately 23%; the fact that men, in a male-dominated society, are over-represented in the labor force by twenty-three percent seems to make this figure an appropriate estimate of the extreme-case upper limit to growth of the womens labor force. This assumption implies a new upper boundary value of q = (0.48318 + 0.23) = 0.71318, which generates a generalized solution form of

Y = [0.38948 * e^(0.38948 * t)]/[1 + {(0.38948/q) * e^(0.38948 * t)}], -- 11

the graph of which follows.

Year	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
%	29.65	28.46	27.18	26.20	25.19	56.54	68.75	70.94	71.26	71.31
L.F.	0	0	1	6	1	8	6	1	4	0

2020	2025	2030
71.31	71.31	71.31
7	8	8

Again, a table is provided for ease of reference.

Growth of female representation in the labor force is staggering here, and probably not particularly realistic. Lack of availability of data requires that time be expressed in units of five years, which may exaggerate the graphical representation of the function; however, this does not negate the fact that the percentage of females in the labor force more than doubles between 1990 and 1995. In order to make this data at all useful, the ordinal nature of time must be taken advantage of; if the difference between two years can be seen only as a difference of a few places in a generalized time series, then the model can begin to take on more meaning. Where 1990 is viewed as simply the one thousand, nine hundred, ninetieth iteration of the series, then the span of a unit of time increases in its variability, and can take on values larger than a single year. Although this assumption increases the applicability of the model, it does so at the expense of its reliability; more importantly, it fails to address more fundamental ethical questions associated with female employment overshooting female representation in society.

Policy Implications

Sustainable economic growth occurs where new jobs are created; yet within this model, the primary engine for growth of female representation in the labor force is female replacement of males in existing jobs. Where females simply replace males at a lower wage, the individual firms operating costs fall, but social costs may actually rise; even if each displaced male worker were replaced by a female in the same household, the overall average household income will fall. Only where male replacement frees up capital for expansion of the labor force can replacement dampen the social costs it incurs; unfortunately, this case increases the number of households earning a wage income while reducing the wage earned. The true social benefits of replacement growth come from the reduction in birth rates that this generates; where female employment rises, fertility should fall, and, under any conditions, reductions in fertility will cut overall costs to society.

It is quite likely that the population effects of female replacement may more than compensate for the effects of male unemployment. In 1990, the labor force growth rate only marginally exceeded the rate of population growth, while a mere five percent of working-age Indians were employed in the formal sector (26 million person labor force, 503 million persons between the ages of 15 and 65, WRD); in a slow-growth, low employment economy, the sort of restructuring of the labor market that female replacement requires may incur only a minor social cost. If this is the case, the benefits of fertility reduction should easily exceed the costs of male unemployment, leading to clear and direct benefits to society, at least in the short run. Long run forecasting is more difficult because the long-term effects of male unemployment at the expense of females is unclear. The direct effects of increased male unemployment in an environment of extremely high unemployment may, indeed, be minor, as discussed above; however, the effective gender transition of the households primary wage-earner, from male to female, may produce significant disruptive forces in the pervading culture.

It should be clear that any increase in the value of women, especially one as significant as this, is acting in opposition to current trends and, therefore, must necessarily act as either the cause or the product of a significant cultural disruption, the effects of which could never be predicted in their entirety. While this may seem to be a rather melodramatic conclusion to make, the uncertainty involved in the decision to consciously change a culture must be taken into full account; the risks involved in such endeavors must be clearly outweighed by the benefits. In so saying, it does appear as if Indias population growth may warrant such strong actions: the negative effects on society, culture, and the environment associated with large population growth rates cumulatively represent the greatest problem India has had to face to date. Sacrificing an indeterminate, and possibly quite large, amount of culture for the preservation of society as a whole is hardly an ideal solution; it is not a first- or second-best solution, but an nth-best solution, the optimal solution subject to a large number, n, of constraints.

One such constraint that has been excluded from discussion to this point is the fundamental lack of employment opportunities across both sexes. Where only five percent of the working-age population is engaged in non-agricultural employment, it is conceivable that the sheer numbers of unemployed men would bid the male wage down to such a point that a significantly lower female wage would be infinitesimal; if the female wage were as low as this suggests, it would actually provide a disincentive for a given woman to leave the home, as her earned wages could not compensate for the domestic work she would be sacrificing in order to enter into formal wage employment. However, in a country that is 70% rural (WRD, 1995), yet concentrates a majority of its educational opportunities in urban areas, a majority of the 95% unemployed are actually agricultural laborers; any residual un- or under-employment may be composed mostly of rural immigrants to industrial centers who lack the education, and therefore the job skills, required for increasingly technical industrial jobs. This implies what we already know to be true about all labor markets: there is no universal wage; instead, wages are graded across positions, based on the skills required to perform a particular job and the responsibilities entailed in it. This model is meant to consider female entrance into higher-skill, and therefore higher wage, employment, where a womans wage can be less than that of a man without being menial; these are the types of job that have an implicit value attached to them and, by association, can raise the perceived value of women within Indian society.

The policy implications of this sort of theorization are heavily dependent upon the amount and the type of economic growth that is stimulated by female replacement. Where the implications to the firm of female replacement are extra-normal profits, the government should be concerned with how and where those profits are invested; the government has the capability to lower the interest rate through the central bank and to provide tax incentives for capital expansion, both of which are powerful investment-stimulating tools. More importantly, the government is the only player in the market that has the power to confront traditional biases against women in employment; it must take the leading role in the stimulation of demand for womens labor that should eventually generate the process described in the model. The government has the ability to make female labor more attractive to firms by increasing female education opportunities, providing logistical and management training and support to firms transitioning towards a greater female/male ratio amongst their work forces, and continuing its long-standing tradition of encouraging female participation in all levels of government.

It seems clear that this program could not succeed if the government were to focus on either the education of women or the generation of demand for their labor alone; both must be given equal attention, and a direct link between the two must be made at every stage of the process. Although a number of approaches to this problem exist, the simplest and most direct may be the best option in the earliest stages; one example would be to increase the degree to which funding of public schools is based on female representation in classes and to provide tax credits to individual firms based on the income taxes collected from their female employees. These types of policies are suggested not only because they reduce the costs to the central government that are generally imposed by recruitment campaigns, but more importantly, because they assign recruitment responsibilities in a more efficient manner; it seems likely that local public school administrators and teachers and the owners and operators of local industry would be more familiar and respected in their communities, and therefore better able to affect social change there, than unknown bureaucrats from economically, if not geographically, distant New Delhi. Under its New Economic Plan, the Indian central government has very successfully turned over many of its powers to more efficient private-sector groups; by concentrating more normative taxes on firms, the government can continue in this policy by privatizing away governmental responsibilities where it can be done at less cost or with increased efficiency in the private sector.

The one policy implication that should not be garnered from this material is that a laissez-faire, free market approach to the economy will provide solutions to social problems. This paper outlines a partial solution to Indias population problems that works in the private sector and probably only on a regional level, but only with governmental support. Without significant government involvement, cultural predilections will continue to overrule profit-seeking tendencies, and the role of women in the labor force will always be inappropriately discounted. Without continued government funding of its own and other, private family planning programs, the supply of contraceptive technology could not meet the increase in demand that would come about from the fertility-reducing effects of female replacement. Most importantly, it is the role of government of the largest democracy in the world to regulate both the use of womens labor in its economy and the reduction of fertility in its society to ensure that its citizens are protected and that its policies create positive and lasting social change and economic development.

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CHAPTER FOUR

C. MAUREEN CUNNINGHAM

THE EFFECTS OF GLOBAL WARMING ON THE POPULATION, AGRICULTURE, AND EPIDEMIOLOGY TRANSITIONS IN THE SOUTH SAHEL REGION OF AFRICA

The Sahel cuts a swath across West Africa from Senegal through Chad. It is the zone just South of the Sahara desert, and is the area into which the Sahara desert shifts in its movements southward (See Map following). Due to expansion and contraction of the Sahara (Tucker et al., 1990), it is difficult to define where the southern border of the Sahel falls. The Sahel is the major transition zone between the more humid tropics to the south characterized by two dry seasons and two growing seasons and the hot, dry, desert to the north. The southern part of the Sahel and the northern part of the humid tropics is the area under study made up of Northern Benin, Southern Niger, and Burkina Faso, called here the South Sahel region (see Map following). While there are some sociological and cultural differences in the different parts of the South Sahel region, the climate, lifestyles and modes of agricultural production are very similar throughout.

The region is labeled the Sudano-Guinean Climate Zone (Martyn, 1992). It is dry and hot, with three identifiable seasons: The first, called the Harmattan, is dry and relatively cool, the second is hot and relatively humid, and the third is rainy and hot. Rainfall is low and unreliable compared to the more humid south where there are two relatively stable growing seasons per year (Simsik, 1993).

The people living in the South Sahel region are agriculturists for the most part, depending on the one annual growing season to provide the bulk of their income and nutritional subsistence each year. Agricultural labor is accomplished with simple tools such as the short handled hoe and the machete (Simsik, 1993). With only these inputs to production, labor is of high importance. The land area under cultivation is fairly small for any given person or family due to the intensity of labor necessary to produce crops. Most farming is of subsistence crops such as millet and sorghum and some commercial crops such as cotton and groundnuts for export (Simsik, 1993, United Nations, 1994). It is important to study global warming in the South Sahel region in terms of the population-environment dynamic in order to develop policies which can be implemented by the governments involved to mitigate the societal and environmental problems that global warming exacerbates. The region has a highly constrained ecosystem. According to Agbo et al, "The greater number of types of ecosystem constraints involved and the greater degree of constraint of these components, the more tightly linked the population-environment dynamic will be in any region (Agbo et al., 1993). Tight linkages between population and environment mean that the more the environment changes, the more the population will be affected. As the population changes (for example grows larger), the environment is highly affected (Agbo et al., 1993). Population and environment are inextricably linked, and must be considered in terms of each other before any policy changes can positively impact a constrained ecosystem.

There are three types of ecological constraints that are apparent in the South Sahel region. The first is geographical. The South Sahel is geographically constrained in terms of water availability which dictates where people can survive. The second type of constraint is ecological. Poor soils mark the entire region, limiting the number of people who can sustain themselves in any given area. Finally, there are economic constraints. These include the populations dependence on subsistence agriculture, as well as their dependence on the fluctuating global market economy over which the local people have virtually no control for the sale of their cash crops (adapted from Agbo et al, 1993).

Interactions between the population and the environment are not the only ones that affect the region. In the world today, action or lack of action in one region can have a strong impact on other regions of the world. An important case in point is global climate change. The people and production of the South Sahel Region have not contributed a great deal to anthropogenic (human generated) climate change, yet global warming (a more simple term for anthropogenic climate change) may strongly change the environment in the region (Glanz, 1992). Through the environment, global warming may influence other sectors of the region such as the population, health, and agriculture.

An appropriate way to look at the population-environment dynamic is through the transitions framework, developed by Dr. William Drake. In the physical world, there are a variety of factors which affect every sector. Transition theory makes explicit the interdependence of sectors, and is an attempt to look at change in a realistic yet manageable fashion (Drake, 1993)

Given that the world is made up of interrelationships across regions and within them, it is admittedly impossible to foresee all aspects of change in any sector. Transition theory gives a framework for examining some of the aspects that cause change. There is a whole family of transitions which includes the environmental and population transitions, as well as the agricultural, forestry, urbanization, epidemiological and other transitions. A transition can usually be broken down into many others, depending on the specificity of the study. For example, one could study the population transition alone, or one could break it down to investigate the fertility transition as distinct from the mortality transition. A transition means a change from one state to another, but does not imply either positive or negative change. In transition theory, change is from some point of stability to another point of stability which may be entirely different from the first. For example, in marginal lands where scrub-cover is the stable state at present, the stable state following a forestry transition may be a desert. Transitions occur similarly on many different scales, both temporally and spatially. Transitions can and do interact with each other and affect each other. From a policy perspective, it is the timing and speed of transitions that may be realistically possible to change, not the actual occurrence of any given transition (Drake, 1993).

In general ways such as those stated above, transitions are similar across space and time, but at a local level, transitions occur in very different ways and are changed by a myriad of local occurrences. In this paper, I will investigate three of the transitions occurring in the South Sahel, specifically the population transition, the agricultural transition, and the epidemiological transition. I will look at the position of the South Sahel in each transition now, and then look at how global warming may affect the progression of the transition, and finally how the governments involved can positively influence the timing and speed of the transitions to ease their negative effects on the population.

Since data for the South Sahel specifically has not been gathered or calculated, I will use data from the three countries which each include part of the South Sahel. While such an amalgamation is not an exact proxy for the South Sahel, given the similarities of the region, an approximate average of the three countries rates and figures paints a close picture to what data collected exclusively for the South Sahel would illustrate. Where possible I include data for all three countries. Occasionally only one or two countries data is available for illustration and that is used as a rough guess of the South Sahels data itself.

GLOBAL WARMING

Leaders of less developed countries often see the problem of climate change as far out of their realm of control. Understandably, climate change is pushed to the side as something which, if it does occur, is seen as so far in the future, and is as yet so unpredictable that it is not necessary or possible to deal with at this time (Glanz, 1992). It is true that the effects of global warming on a regional scale are unclear. It is also true that developing countries have not been a primary producer of greenhouse gasses (those gases which cause global warming to occur) (Glanz, 1990). But climate change, whether human in origin or purely natural, highly affects those peoples who live closely linked to the environment (Agbo et al., 1993). Subsistence farmers, the bulk of the people in the South Sahel as well as much of the developing world, are harder hit by climate change of any type than are populations that have more of a buffer between the environment and themselves. This is true whether that buffer is a personal savings account or improved technology which allows high levels of agricultural production in the face of climatic variation. Policy makers in Benin, Niger, and Burkina Faso, as well as other developing countries need to address the possible impacts of global warming before they negatively affect their people.

The Intergovernmental Panel on Climate Change (IPCC) is made up of researchers from all over the world working with the UN to study the causes, effects, and possible future scenarios of climate change. According to the IPCC, climate change due to human activity is definitely occurring globally. Anthropogenic climate change is caused by the emission of greenhouse gasses (GHGs) which include carbon dioxide, methane, nitrous oxide, halocarbons, and hydroflourocarbons. The most important of these is carbon dioxide (CO2) due to its high concentration and rate of increase in the atmosphere. Greenhouse gasses are produced through industrial production and transportation that depend on the combustion of fossil fuels as well as land use conversion (IPCC Draft Report, 1995). Once GHGs are released into the atmosphere, they act in much the same way as a greenhouse. They trap some of the radiation coming from the earth in the earths atmosphere and do not allow the earths natural cooling process to work as strongly as it would without the high levels of GHGs (Benarde, 1992).

As of yet, the full effects of climate change are not known. A way to look at the possible effects is to set up modeling situations in which many variables at different levels are factored in, such as the rate of GHG production into the future (Benarde, 1992). Commonly accepted models point to a global temperature increase of anywhere from 1.5-4.5 degrees Celsius eventually (Schneider, 1994), and 1-3.5 degrees Celsius by the end of the next century (IPCC Draft Report, 1995). According to the IPCC, In all cases the average rate of warming would probably be greater than any seen in the last 10,000 years, but the actual annual to decadanal changes would include considerable natural variability (IPCC draft report, 1995). Experts on climate agree that temperature change is likely to be greater at the poles than at the equator (IPCC DRAFT Report, 1995). The IPCC projects a rise in sea level from 15-95 cm. by the year 2100 due to thermal expansion of the oceans and the melting of some of the earths water currently contained in ice. Modeling on precipitation is less precise than on temperature and sea level rise. Some models predict more severe droughts and floods, some models predict more severe precipitation events such as increased cyclone possibilities (IPCC draft report, 1995).

While global effects of some degree are inevitable due to anthropogenic climate change, regional effects are highly uncertain to date, and the smaller the region of interest, the less certain the effects become (Stephen Schneider, personal communication). The IPCC predicted in 1990 that in the Sahel, the temperature will eventually increase from 1 to 3 degrees Celsius. Area mean precipitation will increase and area mean soil moisture will decrease in the hot season

(Suliman, 1990). Soil moisture, as controlled by evapotranspiration, is extremely important--regardless of the amount of rainfall. If the water in the soil is evaporating at a relatively greater rate than the rate of increased rainfall, there is less water for plants to use for growth, a matter of vital importance to farmers depending on rain fed agriculture as are virtually all the farmers of the South Sahel region.

In looking at the temperature data available for the South Sahel region which is collected and made available by the National Oceanographic and Atmospheric Agency (NOAA) some interesting, although inconclusive, evidence is apparent (see Figures 1-4). I chose four sites at which data is available for at least 50 years prior to the latest year of data available (usually 1992), and which correspond to my area of study. The four sites I chose are Natitingou and Kandi in Benin, Fada NGourma in Burkina Faso, and Niamey in Niger (see Map near front). Data for some of the sites went back further than what is included but was left out because there were periods of several years with no data whatsoever. For those years in which data is available, but in which not every month is available at a given site, the year is not included for that site only.

When the years of complete data are graphed (represented by the black diamonds in Figures 1-4), a striking aspect of annual temperature is apparent. Obviously, even without the effects of anthropogenic climate change mean annual temperature varies widely at all four locations. By fitting a simple linear curve to the data available for each location, a surprising aspect becomes clear: In all cases except for Niamey, the temperature appears to be declining, albeit very slowly, over time. If, however, a linear curve is fit to the data since 1960, in all cases except for Natitingou, temperature is rising. Even in the case of Natitingou, temperature since 1960 is falling less quickly than temperature for all the years with data available. Since the early 1960s has been identified as the time that global warming may have begun to visibly affect global temperature, fitting the curves from 10 years prior to that time onwards helps ensure that natural variation in annual climate alone is not causing the trends that appear when a linear curve is fitted to the data. When these graphs are made fitting the curve from 1970 onward, temperature is increasing for each of the four cases.

Figure 1

Figure 2

Figure 3

Figure 4

Temperature data alone is not proof that global warming is affecting the region. It is however , an indicator that it may be occurring. But can national policy makers act on a probability? The answer is not only that they can, but that it is extremely important that they do so. In order to take action to protect their populations from the effects of global warming, policy makers need not know what the exact effects will be (Glanz, 1992). By choosing to implement No Regrets policies, the governments of these countries can benefit their societies now, and protect them against the possible effects of global warming in the future. No Regrets policies are those that cause no harm and create benefit without dependence on the future, but developed with a probable future in mind (Glanz, 1992).

In the case of policies aimed at mitigating the effects of global warming, the necessity of such No Regrets strategies become more clear when we consider the highly variable nature of annual temperature throughout history (see again Figures 1-4). Even without global warming, temperature varies widely year by year as illustrated above, causing variation in the ability of agriculturists to produce crops. Graphing the temperature data for Niamey superimposed upon the agricultural production data in Niger for the same time period gives a clear picture of how important temperature variation may be (Figure 5). The three years of least agricultural production per capita all correspond to years with very high mean annual temperatures, a strong indicator of the importance of temperature variation on production, and through production, survival for the subsistence and near subsistence farmers of the region. Whether or not climate is changing in the South Sahel due to human activity, governments can act now to protect their populations against natural climate variation while at the same time helping to prepare them for anthropogenic climate change to come.

Figure 5

THE DEMOGRAPHIC TRANSITION

According to demographic theory (Coale, 1974), the demographic transition as seen thus far has four stages. In the pre-transition stage, birth rates are very high, but are counterbalanced by high death rates. The overall effect is a population with little or no growth. In the early stage of the transition, death rates fall due to public health and medical improvements in the population. Birth rates remain high and a population explosion occurs. In the late stages of the transitions, births begin to fall, and although they still exceed deaths and population continues to rise, the rate of increase is slow. Finally in the fourth stage called the post-transition period, the birth rate falls to the point that it is roughly equal to the low death rate and the population reaches a steady state of approximately zero population growth. This model is based on the experience of more developed countries (Haub et al., 1994) where the transition has occurred smoothly and over a long period of time. There the decrease in death rates occurred slowly and was of endogenous (interior to the region) origin, caused by a gradual increase in knowledge about health and medicine. There was a lag in the fall of birth rates following the fall in death rates, but not so great as to create a large degree of stress either on the environment or on the population.

The South Sahel region, and indeed much of Africa, is experiencing a population transition much more violently and quickly than the more developed regions did. The South Sahel is currently at the point of change between the early and late stages of the transition. Changes to the death rate came relatively quickly (the early stage), beginning around 1950 in the form of life-saving vaccinations and medical technology provided in large part by international aid agencies (Haub et al., 1994).

Birth rates, on the other hand, have remained relatively constant. An amalgamation of the population growth for all three countries in the South Sahel region gives a fair idea of what the rates are, given the similarities between Northern Benin, Southern Niger and Burkina Faso. At the present time, the crude birth rate (CBR) per 1000 people in the population per year in Benin is 48.09. In Burkina Faso it is 48.8, and in Niger it is 57.35, while the crude death rates (CDR) per thousand people in the population per year is about one third of the birth rates at 14.8, 18.19, and 22.44 respectively (CIA, 1995). Since the growth rate percent (minus migration) is equal to births minus deaths divided by ten, the region has an overall growth rate percent of approximately 3 (3.1 in Benin, 2.8 in Burkina, and 3.4 in Niger (World Population Council, 1995). This number may not seem very high, but consider that a growth rate percent of three means that if the growth rate remains unchanged, the number of people in the region will double in only 20 years (see figure 6 below).

Figure 6

Figure 7

By the year 2025, the population in the region will be approximately three times its present level. Perhaps even more striking than the level of increase is the irrevocability of the increase. Due to population momentum and the slow speed of decrease in the growth rate, population will continue to climb throughout the foreseeable future even though growth rates are projected to begin falling in this decade. In the South Sahel region, population momentum rests to a large degree on the age distribution of the population. Nearly half of the population at the present time is under the age of 15. Thus, a huge majority of the population is in, or will be moving into, their reproductive ages within the next 15 years. Even if the number of children born per woman fell dramatically, the number of people having children will keep the population growth rate high (see Figure 7).

Figure 8

The effects of population density increase on the South Sahel region will be strongly felt. Whereas at present the population density is about 40 per square kilometer (49 in Benin, 38 in Burkina, and 6 in Niger (World Population Council, 1995), under the present UN projections for future growth, the population density will increase to about 90 per kilometer by the year 2025 even though population growth is falling (see Figure 8 below). Nigers population density is very low in the mostly empty upper portion of the country. The bulk of its population is in the South Sahel region where farming is difficult but possible, unlike the desertic North. A population density of 40 per square kilometer is not terribly high, but for a subsistence farmer with low crop yields, it may be close to what the land can bear and still provide sustenance for its inhabitants. Thus, the population density, while low compared to some regions is high for the South Sahel region due to the constrained ecosystem and the modes of agricultural production. People are not acting to limit their fertility general-

ly in the South Sahel Region. Contraceptive use levels by women are very low: approximately 9 percent of Benins women ever uses contraceptives, and about 1 percent of Nigers and Burkinas women are contraceptive users.

One possible scenario of what will cause population to fall eventually in the South Sahel is a Malthusian one of widespread death due to starvation when the population gets too high to support itself off the land, or death due to wars for land or rights to production. Another is that the population will eventually be artificially supported by the international aid community, and become a sort of welfare exclave of the western world (Hill, 1990). Neither scenario bodes well for the region, and policy makers need to address the problems of high population growth rates before the region moves any closer to either one.

In order to make effective policy, causes behind high population growth, not just the mechanics of it must be understood. The average number of children per woman is nearly 7 in the region (World Population Council, 1995). Why do the people of the South Sahel continue to have large numbers of children? Paratha Dasgupta offers a model which helps to explain the phenomenon of high population growth in an environmentally constrained ecosystem. Population growth, poverty and environmental degradation are all tied together in a positive feedback loop (Dasgupta, 1995). As the environment becomes more degraded, people must work harder or pay more to obtain the same amounts of food, wood, and clean water from the environment which increases the level of poverty. As poverty increases and the environment becomes more degraded, people need to have more children both to act as laborers and to ensure that the parents will be provided for later in life. An increase in population puts even more strain on the environment, making adequate production or use of the land again more difficult. Even more children are needed to roam farther afield in search of wood, to work the fields or in the case of some villages in Northern Benin, to chase wild baboons away that destroy crops and livestock. With more mouths to feed, each family must farm more land and leave less land fallow (a traditional practice which allows the land to replenish its nutrient cont-
ent), which leads to lower yields per hectare and, again, increased poverty.

In Tanougou, a commune in northern Benin the likelihood of such a cycle is apparent in looking at fuel wood needs. As the number of people in a household increases, so does the need for more wood but at a lower rate than the rate of family size increase. By increasing a household from 2 to 6 people (a threefold increase) for example, the need for fuel wood on average only doubles. Moving from 6 to 12 people in a household the need for fuel wood increases less than two times (Agbo, 1993). In a society where people must spend several hours a day ranging further and further afield to collect wood, and where children are able to perform the task, such as in the South Sahel, people can ill afford to limit their fertility.

This ever widening cycle of poverty, environmental degradation, and population growth is increased by the power structure of the local communities. The South Sahel region is marked by control by men over most resources, including the resource of reproduction. Women cannot chose to have fewer children, because the social structure does not allow it. It is the women, however, who bear the majority of the burden of raising children, including maternal morbidity and mortality as well as the economic burden of raising children through early childhood (Dasgupta, 1995). As womens education levels and ability to participate fully in the economic sector increases, there is a tendency for fertility rates to drop. This may be due to the increase in the cost of a woman bearing child after child. Such costs include lost opportunities to work and receive income from work due to childbearing, illness caused by childbearing, and child rearing (Dasgupta, 1995).

In the South Sahel region, literacy rates for women are very low (exact rates are: 9% in Niger, 6% in Burkina Faso, and 16% in Benin (WHO, 1991). Both men and women produce crops, and traditionally have separate fields, giving both groups nominal economic power, but generally women must work in the mens fields as well as working their own. Women are responsible for feeding their families from their crops directly or from the sale of them, while mens crops are more often cash crops sold for export.

Until the ultimate cause of high fertility are changed, including the need for children as labor to survive, as well as the lack of economic and educational opportunities for women, the people of the South Sahel will not be able to lower their fertility rates.

AGRICULTURAL TRANSITION

The agricultural transition has followed a trajectory similar to the worldwide population transition. For many centuries, agricultural production kept pace with human population (Drake, 1993). There were periods of famine due to war, drought or other climatological disasters, but on a large scale, human populations were able to produce enough to feed themselves. Increases in agricultural production came through the increase of the amount of land under cultivation, and improved methods of production. Drake identifies the shift in increase from amount of land under cultivation to improvements in productivity per hectare as the beginning of the agricultural transition (Drake, 1993). The transition includes the period of increasing returns on inputs into fixed land holdings, and eventually reaches a stable point when a given area of land cannot profitably be made to produce more output. According to Drake, the shift from size to intensity is especially remarkable at the individual farmer or family level at which the amount of land owned or open to use may be fixed, leaving a farmer only one alternative to increase production: increased growth intensity. If increased intensity does not occur, but population continues to increase, rural to urban migration will occur, giving those who remain on the land more area to cultivate.

The South Sahel region is at the early stages of this transition. The vast majority of people in the region are farmers (over 90% of the labor force in 2 of the 3 countries involved are agriculturists (CIA, 1995), and almost all farmers work on small, family-run farms. Some cash crops, mostly cotton, are produced (CIA, 1995). Food crops are varied and include: sorghum, millet, cassava, rice, tubers, and others to a lesser degree (UN, 1994, and CIA, 1995). In general, women grow food crops and men grow both food crops and cash crops. Agricultural production is accomplished using traditional methods and only the most simple of tools: short handled hoes, shovels, and machetes. Agricultural production is highly labor intensive, and yields are low. For example, in Niger, the profit in terms of food produced per hectare of arable land is at about $120 in constant US 1985 dollars per year (WRD, 1995). Considering that a family with 4 people working can cultivate slightly more than 4 hectares of land on average (this statistic is for Tanougou in northern Benin, Agbo, 1993), the amount of food or profits produced is very low. Most land is broken into small plots of less than a hectare to one or two hectares, with one family farming several plots. Little in the way of technological advances have been brought in. Fertilizers and pesticides are used, but due to their high cost they are not used in the recommended amounts. Some livestock is raised, mostly for family consumption, except for Burkina Faso where a substantial number of cattle and sheep are raised for sale (UN, 1994, and CIA, 1995).

The soils of the region are relatively poor and non-productive. In the past, this was a manageable problem in that the population in any given area was low enough to allow long periods of fallow between periods of production which gave the land the opportunity to replenish its nutrient content. As population increases and more pressure is applied to the already constrained ecosystem-system, periods of fallow are decreased out of a necessity to use the land for food production. Land that used to be left fallow for a decade or more in between each several year period of use is now only being left fallow for 4 or five years. Another common practice which decreases the fertility of the soil is burning off the ground cover which grows up in times of fallow and between harvests. In a region of no winter to naturally break the insect and pest cycle, burning the fields helps to accomplish this vital task for production (Schneider, personal communication), but much of the organic matter on the land is in a sense wasted by being burnt off instead of being used to enrich the soil. Fire also destroys any unprotected trees which serves to increase the shortage of fuel wood in the area (Agbo, 1993). Finally, fire leaves the land open to wind and water erosion until substantial plant cover is replenished. Some fertilizers are used in an effort to substitute for the loss of soil fertility, but for the most part these inputs are too expensive for families to afford (Simsik) or unavailable to be used correctly. When they are used, fertilizers have their own long term debilitating effects on the soil which necessitates ever greater inputs of fertilizer .

Shortening fallow periods and field burning is impoverishing the soil and ever decreasing yields per hectare. This creates the need to try to cultivate even more land to produce enough to survive. The need for labor to work the increasing landholdings leads to an increased need for children. More children serve to increase the pressures on the land, both through need for agricultural production and need for the fuel wood and other resources that the land provides. This cycle will continue to reproduce itself and expand until the population can feed itself without relying on the practices that serve to keep the cycle in motion.

EPIDEMIOLOGICAL TRANSITION

The basic epidemiological transition is highly related to both the agricultural and demographic transitions described above. In the early stages of the transition, most death is caused by infectious disease and malnutrition related disease (Drake, 1993, and Dewey, 1986). There is a high probability that any individual will contract a mortal disease and die before they reach old age. As public health and sanitation measures take effect, such as clean water provision and food safety standards, the first stage of the transition begins. Infectious disease and malnutrition related disease take fewer young lives, and people begin to live longer on average. As medical technology improves, vaccinations are administered against many infectious diseases, and food becomes more and more secure due to agricultural improvements. Living into old age becomes the norm. Death is no longer caused by infection or malnutrition for the most part, instead it is due to a whole host of degenerative diseases such as heart disease and cancer. Degenerative diseases existed previous to this stage, but since they affect the elderly much more often than the young, they were rarely seen. This last stage has been reached in much of the more developed world, and life expectancies at birth have soared into the 70 and 80 year ranges (Population Reference Bureau, Inc., 1995). The majority of people in the West live into their retirement years and experience one or more of the degenerative diseases from which they eventually die (Drake, 1993, and Dewey, 1986).

Figure 9

In the South Sahel region, the transition is underway to some extent, but it has come about in a very different manner than it did in the West. Instead of a decrease in illness and death at young ages beginning with public health measures as was seen in the West, the initial decrease in death rates in the South Sahel came primarily from vaccinations and improved medical technology. For example, in the South Sahel region today, only about 35% of the rural population has access to safe drinking water (43% in Benin, 31% in Burkina Faso, and 32% in Niger) (WRD, 1995). Sanitation services, such as latrines are in even shorter supply with approximately 12% of the population having access to them (5% in Burkina Faso, 4% in Niger, and 35% in Benin). On the other hand, a large proportion of infants are immunized now against the childhood killers including tuberculosis, diphtheria, polio, and measles (WRD, 1995). Thanks to the World Health Organization, small pox has been wiped out. Antibiotics are now available to those who can get to health care facilities. Access to medical facilities is low however, with overall access to a clinic or hospital at less than 50% (WRD, 1995).

The effect of the changes in health care and medical services has increased the life expectancy dramatically since international aid agencies began working in earnest in the 1950s (see Figure 9 above), but in all three countries of the South Sahel, life expectancy is still quite low by more developed countries standards. Since life expectancy is a measure of the average age at death, it is also an indicator of general ages of death across a population. A low life expectancy such as that seen in the South Sahel Region is indicative of deaths due to infectious disease and malnutrition related disease because it shows us that a large percentage of the population is dying before they reach old age when degenerative diseases generally set in. Infant mortality rates also can be used as rough indicators for death rates across all age groups. In a region with high infant mortality, there is likely to be high death rates across all age groups, indicating high death rates from infectious and malnutritional diseases. Infant mortality has declined somewhat in the South Sahel mostly due to improvements in vaccinations and medical technology available, but it remains very high, at 109 per thousand live births annually for Benin, 134 per thousand for Niger, and 137 per thousand for Burkina Faso (WHO, 1991).

Figure 10

Due to a lack of reporting, morbidity rates (rates of illness) are not well known for most of the world. A study was carried out in Burkina Faso which indicates that the leading causes of visits to health clinics and hospitals for children under five in that country are, in order of rates, malaria, diarrheal disease, respiratory infection, and malnutrition related disease (See figure 10) (Konate et al., 1994). This information roughly corresponds to the World Banks assessment of mortality causes for children in demographically developing countries (World Bank, 1993). Children under five bear a large percentage of the burden of communicable disease. In Sub-Saharan Africa, when infectious disease occurs, 63.5% of the time it is to a child under five; 32.1% of non-communicable disease (including malnutrition) is borne by children under five. The corresponding figures for children in the more developed countries of the world are: 29.3% of communicable disease and only 4.3% of non-communicable disease (World Bank, 1993).

The overall infectious disease rate for people of all ages is extremely high in the developing world. The daily adjusted life years lost (DALYs) due to any given disease or adverse situation (such as malaria or lack of clean water) is a useful measurement of disease rates. It takes into account both loss of life and loss of health while alive. In Sub-Saharan Africa, the rate of DALYs lost to people of all age groups due to infectious disease is estimated at 408.7 per 1000 people. The corresponding rate due to infectious disease in the more developed world is only 11.4 DALYs lost per 1000. On the other hand, in the more developed world the non-communicable disease rate is closer to that of sub-saharan Africa at 92 DALYs lost per thousand people. Sub-Saharan Africas non-communicable disease rate is 111.4 DALYs lost per 1000 people. This rate is slightly higher than in the more developed world, but it is apparent from these figures that proportionally, the vast majority of disease burden is caused by infectious disease in Sub-Saharan Africa, while the majority in the more developed countries is caused by non-communicable, degenerative disease.

The epidemiology and agricultural transitions include a change from food production for individual use to crop production for sale. As productivity increases, a family can grow more than they themselves need. Selling the excess production, or growing strictly cash crops, is a way to save what is produced and create a buffer against times of famine or hardship (Dewey, 1986). Such saving is virtually impossible in a purely subsistence farming situation for longer than the year or so that excess food can be conserved. This transition can be enforced by the government by the need to pay taxes or the need to have money available for other things such as school fees and transportation.

Once farmers move from purely subsistence farming to some subsistence and some market crops, food consumption is no longer equivalent to what is produced. A movement to cash crops takes control of productivity, in terms of profit, out of the families hands and puts it into the markets. For farmers with large and highly productive landholdings, this change means more luxury and diversity of diet, but for a marginal farmer the switch can lead to a decrease in nutritional intake if the farming family does not make enough money to purchase adequate food (Dewey, 1986). Often the most fertile land is converted to cash crop use, leaving the more marginal land on which to produce food crops for family consumption. In periods of low rainfall or other climatic catastrophe, those marginal lands produce little to nothing. The more fertile lands may still be made to produce crops, although to a lesser extent than in high rainfall years, but money has many uses besides food purchases. Income from the sale of these crops may be used up before food is gone for other things such as paying taxes and school fees. Over time, if a farming family is successful and the market remains high for their cash crops, the savings lead to the ability to increase either holdings or intensity of farming. The increase leads to more savings and more increase. This cycle, where it is possible, can lead to smaller farmers being pushed out because they cannot compete with the higher technology production of the neighboring farmers who can afford to sell their products for less (Dewey, 1986). Rural to urban migration is the result, as we have seen in the United States.

The South Sahel region is at present in the very early stages of this part of the transition. Some cash crops are grown, mostly cotton, but, as are so many developing world producers, the ability to make profits is at the mercy of the international market. Farmers frequently turn their best land over to cotton growth, with the idea of including it in their regular crop rotations. Despite the high nutrient use of cotton plants (Simsik, 1993). The soil becomes impoverished, and when it no longer will produce cotton in large quantities, it is turned back over to food crop production.

Figure 11

Another result of a change to cash cropping is a decrease in the variety of what is grown (Dewey, 1986). Evidence shows that very traditional cultures practicing subsistence farming generally have highly nutritional diets. In the South Sahel, it appears that in years without drought the area is very close to food self-sufficient in terms of calories (see Figure 11). In terms of nutrition there is a deficiency of vitamins and nutrients leading to high rates of malnutrition especially in children. The prevalence of malnutrition for children under five is estimated at 46% in Burkina Faso, 49% in Niger, and 35% in Benin (World Bank, 1993).

The epidemiological transition is underway, but due to limited access to care, agricultural constraints on good nutrition, and poor public health and sanitation, the transition is moving very slowly.

THE EFFECTS OF GLOBAL WARMING

The demographic, epidemiologic, and agricultural transitions are all in progress in the South Sahel. The timing and speed of all three are influenced by many factors, not least of all each other. Perhaps already, but more likely in the near future, the rate of change in these transitions will begin to be influenced by the effects of anthropogenic climate change. Although we are far from understanding all the effects global warming may have, when we look through the lens of the transition theory, we can predict some of the possible effects of human induced climate change. In general, the most likely changes that global warming will bring are to exacerbate the negative effects of transitions already in progress.

Perhaps the most direct change due to global warming will be in the agricultural transition. In the South Sahel, rainfall amount and timing are vital to the growth of crops. If global warming creates either more drought in the Sahel or increased volatility in precipitation as many predict (Suliman, 1990, Glanz, 1992, IPCC, 1995), the effect will be to increase the speed of the present circular trend of decreasing production per hectare leading to the necessity to cultivate more land which in turn decreases the revitalizing fallow periods and impoverishes the soil further. Increased drought and failed crops leave the earth open to wind and rain erosion when the rain does fall. Erosion leads to increased desertification and impoverishment of soil fertility (WHO, 1990).

Increased drought or precipitation volatility due to global warming may also lead to an increase in out-migration to urban areas due to a decrease in the ability to survive (Doos, 1994) in the South Sahel. The migration and urbanization transitions were not discussed in detail in this paper, but in brief, if jobs or other sources of survival are not available in the urban centers where people of the South Sahel migrate, migration will serve only to swell the already existing problems of urban poverty and unemployment.

Due to a decrease in the ability to produce at the lower latitudes, global warming is expected to necessitate a net increase in imports of cereals from 20-50% into the developing world (Fischer et al., 1994). The average decrease in crop yield of cereals due to global warming in the developing world is 10% (Fischer et al., 1994). There is no reason to believe that the South Sahel region will be immune to these effects. Policy options must be considered and implemented soon to try to avoid the negative agricultural effects global warming will cause.

Global warming will indirectly effect the population transition. Population, poverty and environmental degradation are intertwined in a positive feedback loop (Dasgupta, 1993). Global warming, through increased drought and volatility will add inputs into the loop in the form of worsening environmental conditions in the South Sahel. As the environmental conditions worsen, people will need to have even more children to do the work necessary to survive. As cereal production and other crop production decreases due to worsening agricultural conditions, the already tenuous state of nutrition of the South Sahel may worsen. There will be 40-300 million more people at risk for hunger due to climate change worldwide (Patz, 1995). More malnutrition will lead to a higher risk of death, especially for young children. As childhood mortality increases, people may feel that they must have more children to replace the children they have lost, to insure that a certain number of children survive, or to insure their own futures when they become too old to work (Dasgupta, 1995). This trend is already occurring in the South Sahel. Global warming will serve to increase the problem however and cause it to move forward at ever increasing rates.

On another level, the worsening agricultural conditions due to global warming and the already occurring population dynamics will lead to increased poverty in the already poor region. Increased poverty leads to fewer economic possibilities, and also less money to pay school fees. Parents in the South Sahel are extremely unlikely to send their girls to school if they cannot afford to enroll all their children. Instead, boys go to school when the parents can afford to send any children at all. Since educational and economic opportunities for women tend to decrease fertility (Dasgupta, 1995), the opposite is also true-- where fewer women have such opportunities, fertility tends to increase.

Global warming will not alter the path of the population transition as it is occurring now, but it may drastically increase the rate at which it is occurring. Fertility rates are high at present, and will get higher still if the effects of global warming are not mitigated. Policy changes cannot stop increases in population, but they can help to slow down the increases to give governments more time to provide infrastructure and services to the growing population.

The effects of global warming on the epidemiologic transition are in many ways tied to the population and agricultural transitions. According to the World Health Organization, global warming may directly increase health risks, especially for those people who have immature regulatory systems, such as infants and young children, and those with failing cardiovascular, respiratory, renal, and other systems (WHO 1990). Increasing malnutrition is likely to occur, as described above. Malnutrition will also potentially increase due to less diversity in diets. As the climate warms, and drought increases in the South Sahel, it is likely that some varieties of edible plants will not be able to adapt to the quickly changing climatic conditions. Since the population of the South Sahel relies for the most part on the crops the people themselves can grow or gather, a decrease in varieties of crops may lead to a decrease in the nutritional value of the local diet.

Temperature is a major determinant in disease vector infectivity. It affects replication, maturation, and length of infectivity of vectors (Patz, 1995). Infectious disease rates are very likely to change due to changing climatic conditions. While droughts are likely to intensify in the South Sahel, the amount of rainfall is expected to increase. Increased evapotranspiration will remove a greater percentage of moisture from the soil, making both the earth drier and the humidity higher than at the present time. Increased temperature and humidity tend to intensify the biting behavior of most insects (Patz, 1995). Since many infectious diseases in the South Sahel, most notably malaria, are passed through insect bites, it is likely that the rate of infection of such diseases will increase.

Incubation periods for many viruses such as dengue fever, one of many arboviruses found in sub-saharan Africa, may decrease. For example, it was found that at 30 degrees Celsius (a temperature experienced in all parts of the South Sahel during certain months) the incubation time for dengue fever is 12 days. When the temperature is raised to 32-35 degrees Celsius as it may be with global warming, the incubation period is only 7 days. This effect alone leads to three times the transmission potential of dengue fever (Patz, 1995).

With global warming, the relative burden of infectious disease on the population will probably increase from its already high levels in the South Sahel, as will the relative burden of malnutrition and malnutrition related disease.

POLICY CHANGES TO MITIGATE THE NEGATIVE EFFECTS OF GLOBAL WARMING

Since the exact effects and magnitude of effects of global warming on the South Sahel are not known, it is important that any policy implemented will also benefit the state and the people if global warming does not impact the South Sahel region as is expected. In the South Sahel the most likely effects of global warming are to increase the speed and magnitude of the already occurring negative effects of transitions. No Regrets policies are relatively simple to envision in this case: they must be policies which have the power, when implemented, to decrease the speed and magnitude of the most likely problems approaching. They must also lead to positive changes for the environment and societies now. By implementing No Regrets policies, the governments involved can provide the local population time for the international community and the domestic communities to discover effective, long term mitigative procedures. If no policy is taken to mitigate global warming now, a very real possibility is that the state of the population and environment will deteriorate to such a great degree that long term solutions are impossible or are made extremely costly and difficult. Since pertinent policy changes will all have some cost associated with them, it is necessary to chose policy changes carefully which could possibly be implemented by the governments involved. The international communitys assistance in funding new policy implementation may be of extreme importance. Also, since global warming is itself mostly a result of activities in the developing world, ideas such as debt swaps in return for policy implementation should not be ruled out.

One of the gravest dangers that global warming poses to the South Sahel region is to decrease the populations ability to produce or purchase adequate amounts and types of food to achieve and maintain a healthy diet. There are several fairly low cost policies which could be implemented to help alleviate this problem, while improving already low nutritional standards. First, the governments involved should enlarge the agricultural extension services to the rural regions of the South Sahel. Through these agencies, the states need to encourage the maintenance of food crops for local consumption as well as home gardens to improve both available calories and available nutrients no matter what the state of the international economy for cash crops is. At the same time, extension agents should educate local farmers about the depletive effects of cotton production on the soil, not in an effort to cut out cash cropping, but instead to ensure that cultivators do not turn their most productive lands away from food crops. Agricultural extension workers should train cultivators in methods of composting, interplanting, cropping of fallow lands with nitrogen fixing plants, and erosion reduction techniques to improve and maintain the fertility of the soil. Agriculture extension agents can also play a key role in introducing drought resistant varieties to the area. Reforestation efforts should be supported by the extension offices. Decreasing land cover opens up the land to greater degradation and loss of fertility, especially in times of drought when new growth is likely to be slow in covering and protecting the land. Reforestation can also directly decrease the work load of the population by providing replenishable fuel wood to the population.

Secondly, the local social centers, health and nutrition centers, and clinics should be enlarged and the staffs retrained. The staff of these health related centers should become more actively involved in educating families about nutrition and maintaining a healthy diet using locally grown foods. If possible it would be beneficial to expand both the health and agricultural sectors to a village level whereby each village had trained members who could both disseminate information to the public and receive new information and techniques from the government. One low cost alternative would be to train school teachers in health and agricultural techniques. School teachers are respected members of the community in the South Sahel, and many people are willing to listen to them. If they were trained well, they could act not only as teachers of children, but also leaders in new technology.

Improving food security may of itself decrease population growth, but without more inputs it is doubtful that the effects on population would come quickly enough to help avoid the worst problems of overpopulation. The governments of the South Sahel need to ensure that the population has access to contraceptive education as well as contraceptive methods. Health clinic staff should be trained to provide both at low cost. Men and women should be targeted for contraceptive education since both are of vital importance to decisions of fertility.

Efforts should be made to improve educational and economic opportunities for women also since such opportunities have the effect of lowering fertility. One way that this could be done would be to insist that development agencies provide equal opportunities to small business projects to both men and women. Often, development projects target men because they are at liberty to take on new projects, while projects that target women must take children and family responsibilities into account. Education for girls can be encouraged by lowering school fees and by educating the public, perhaps through school teachers, as to the advantages of educated women in terms of improved nutrition and health for the whole family and improved earning potentials.

The increase in the infectious disease burden that will be borne by the people of the South Sahel due to global warming can also be mitigated to some extent. Again, education can play an economical and important role. The local clinics and health centers, if properly staffed and trained can provide education and services to the populations to avoid and treat malaria and other infectious diseases. Techniques to decrease the number of dengue fever and malaria carrying mosquitoes should also be disseminated through the clinics and village health centers. The use of bed nets should be encouraged, especially for children, to prevent infection at night, and if possible should be provided at low cost.

The people of the South Sahel must react to the threat of global warming. They cannot do this however without the support of their governments through the provision of training, salary for staff, and supplying of local outreach offices. By implementing these policies now, the governments involved can mitigate the potential negative effects of global warming. At the same time, they can alleviate some of the problems already at play in the region. If governments do not take action until they know the exact extent and form of damage due to global warming, the result will necessitate greater input to reverse the negative trends and not alleviate many of the problems of climate change.

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CHAPTER FIVE

ANDREA I. FRANK

POPULATION DYNAMICS AND URBAN GROWTH PATTERN

Cities are nodes of mans greatest impact on nature, the places where he has most altered the essential resources of land, air, organisms, and water. The city is the quintessence of mans capacity to inaugurate and control changes in his habitat. Through urbanization man has created new ecosystems within which the interaction of man, his works, and nature are complex. This complexity - and the importance of our understanding it - grows as cities burgeon in the modern world.

--Marcus and Detwyler

Introduction

The Urban Age

In view of societal evolution urbanism is a very recent development. Considering that in 1800 only a meager 3% of the worlds population lived in cities over 100,000 (Detwyler & Marcus, 1972) - the twentieth century may well be called the urban age. In 1969 Davis speculated that in 1990 more than half of the globe's population would be living in cities of 100,000 or more (Cities, 1969). This prediction was remarkably good. According to World Resources Data Base (WRD), as of 1995, 45.2% of the worlds population is living in urban centers. The portion of urban population in South America (78%), Europe (75%), North and Central America (74%) and Oceania (71%) and the former USSR (68.1%) lies well above this mark; whereas Africa and Asia still show percentages under 40%. Within each continent we find a wide range of urbanization for individual countries.

It can be generalized that countries with a currently low percentage of urban population experience the highest annual change rates. Urbanization is therefore more significant in those countries than in countries with an already high percentage of urban dwellers. For example, Canada, the United Kingdom, Australia, the US or Sweden had a percentage of urban population of more than 70% in 1965. This figure did increase only marginally over the past 30 years. Countries with less than 30% urban population in 1965 experienced dramatic changes (Table 1).

Urban Population as a Percentage of Total

Country	1965	1995	%Increase
United Kingdom	87.1	89.5	2.4
Australia	83.0	85.2	3.2
New Zealand	78.9	84.3	5.4
Sweden	77.1	84.7	7.6
Canada	72.9	78.1	5.2
Turkey	34.1	68.8	34.7
South Korea	32.4	77.6	45.2
Honduras	25.7	47.7	22.0
Kenya	8.6	27.7	19.1
Botswana	3.9	30.9	27.0

Table 1- Country Comparison of Urbanization Rate

With the earth's growing population the continuation of the urbanization trend and of urban growth is more than likely to persist. Urban form and development vary a great deal. In view of the complexity of the system and the multitude of interacting variables it seems presumptuous to think that urban dynamics and growth can be controlled and governed. It is however assumed that certain measures and policies could help influence changes toward a more favorable and "harmonious" development and shape of urban centers. With most of our earth's population living in urban areas, the creation of a livable and environmentally sensitive urban habitat is not only a moral but a survival need. Increasing the understanding of the urban-population-environment dynamics might be a first step towards addressing this demand. An improved insight in those dynamics then might help to devise policy to manage urban development in a fashion that sustains the environment, preserves valuable natural resources and biodiversity and mitigates negative effects.

Urbanization: Factors and Problems

The reasons for urbanization are manifold. One reason for the increase of the urban population is total population growth. The rise of mercantilism drove the urbanization in 16th century Europe (Hartshorn, 1992). More recently, urban growth stems from the shift of labor force from agriculture to industry and service sectors; the latter two are generally located in cities or urbanized areas, thus serving as attractors for human migration and agglomeration. Other motivations to move from rural to urban settings are job opportunities and education. The benefit of the city versus the country can be summarized as the maximization of stimulation, exchange and opportunity with a minimization of travel time (Register in Aberley, 1994). This is certainly one view. During the early stages of European urban history the city represented freedom. Still, city life today is associated with a sort of independent and anonymous living.

The human-imposed order within the city boundaries suggests security and safety from untamed nature or enemy forces. Modern man's fear is derived from dangers within the city. In many cases the aspect of safety and order of the urban center has lost its validity. The inner city often is perceived as unsafe and dangerous. Other benefits, such as minimization of travel time, are often offset by the increasing physical size of the urban area. In a spread out multi-million person city that covers several hundred square miles it can take considerable time to get from one destination to another. Automobile travel is slowed down due to speed limit and traffic density. With no efficient public transit system in place it might take longer to cover the same distance than if one had to commute a similar distance between rural villages.

Continued (rapid) urbanization generally poses a number of problems. Housing and infrastructure has to be provided for an increasing number of city dwellers. This requires planning and the resolution of land use conflicts. If the influx of new urban residents exceeds the city planners capabilities to plan lots and streets for new neighborhoods it often results in poorly planned and uncoordinated growth development. In so-called lesser developed countries (LDCs) with high population growth rates, migrants with little and no economic resources often settle illegally on vacant areas in, or adjacent to, large cities creating pouvre barrios or squatter communities.

If the city does not meet the expectations for opportunities, jobs and wealth, dissatisfaction can lead to criminal or aggressive activities. Stimulation, while good and needed for human development also has a flip-side. Life in a dense and crowded environment also can pose enormous stress upon the city dweller, possibly leading to various health and behavioral disorders such as depression, illness or aggression.

Cities use large amounts of energy, for industries and to heat and light thousands of homes. The energy is often created by burning fossil fuels, which leads to air pollution. Pollution of the air and water, human and industrial wastes causes negative environmental degradation and imposes on the quality of life and well being of urban residents. Managing growth in order to mitigate environmental degradation will be of utmost importance to ensure a livable urban setting for the future (Hartshorn, 1992).

In summary, problems of urbanization are especially pertinent and difficult to address in rapidly changing cities of the third World (Cadman & Payne, 1990). These periods of rapid urbanization or de-urbanization can be regarded as periods of transition. Transitions are times of vulnerability; in the case of urbanization they are a threat to the integrity and vitality of a city (Drake, 1992). Rapid urbanization is potentially unhealthy and equally harmful to urban residents, the functioning of the city and the natural environment.

A Morphological Approach to Population Dynamics, Urban Growth and Urban Form

Development of Urban form

Many studies of urban growth development and form in the past have taken a historical or a functional perspective. The historical perspective reveals a cycle of growth and decline, formation and restructuring of the city (Cadman & Payne, 1990). Towns and villages have been categorized according to physical growth pattern into cluster and linear band types or hierarchies of rank-size (Hartshorn, 1992; Christaller et. al.). The functional approach perceives cities as an organizing center, serving typically a predominant function such as banking, administration, or services. We distinguish trade, military, industrial or company towns and many more. Geographers also have categorized cities in terms of their spatial location as coastal or river cities and so forth (Hartshorn, 1992). While each of these different perspectives is interesting and valid, they fail to address the system dynamics of urban development in a more comprehensive manner.

Systems approach and Transition Theory

Marcus & Detwyler et. al. (1972, 1992) suggest viewing the urban agglomeration as a dynamic system or even as an ecosystem. Systems are not static, but generally evolve over time. At times, however, systems change rapidly due to a changing systems component (i.e. population). In terms of urban form other systems components that trigger change are transportation modes and technology amongst others. From a systems perspective of view, periods of change can be viewed as temporarily bounded or transitional (Drake, 1993). Periods of rapid change will be followed by periods of relative stability. Transition theory assumes interdependence and relationship between transitions of different sectors such as agriculture, education, etc. This means the amplitude and time frame of one transition, i.e. urbanization is likely to be influenced by others, such as education. Implications for society may be enhanced or reduced, if the timing of transitions can be influenced by policy.

Urbanization Transition and Urban Shape

This study proposes to look at urbanization from a spatial point of view investigating the linkage of population growth, urbanization and urban shape. It will explore population changes in time and the corresponding spatial changes of urban form. The investigation is based on the premise that urban form is the physical manifestation of urbanization. Urban growth is a result of population growth, rural-urban migration and urban expansion. The author believes that the rate and time of change in those dynamics and the accompanying fringe conditions (landscape, technologies, climate etc.) will determine the urban shape (Figure 1). In a generalized way, these factors can be attributed to either the natural environment or the human society. Although the determinants for urban form of human origin, such as technology, transportation systems and culture may dominate, topography and land form are especially influential in early spatial patterns (Detwyler & Marcus, 1972).

Figure 1 - Influences on Urban form

Towards a morphology of urban form

The dynamics of urban-population-environment systems are complex. Transition theory at the global level and at the local level will be used to investigate urbanization trends. In conjunction to the urbanization data a number of factors that may influence urbanization, such as industrialization, transportation technology etc. will be explored. These factors are identified and linked to physical development pattern. It is assumed that different values of factor sets will result in different physical growth pattern. Furthermore, it is assumed that the timing of transitions in other sectors will influence the growth pattern of urban agglomerations as well. An attempt is made to develop a morphology of urbanization stages based on change and behavioral similarities at a national level. The categorization of urbanization stages will become a framework from which a morphology of urban development pattern at the local level can be devised. This local morphology probably will be correlated to behavioral pattern (i.e. traffic) and pattern in the environment (i.e. topography) if appropriate [Adams, ref. comment]. The author hopes that a general survey of structure and form of urban development could be helpful to derive a typology or classification of certain trends. In the long run, a morphological study may help to indicate development pattern that are preferable in respect to newly developed environmental value systems.

In morphological terms a range of different classes of cities is imagined. A morphology could contain simple size distinction (small, medium, large) as well as functional-structural categories (old, new, dense, dispersed, high-tech, low-tech, etc.). In terms of development, transition theory will help to envision likely future development depending on the initial conditions of an urban system. Since technology and industrialization are thought of being major shape factors of urban growth this study starts developing an initial morphology of urban form with respect to the changes in transportation modes and urbanization. In particular individual motorized transportation is investigated for its impact on urban form. When linking urban growth and transportation technology the following scenarios for urban shape development can be constructed. A possible test for these morphologies, would be a study of urban shapes comparing urbanization and development pattern.

Three initial morphologies for urban shape and change of transportation modes were developed:

1) Introduction of individual automobile transit prior to major urban growth >

- increase in urban area
- decrease in density
- low overall urban density (except may be historic core)
- transportation arterial location greatly influence urban form
- depending on the size, satellite-like subcenters might form.

The new urban growth is build for the automobile.

2) Introduction of individual automobile transits during the urban growth period >

- a chaotic state (planners are caught in the dilemma between accommodating people or cars)
- dense traffic
- major pollution
- urban area, that is structure in an ad hoc fashion probably with decreasing density
- opportunities and dangers depending on economic situation and policy decisions

3) Introduction of individual automobile transit post urban growth period

- major redesign of the city structure (retrofitting the city for the car)
- relative high density
- traffic congestion
- pollution and noise (if not mitigated by policy)
- can potentially degrade quality of the city structure

Note: It is very likely that the effect of the transportation technology transition varies depending on the size of the city or town. A

small town will be less affected by it than a large town. This is a matter of geometry and existing density. For these examples growth is assumed
unrestricted by landscape, political borders, or policies. Doxiadis organic growth model also predicts distortions along transportation routes at advanced stages of urban development (1968).

Figure 2 - Morphologies

Urbanization Analysis

The study uses various analysis techniques to explore the feasibility of linking urban transition and urban form to a shape development morphology. It looks at many different aspects of the problem, trying to understand it without however being exhaustive or comprehensive. Hopefully, some different views regarding urbanization can be presented.

Methodological Approach and Data

The methodological approach in this study is twofold. Global and local level data will be investigated. This is to emphasize the scale dependence of the issue.

First, a general investigation of urbanization at the global level is conducted. This is to establish a general notion of the linkage between population growth and urbanization While there is a global urbanization trend, we probably can observe the urbanization transition at different stages, its beginning, in full force or at its conclusion for different countries. The global urbanization trends are investigated looking at time series data from the World Resource Data for 42 Countries. Urban, rural and total population development are explored and displayed. Urbanization factors that are viewed as influencing urbanization and urban form will be investigated in relation to the urbanization transition in the hope to discover correlation and linkages. One of those factors is the level of technology available in the country.

Secondly, local level data will be investigated in respect to urban development and urban shape. The urban development of 5 major US cities over the past four decades serves as starting point for this investigation. Then, a more in-depth study of urban shape is conducted comparing Boston, MA and El Paso, TX. The study is based on US census data. An attempt was made to link the results of the investigation to urbanization factors that were thought to be shape-determinants.

Urbanization at the Global Level

National Comparison of Urbanization Levels

On the basis of availability of desired data, a total of 42 countries were selected from the WRD (see Table 2). Initially urbanization information was mapped on a world projection using ATLAS GIS for Windows. Two other factors were mapped in succeeding maps; the I_index and a correlation of the urbanization and I_index. The I_index was calculated to provide some sort of measure for industrial productivity by dividing Gross domestic Product (GDP) industrial share (%) by the workforce in the industrial sector (%). The index is adjusted through multiplication by total number of workforce and division by total GDP. Supposedly this index will give a indication of the extent of industrialization. With at high output of the industrial sector shown by a relative large share of the total GDP achieved by a small share of the workforce should result in a large index. It is assumed that when few people achieve a large proportion of GDP it is a result of automation and high technology. This would indicate a high level of technology.

Map 1 presents a general overview. It displays the 42 selected countries according to the proportion of people living in cities. The distribution for the four ranges was customized for the purpose of this display. The 8 countries at the top of the list in terms of percentage of their total population living in cities are in descending order: Singapore, Belgium, Venezuela, Uruguay, United Kingdom, Netherlands, Denmark and Australia. In terms of land area, except for Australia, these countries are fairly small, suggesting that there might be a correlation of land area and degree of urbanization. Australia then would be an outlier, since despite large areas of land most people live in cities. On the other hand, Australia might be right in the ball-park, when using hospitable area instead of total land area. Due to the limited data used for this study, however, the author opted not to pursue any further investigations in this direction.

The display of the urbanization transition for the 42 countries reveals three distinct pattern. Urban, rural and total population development is plotted over time (see Figures 3a, 3b, 3c).

Pattern A

This pattern shows a declining rural population and an increasing urban population. Around 1990 to 2000 the total population growth seems to level or decline. Pattern A countries are reaching or have reached the end of a fairly typical urbanization transition. The urban population percentage stabilizes at a fairly high level of 70% of the total population or higher. Over the transition period the rural population dropped to a fairly low overall level. These countries typically have a high I_Index (Figure 3a).

Pattern B

Pattern B countries are at the beginning or in the midst of their urbanization transition. A high growth rate for the urban population is accompanied by a (soon) declining rural population. The total population growth rate is quite high (3%++). The end of the transition in this pattern is projected beyond the year 2010 or later (all data and projections WRD). These countries typically have a low I_Index (Figures 3b).

Pattern C

Pattern C countries have a very low stable rural population. The urban population is however growing in linear fashion. There seems to be no leveling or change in that trend for the next two to three decades (WRD prediction). All population increase seems to occur in the cities. The countries with this urbanization pattern are Australia, Canada and the USA, three major immigration countries (Figures 3c). This suggests that a large proportion of the urban growth is due to inmigrating foreigners.

Figure 3a - Pattern A

Figure 3b - Pattern B

Figure 3c - Pattern C

Urbanization and Technology

Technology and industrialization seemed to be major factors that drove urbanization in the past (Hartshorn, 1992). These factors had a great influence in changing land use pattern (Sinclair, 1967). A further investigation of the link of urbanization to industrial production/technology appears promising

Map 2 displays the calculated I_Index (Industrial GDP/workforce industrial share). The high ranking countries are what is often designated as the Industrial Nations. The order is somewhat surprising with Norway at the top and the US ranked sixth. The listing might appear skewed since strong industrial nations such as Switzerland and Germany could not be included due to the lack of comparable data.

Map 3 shows the correlation between the I_index and the percent urbanization for each country. The findings are interesting. There is a group of three countries Norway, Finland and Japan with a correlation factor of 1.5 or less, meaning that the percentage of urban population and the numerical value of the I_index are almost the same. A high correlation factor indicates a discrepancy of nominator and denominator. This means that despite a low level of technology and industrialization there is a high percentage of people living in urban areas. This means that urbanization preceded industrial development and must have been triggered by different factors. It also means that urbanization will occur under different premises than in the countries with a low correlation factor. Countries with a high factor are in descending order Pakistan, Sri Lanka, Honduras, Philippines, Romania, Egypt, Panama, El Salvador, Costa Rica, Turkey, et. al. Most of those countries are at the beginning of their urbanization transition (Figures 3a-c, 4a, 4b, 5a, 5b).

A complete list of countries with their ranking of urban population,

I_index etc. is shown below.

Rank #	Country	Urban Popin %	I_Index %	Urban/I_Index
1	Norway	77.002525	64.9283	1.1861141
2	Japan	77.943899	55.4794	1.4051541
3	Canada	78.137155	51.4949	1.517521
4	Belgium	96.650384	47.3575	2.0411908
5	Finland	60.285375	46.0019	1.3105516
6	United States	76.237184	45.9387	1.6598559
7	Sweden	84.737262	45.6385	1.8570515
8	France	72.788174	45.0832	1.6146445
9	Netherlands	88.915414	44.6254	1.9927255
10	Denmark	85.477658	41.7588	2.0473691
11	Italy	70.540494	40.9309	1.7247065
12	Austria	60.628419	38.8964	1.5589719
13	Australia	85.167412	37.2962	2.2839209
14	United Kingdom	89.461725	34.704	2.5781477
15	Spain	80.652307	27.9247	2.8886929
16	New Zealand	84.290541	27.6005	3.0190022
17	Singapore	100	19.9111	5.0226017
18	Mexico	75.298388	18.8261	3.9996807
19	Venezuela	92.87809	16.3011	5.6980423
20	Uruguay	90.301318	13.6092	6.6398028
21	Trinidad&Tobago	66.50038	13.3537	4.9880179

22	Greece	65.034624	12.9655	5.0181037
23	Korea, Rep	77.628259	12.3138	6.3061137
24	Guatemala	41.465022	11.3321	3.6597548
25	Ecuador	60.615801	11.316	5.3594873
26	Colombia	72.721575	10.9699	6.6351802
27	Ireland	58.402998	10.6801	5.4684455
28	Portugal	36.361797	9.92898	3.6655037
29	Paraguay	50.684652	7.95855	6.3754279
30	Poland	63.868236	7.62871	8.3816583
31	Jamaica	55.359246	6.92128	7.9998911
32	Turkey	68.767733	6.86745	10.024451
33	Panama	54.870252	5.02267	10.930329
34	Costa Rica	49.707944	4.94479	10.144478
35	Romania	56.183791	4.44702	12.625571
36	El Salvador	46.67129	4.41119	10.583059
37	Egypt	44.763239	3.81796	11.748882
38	Indonesia	32.529271	3.63699	8.936613
39	Philippines	45.677693	3.61282	12.653101
40	Honduras	47.654155	3.47418	13.733186
41	Pakistan	34.692607	1.80723	19.273671
42	Sri Lanka	22.3809	1.58441	14.165127

Table 2: Industrial GDP/Industrial workforce Index

Different Urbanization Catalysts

As a consequence of the map evaluations, the countries with the extreme values of the urban - I_index correlation appear to be interesting in terms of transitions. The charts below show the urbanization transition for Norway, Finland (%Urban/I_Index factor of 1.18 and 1.31) and Pakistan, Turkey (%Urban/I_index 19.27 and 10.02). The most remarkable difference between the two pairs seems to be that the energy consumption seemed to raise parallel to the urbanization in Norway and Finland. Both countries show a similarly high per person consumption of energy of about .2 Terajoules in 1991. For Pakistan and Turkey the per person energy consumption in 1990 is about 1/10 of the energy consumption observed in the two industrialized nations. Turkeys urbanization level (68%) is higher than Finland's (60%). The climatic differences may account only for some of the difference.

It is assumed that this difference in energy consumption will lead to a dramatically different urban shape. Since data for city density, population and shape is difficult to obtain in the short period of time available for this project the impact of technology, i.e. the availability of the automobile (expressed also through an increased energy consumption per person) will be investigated in a modified way; at the local level (for US cities).

Figure 4 a - Urbanization and Energy Consumption Trend in Norway

Figure 4 b - Urbanization and Energy Consumption Trend in Finland

Figure 5 a - Low Energy Urbanization in Turkey

Figure 5 b - Low Energy Urbanization in Pakistan

Local Urbanization

The urbanization at the local level is examined for five US cities using census data. The urbanization development of three cities with a population of about 1/2 million in 1990 was traced, as well as that of two multi-million person cities. As assumed earlier, despite an increase of urban population at the national level, some cities decline (Figure 6). Some of the cities that had major growth before the advent of individual traffic and others grew in the automobile area. Density seems to be one factor that impacts urban form. In comparing the growth rate - density correlation of 5 major cities we find a strong correlation of rapid growth and high spread. However there are many more factors and additional research is needed.

Figure 6a - Urban population development

Figure 6b - Urban population development

Figure 7 - Population Density Development

The generalized data however may be misleading. Therefore a comparison of spatial density distribution was conducted for two of the five cities investigated.

City Shape: Boston, MA versus El Paso, TX

The theory, just to recap, is that the time when the urbanization transition occurs will have a significant impact on the urban shape that is formed. It is in fact the context or conditions under which urbanization occurs that will impact the form. Technology is viewed as one of the important shape factors.

With Boston, MA and El Paso, TX we have two cities that have approximately the same size by population; with Boston having a population of 551675 in 1992 and El Paso having 543813. Both cities are constrained on how freely they can grow in some sense, with Boston having the Atlantic Ocean restricting growth to the south and east and El Paso having the Mexican border. In these terms the two cities are comparable. However, Bostons growth rate over the past 40 years was moderate or even declining, while El Paso went through a major post World War II growth spur. In 1940 El Paso had a population of about 100,000 (D'Antonio & Form, 1965). Boston's population exceeded 100,000 between 1840 and 1850 (Kennedy, 1992)1. The existing urban shape of the two cities is very different.

The diagrams below map the shape components of population density and spatial distribution for Boston and El Paso. They were created using 1990 US census data for the city proper boundaries. At the block group level, population data, area, longitude and latitude for the centroids of each block were collected by extracting the appropriate files in electronic form and saved as text files. At this level 100% population count data is available. Block groups have an absolute population count between 700 and 2000 persons. The granularity of this data level ensures enough data points to get fairly accurate results for a density mapping. 700 + data points (blocks) were identified for Boston and 600 + for El Paso. However the variation of population within each block was felt to be too large to merely map the population. Thus, the delimited text files were read into a spreadsheet program (EXCEL) and reformatted for import in a statistics package (SYSTAT). Within the statistics package a number of computations were performed to calculate the population density per square mile within each block.

A simple no-frills 2 dimensional plot was chosen to display the data spatially. The latitude variable was chosen for the y-Axis and the longitude variable was plotted on the x-Axis. The level of density is distinguished by color (Figures 8a,b) and size (Figures 9a,b) of the symbol plotted on the centroid of the each block within the citys jurisdiction. For representation purposes it was necessary to multiply the population density per square mile with a factor of 1/1000 to ensure the variable was in a suitable range. The data for both cities was forced onto the same scale in order to make the graphs more easily comparable.

Although the plot where density symbols are sized by value evokes a more shape like image this might be deceptive. This is not the real city shape. The density is so high that the symbols overlap or touch each other creating a black seemingly solid city. The colored plot may be more honest however it is somewhat hard to translate it into a meaningful interpretation.

The Boston shape plot below shows a very dense, and compact city shape with a high population density. Most dense areas are located in the older parts of town. Some less dense areas are found in southern parts of the town where the city extends into more rolling land.

In contrast, El Pasos population density on average is 1/5 or less. The urbanized area is spread out along the major arterials. There are some areas of higher density, curiously enough one at the eastern fringe of the city.

Figure 8a - City of Boston Shape in 1990 (Density by Color)

Figure 8b - City of Boston Shape in 1990 (Density by size of symbol)

Figure 9a - City of El Paso Shape in 1990 (Density by color)

Figure 9b - City of El Paso Shape in 1990 (Density by size of symbol)

Conclusions

This paper is but one little puzzle piece in gaining insight into the urban-population-environment dynamics and especially the linkage of urban development and shape. Despite the rudimentary results, some thoughts on policy implications are presented. Many more issues became obvious for future research.

Discussion of Results

While globally there is a definitive trend towards urbanization, the urbanization transition is already concluded in some of the countries investigated, such as Japan, Denmark, the UK. Other countries are at the beginning or in the middle of the urbanization transition, such as Pakistan, Indonesia, and many more. The further course of the urbanization transition in these countries in terms of amplitude and speed will depend on the course of their demographic transition. The sooner overall population growth can be slowed the sooner the urbanization transition will level. It is likely that the urbanization transition will lag behind the demographic transition for a few decades while rural to urban migration persists. A general time frame for this lag could be derived from looking at industrialized nations which have gone through both transitions successfully (Japan, Denmark, Norway).

At least three countries could be identified that go through a somewhat distorted transition, which are Australia, Canada and the US. These are major immigration countries. Urban population increases in a linear fashion, while the rural population remained constant for the past 45 years. Besides rural to urban migration of younger members of the population, most immigrants seem thus to move to cities. Ports of entry and coastal cities are likely to grow more than cities in the interior of a country, since these are the places where immigrants naturally arrive and mostly settle.

Depending on the specific characteristics of a country it can be assumed that between 80% and 90% of a country's total population will live in cities and urbanized areas. Some places with stringent land constraints will reach virtually 100% urbanization such as Singapore and Hongkong. Country specific characteristics influencing how high exactly the percentage of future urban population will be could possibly be derived from a conglomerate of factors such as landscape, level of technology, historical patterns of settlement, culture, available land area, total population density, policy and others. The author can only speculate at this point about the importance of each of those factors, but future research might be able to show patterns of development and correlation, particularly between land area, density and the total urbanization quota.

In comparing the urbanization of industrialized nations with those of lesser developed countries it becomes quickly obvious that the urbanization happens under different conditions. The study looked at just one factor, which was energy consumption. In Turkey for example, the overall urbanization is at a higher level than in Finland - however with only a 1/10 of the energy consumption/per person. Urbanization in Turkey is based not necessarily on industrialization and improved technology (Turkey's relative low I_index also points to that direction). Urban shapes and urban living thus will look different in those countries. As Sinclair (1967) pointed out J. von Thunens land use model does not apply any more for the US or other industrialized nations but may be still valid for lesser developed countries. With urban expansion due to rapid urbanization it will be interesting to see, if new and what values will govern the development. Comparative investigations of city shapes and form in countries with high respectively low energy consumption could be an interesting future research topic.

In terms of all transitions the issue of scale is important. While in general, the urban population in the US is increasing, locally decline is also observable as can be seen for the development of Chicago and Boston. Since both cities are nuclei of larger metropolitan areas the decline of center areas also could be viewed as a decentralization and dissemination trend. While studies in the past were successful in providing empirical data on the "flattening density function" and post World War II suburbanisation (Mills, 1969; Newling 1966), the causes for the trend are not agreed upon.

The local level research conducted for US cities and the shape investigation for Boston and El Paso in particular suggest that it matters when and under what conditions urbanization and urban growth occurs. The much older city of Boston experienced major growth and land expansion in the past century. Due to the relative limited and slow modes of transportation at the time, Boston's density is high, even today. In comparison, El Paso's major growth spur occurred post World War II where a change in technology brings about cost efficient personal transportation. At a comparable population size in 1990 (ca. 500,000) urban densities of El Paso are about 1/5 of Boston's densities. Figures 8 and 9 show the differences clearly. Doxiadis organic urban growth model (1968) anticipates a distortion of urban growth away from a compact form along radially outbranching transportation arterials, however not to the extent observed for El Paso.

The shape development analysis conducted for this study has several backdrops. While for El Paso the city limits and the urbanized area are fairly congruent, it is not for Boston. The area of Boston proper did not expand since 1912 (Kennedy, 1990). So, in order to examine the shape of urban growth development it probably would be better to look at the shape of the metropolitan urbanized area rather than city limits. Data availability is a problem, since census tracts and jurisdictional boundaries do not necessarily reflect urbanized land and its boundaries. Remote sensing and satellite imagery might overcome this problem, however since this data has been only recently released to the public time series over decades are a problem.

Policy Recommendations

There are two types of policy recommendations: Country and Local Level. The suggested policies are very general at this point. They aim at improving the quality of urban agglomerations. This is defined very roughly as lowering the negative impact on the environment and decreasing the energy/resource exchange flows between the urban ecosystem and the surrounding ecosystems, mainly by looking at shape and density of the city. The recommendations are based on the broad (and maybe at times invalid) assumption that a denser and more compact city is likely to be more sustainable (Dantzig & Saaty, 1973)

Country Level Recommendations

It seems sensible to categorize the policy recommendations according to the stage of urbanization a country or nation is at (Pattern A, B, C)

Pattern A (Concluding Urbanization Transition)

=> Stabilize status quo (you do not want to have cities disintegrate after booms, marching right into the next transition)

Improve efficiency of urban city (lower emission, water use, public transit)

Mitigate environmental effects in surrounding areas

prepare for downsizing of the city or industry

consolidate metropolitan areas and provide for coordinated strategies

(jurisdictional problems)

Pattern B (Starting Urbanization Transition)

=> slow urbanization down, or at least try to influence development

Improve opportunities in the country side

make vision plans (although there seems to be no time)

provide public transit

promote density and neighborhood clustering, decentralized

avoid depletion of environment

Pattern C (Immigrant Countries)

=> try to influence urban development

provide public transit

promote density and neighborhood clustering, decentralized

avoid depletion of environment

Local Level Recommendations

Local recommendations must be much more specific to the individual situation of the city.

Future Research

Much more work in terms of developing urban shape morphologies has to be done. The author envisions that harmonious correlation can exist between urban form and environmental features. These harmonious correlation will be perceived as beautiful and particularly pleasant. It also could be characterized as being stable and sustainable. Or yet in other words, a preferable city shape is achieved by optimizing the urban metabolism2 for the surrounding landscape. During rapid changes of either the environment or population (characteristics) the harmony of this correlation will be disturbed. The author further expects to find different patterns and correlation at different scales. So the harmonious urban-environment pattern will be different for a population of 10,000 or 100,000.

A harmonious relationship between urban agglomeration and environment can be described as follows:

the urban form complements or assimilates the landscape, i.e. in color, form, character and scale3.

the size of the city and its energy and resource demands do not cause drastic changes in the landscape.

Beauty, harmony and pleasantness are difficult values to measure. It is may be possible to find indicators such as crime rate, rating of quality of live, migration rate, traffic congestion to evaluate the level of compatibility of the urban system at its current stage with its surrounding environment. For the environment measures of biodiversity, decline or increase of renewable resources, fertility of the land, need to fertilization in agriculture etc. Since both factors are interrelated a depletion of the natural resources in the vicinity of an urban agglomeration may as well further decrease the quality of life in a city.

As described earlier, urban form can be conceived as a result of the different factors such as culture, technology etc. (Figure 2). Cities in the mountainous countries like Austria or Nepal and Tibet will have a different shape than a city in a desert landscape. Growth pattern and urbanization pattern will be different as well. It is much easier to build a city in a valley on flat ground than on the slope of the hills. But flooding of rivers in this valley might be a threat and the valley ground must be kept free from development for agricultural usage. Diverse and rugged topography might favor many smaller town over one or two very large ones.

In contrast, the desert landscape might favor larger agglomerations along a river or at some other water source. It will be easier to distribute the water within a large city than build a pipeline to supply many smaller towns dispersed in the landscape.

Technology is an important modulator of urban form. However, it tends to exert an increase in energy consumption that might be counterproductive in developing sustainable cities.

NOTES

1. Boston and El Paso are different in age. The settlement of Boston began around 1630. Boston reached its peak in terms of spatial extend of city limits in 1912. The first permanent settlement on the present site of El Paso was in 1827. It was known by its present name by 1859 and formally chartered as town in 1873 (Kennedy, 1992; et. al).

2. Urban metabolism views the city as an organism, an open system, with inputs and outputs from and to the environment (H. Girardet in Cadman & Payne, 1990).

3. The conceptual idea of complementation of man-made world and nature is discussed in Norber-Schulz (1984). The structure of the natural place is complemented by either adaptation of the same structure in the man-made artifacts or contrasted; i.e. diverse landscape with multiple features is "harmoniously" complemented by a small scale architecture with lots of detailing like we find it in Norwegian wood carvings. The large scale desert landscape is complemented with geometrical simple artifacts, straight lines, square features, monumental. etc.

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CHAPTER SIX

AJAY GUPTA

CURRENT ECONOMIC TRANSITION IN INDIA AND IMPLICATIONS FOR OTHER TRANSITIONS

Introduction

Since winning independence from Great Britain in 1947, India has been thrust abruptly into the 20th century. Modern, industrial, medical and infrastructural techniques have been grafted onto a society still characterized by age old beliefs and class structures, without undertaking badly needed reforms and dealing with the issues of inequality in distribution of resources and incomes. These policy decisions have proved vital for the transitions India has been undergoing, one result of not undertaking badly needed reforms has been the limited adaptive capacity of Indian society to change. This has consequently influenced the trajectory India is taking through its key transition and exacerbated the pressures on Indian policy makers. Compared with other countries in Asia such as Korea and Malaysia, India has certainly not performed well in the sectors of alleviation of poverty, economic growth, per capita income. In this paper I will briefly address some vital transitions affecting India, how these created the need for change and consequently influenced Indias economic policy.

A family of transitions

The demographic is critically important to Indias long term stability. With a population of 900 million in 1994 India is currently the second most populous country in the world. As figure 1 below shows from 358 million in 1958, Indias population has increased dramatically to its present numbers.

Figure 1. Population Growth in India. Source: World Resources Database 1995

The population growth rate in India is currently 1. 9 percent and is not expected to decrease further at least until the turn of the century (World Resources, 1995). The reason for Indias rapid population expansion can be traced to the availability of modern foreign technology from the west. These technologies were developed in the west over several hundred years during which societal norms concerning the need for large families changed. As birth rates decreased, mortality rates due to technological improvements, also declined. In India, however, the sudden availability of these technologies resulted in death rates declining precipitously while birth rates remained constant resulting in a boom in the population.

Rapid population growth in India creates many pressures. In rural areas it calls for intensified agricultural production to feed the growing numbers of people, which raises the risk of environmental degradation. Due to the intensification of agriculture, fallow periods needed for soil to regenerate are overlooked and cropland loses fertility which in turn, creates pressure to convert forests into cropland. Demands upon forests for fuelwood and grazing increase in tandem with population pressures. As family sizes increase, agricultural plots get smaller and the need for credit to purchase inputs to intensify production methods, or avert hunger, increases. The availability of credit from banks is inversely related to the size of the plot, which drives poor farmers to usurious moneylenders. The resulting need to repay loans or to escape from being trapped in such a desperate situations is one of the reasons behind rural to urban migration.

Indias urban population currently comprises 26 percent of the countries population and is expected to keep increasing. Public health spending per capita is over 6 times higher in urban areas than in rural areas and urban dwellers manage to earn almost twice the amount of their rural counterparts (World Resources, 1995). Greater access to social services in urban areas acts as a magnet attracting people to cities. Most Indian cities consequently are ringed with slums and squatter settlements in which typically half of the cities population resides. The prevalence of diseases rises resulting in increased expenditures by the government which also has to provide industrial employment for urban dwellers. A large and growing middle class also creates a demand for consumer goods and also consumes more resources and energy. Urban dwellers also tend to be more aggressive and politically active than their rural counterparts and exert political pressure which cannot be ignored Therefore expectations on the government and demands on it have risen in tandem with increasing expenditures, driving the need for economic performance to alleviate these pressures.

Confronted by these combined problems Indias government tried to expand the countrys industrial base to provide employment, by building a monolithic public service sector and by intensifying agriculture. Indian policy makers tried to adopt the best characteristics of capitalism and socialism and developed a form of economy called the mixed economy. The key facet of this was protectionism. Foreign access to the Indian economy was restricted to 49% of equity holdings in Indian firms and even this was discouraged. The state took on responsibility for providing the basic needs of the people through a large public sector which handled 18 key sectors. The industrial infrastructure was comprised mostly of public sector companies which were, however, mismanaged, poorly run and consequently incurred huge losses, draining the exchequer.

Import substitution strategy in which trade and industrial incentives were biased in favor of production for the domestic market was emphasized. However, the inward looking focus on industrialization, and the excessive protection offered to industry by licensing and exorbitant import tariffs did not put any pressure on industry to reduce costs and increase efficiency. The result of this protectionism was that India could not produce key raw materials which had to be imported. Exports could not keep pace with imports and therefore therefore there was a gap in foreign exchange balances which was postponed by foreign borrowing and using remittances from Indians living abroad. Indian companies ended up relying more on costly capital than labor and industrial growth failed to generate much employment. The pattern of investment became highly elitist oriented, energy intensive, import guzzling and capital intensive.

Fiscal deficits created by pumping excess money into the markets comprised 11 percent of GDP in 199, 1limiting the governments ability to intervene effectively(Ghosh, 1994). The deficit created excess demand which couldnt be satisfied by domestic production and therefore increased demand for imports and created an inflationary environment. Inflation created an upward pressure on interest rates, raising the costs of production all around which eroded competitiveness of Indian goods abroad. Rising interest costs added to the governments debt burden and played a role in adding to the budgetary deficits. Along with the revenue and expenditure accounts. See Figure 2 below. The narrow base of the tax structure, lack of tax on agricultural income and extortionate taxes among the middle to upper class, encouraged evasion. The expenditure account was burdened by massive subsidies reaching 2.5 % of the GDP in 1991, public sector and defence spending, therefore the government had to resort to borrowing. The public debt to GDP ratio approaching 60% in 1991, limited the governments ability to spend on vital social sectors such as infrastructure, education and health(Minocha, 1994).

Figure 2. Central Government Deficit. Source: World Resources 1995

This structural malady reduced India to a minor player in the global economy. The controls on production, licensing restriction along with high protective walls fostered monopolistic trends within the industry. The lack of competition ensured there was no pressure for change and the technological revolution which spread from the industrial nations to other Asian neighbors passed India by. Indian companies produced inferior goods which could only be sold in the domestic market. Since India does not have major reserves of petroleum its reliance on imports of petroleum and other bulk products consumed by the industrial sector required large amounts of foreign exchange which ensured large trade deficits on a regular basis since Indian industries earned negligible amounts of exchange through exports.

All these factors increased Indias vulnerability to shocks, to finance these rising deficits India had to increasingly resort to costly foreign borrowings. This led to a huge foreign debt and the rise in debt service payments further weakened the balance of payments (Singh, 1994). This situation came to a head in 1991 when oil prices rose as a result of the gulf war and foreign exchange remittances from Indians in the gulf dried up. The foreign exchange reserves reached an all time low with the government in danger of defaulting on interest payments on foreign loans. To escape default the government took out an emergency loan of $2.2 billion from the IMF(Foreign Trade, 1995). Part of the of the conditions attached to the loan were to restructure the economy. The government used this opportunity to introduce a comprehensive package of measures aimed at reforming the inflationary and wasteful tendencies of the economy. A key point which needs to be made is that although the fiscal crisis of

1991 precipitated the shift in economic policies, these were long overdue. Pressures created by the other transitions were being felt much earlier and the government made a tentative attempt at economic reforms in 1984 which were subsequently abandoned. By 1991 pressures and indicators of crises from the other transitions could not be ignored any longer and provided impetus for change.

New Economic Policy (NEP)

The Government of India has begun implementing a comprehensive package of reforms aimed at correcting the distortions and weaknesses of the economy. The reforms fall broadly in to two categories: stabilization procedures and structural adjustment package. Stabilization procedures involved a sharp devaluation of the rupee to 50 percent of its previous value, drastic cuts in fiscal deficits of the government and huge borrowing from the IMF. The accompanying credit squeeze and rise in interest rates contained the inflation drastically from 17 percent in 1991 to about 6 percent in 1993 (Sinha, 1994).

The structural adjustment policies are wider ranging and are aimed at opening up the Indian economy to foreign competition and encouraging foreign investment. Structural adjustment measures attempt to unshackle industry from the myriad of administrative and legal controls which plague it. Restraints on growth such as industrial licensing have been removed for all new units and expansion of industrial units. Most public sector undertakings will soon be privatized and only six areas of strategic concern have been reserved for the public sector, such as mining, oil and gas exploration and exploitation, defence. Private and foreign participation is invited in some specific areas of these (Ministry of External Affairs, 1995).

India is seeking access to foreign capital and technology.With this end in mind, direct foreign investment of upto 100 percent is allowed and actively courted. Full repatriation of profits by private foreign investors who want to set up wholly owned power generation units in India is also feasible. An area, India is actively courting foreign investment in is the power sector. India needs to double its existing power generation capacity which would only be possible with foreign technology and help. Domestic industries have also been deregulated and delicensed and foreign capital and foreign equity participation is encouraged in Indian companies. According to Indias Finance minister the journey on the road to self reliance has begun. Self reliance in todays world means the ability to earn foreign exchange to pay for all imports(Singh, 1994). With this end in mind reforms in export and import policies have been undertaken and form the cornerstone of the new program. Integrating Indias economy with the world economy is expected to increase competition, flow of capital and technology to India and lead to more growth and increased employment. From a stage of believing, government regulations would ensure social justice, the current government has switched to a belief of market mechanisms ensuring growth and eventually poverty alleviation. The planning process and the public sector will take a back seat and market forces will be relied upon. Some key features of the new policy are discussed below.

Reliance on Foreign Capital and Debt

The impetus for adopting reforms was provided by the critically low state of foreign exchange reserves in 1991. An emergency loan of $2.2 billion was taken out from the IMF to tide over the crises. Today the exchange scenario is looking much better with reserves standing at around $27 billion, enough exchange to pay for eight months of exports.(Ministry of External Affairs, 1995). However, Indias net indebtedness has increased sharply by $18 billion. Adding to the existing indebtedness of $ 75 billion, shown in figure 3, Indias external debt is expected to rise to $93 billion making it the second largest debtor nation in the third world after Brazil, see figures 3 and 4, below. Indias public debt to GDP ratio is approaching 60 percent of GDP. Interest payments on servicing foreign debts currently make up 4.5 percent of GDP and over 50 percent of current expenditure, as cas be seen from figure 4 debt service expenditures are approximately equal to current borrowing, which is creating a short sighted, cycle of incurring more debt to service interest payments (Sinha, 1994). South Korea and Malaysia avoided the debt trap during the 80s even though their debt was much higher. They did this by a fast expansion of exports which reduced their debt service to exports ratio. On the other hand Brazil and Mexico got caught in the debt trap in the early 80s with debt to GDP ratios of about 31% because of slow growth of their exports.

Figure 3. External and Long Term Public Debt.

Figure 4. Debt Service Expenditures and Current Borrowing.

Source: World Resources Database 1995

India is trying to attract foreign capital for investment in industries and infrastructure. The NEP is promoting joint projects and equity participation in India and allowing upto 100% equity participation. It is particularly trying to attract investment in power generation and utilities. Foreign investors have poured more than $ 1 billion into the economy and an additional $ 5 billion into the stock market. The U.S. is the single largest investor with forty percent of the investments approved during the period 1991-1993 (Foreign Trade, 1995). The main areas of investment so far are in oil refining, power generation and consumer goods. Investment in India however, is still hampered by its continuing low credit rating. Standard and Poors, a leading U.S. credit rating agency recently decided to keep Indias long term credit rating at BB+ which is non investment grade (Prasad 1994). Despite this setback, foreign investment is expected to increase dramatically due to the incentives provided by the government such as automatic approval of projects, profit repatriation and convertibility of the rupee, use of foreign brand names. Indias decision to join GATT is also going to be a factor in this regard.

Export- Import :

India plans to achieve a high rate of growth and avoid the debt trap which has plagued countries like Mexico, through a policy of aggressively promoting exports and reducing its dependence on imports. India wants foreign companies to set up bases for global operations and generate exports. India has several characteristics conducive to this. It has a vast pool of skilled technical manpower and a developed industrial base. It has a history of entrepreneurship and a legal system which countries like China lack. Underscoring this, exports soared 20 percent in 1993 compared to 1992 however, imports have also increased by 23.9% and as in the past continue to outstrip exports, see figure 5 below.

Figure 5. Exports vs Imports

Exports are limping because of the higher rate of domestic inflation compared to other countries worldwide. This raises production costs which prices Indian goods out of foreign markets. The trade deficit has therefore continued to increase to 2.2 billion in the first four months of 92-93 as opposed to 770 million during the same period in 91-92 (Prasad, 1994). Most assumptions of India being able to repay its debt and interest payments have been made on the basis of assumptions of exports outstripping imports. This seems uncertain given the current worldwide recession in developed countries and the collapse of the Soviet Union which accounted for 16 percent of Indias export market (Sinha 1994). Korea and Malaysia avoided the debt trap in the early eighties by vigorous expansion of exports when the world economy was more open and booming. In the nineties this achievement may be harder to duplicate. According to the 1992 human development report of UNDP, 20 out of 24 industrial countries are more protective today than they were 10 years ago (UN, 1995). Although it is too early to tell, exports are expected to increase since profits from exports are exempt from taxes and foreign companies will be allowed to repatriate profits, India is specifically targeting intra firm trade i.e. companies obtaining components for products from different areas for its exports. This is where Indias large skilled manpower base and infrastructure and resource base will hopefully make a difference.

Government Expenditures and Revenues

The NEP intends to reduce government expenditure in the market and redirect it towards social and poverty alleviation programs. Sick public sector enterprises will be closed and phased out and foreign equity participation invited where ever possible. Public sector monopoly will be maintained in six key sectors, some with foreign assistance. The government intends to focus most of its expenditures on several key areas such as defence, poverty alleviation programs and creating employment. The NEP intends to cut all subsidies including those to agricultural and to rural industries. No action has however been taken to reduce the bloated administrative expenditure. The continuous increase in government expenditure particularly in budgetary subsidies together without reforming the tax system and continuing losses in the public sector have also contributed to the budgetary gap.

Tariffs have been rolled back from nearly 300 percent to peak rates of 50 percent with most duty rates unified at 25 percent (India Budget Statement, 1995-96) with further reductions planned. The complex and inefficient tax structure which is a cause for concern has been reworked to reduce customs and excise taxes and corporate taxes and personal tax exemption limits have been increased. However, it is still far to narrow with the bulk of the governments revenue coming from excise taxes and taxes on interstate commerce. Agricultural income and rural industries are not taxed which excludes 70 % of the population from the tax net. Although the number of Indians paying taxes is low, for those who do pay taxes, rates are high, therefore evasion is rampant. The government is attempting to widen its tax base and has proposed establishing a tax on agricultural income. Due to political opposition this has not been implemented therefore, the governments revenue gathering abilities are severely limited.

Fiscal Imbalances, Inflation and growth

The NEP succeeded in bringing the rate of inflation down from 17 percent in 1991 to about 6 percent in 93. The fiscal deficit has been brought down from 11 percent of GDP in 1991-92 to 5 percent in 92-93. Economic growth has been a modest if unspectacular 5 percent and the stock market is trading near its all time high (Sinha, 1994 and Foreign Trade, 1995). However, with the population also growing at 2% per annum India has to aim at a higher rate of growth to record a improvement in the standard of living of its people. According to the eighth five year plan, the number of persons requiring employment would be 58 million during 92-93 and 94 million during the 10 year period 92-2002. These comprise a 23 million backlog of unemployment in 92, an estimated increase of 35 million in the labor force during 92-97 and by another 36 million during 97-2002. The adjustment measures will also add an estimated 11 million to the list of the unemployed. These figures imply the real growth in employment generation should be about 4.5 percent per annum if full employment is to be reached by the end of the eighth plan and 3.5 percent if it is to be attained by the end of the ninth plan (Sinha, 1994).

There are criticisms that the reductions in deficit have been brought about by the soft option of reducing capital expenditure and postponing settlement of dues to domestic creditors. The adverse effects of this, on investment, growth rate and employment generation are a bomb in waiting The governments plans to close large public sector firms will also create a large amount of unemployment. The government hopes that these will be absorbed by new enterprises which will also provide full employment. However, if production trends continue as in the past most of the new enterprises and projects will tend to be capital intensive due to the availability of large amounts of foreign technology, foreign is geared toward employing as little labor as possible.

Implications for other transitions

Demographic Transition

There are vast demographic differences among Indias various regions. The transition from high to low fertility is nearly complete in some states, notably Kerala and Tamil Nadu in the south, with average fertility rates of two children. Indias demographic vulnerability is concentrated in a few states in the north, most notably Bihar and Uttar Pradesh which have fertility rates as high as eight children per woman. The impetus for population growth can be traced to the inequalities which characterize Indian society. People are not poor because they have large families, they tend to have large families because they are poor since in this case wealth flows from child to parent. Large families are in the economic interests of poor parents, in a situation like this having more children is a sensible and rational thing to do. Countries such as Sri Lanka and even Kerala a state in India, which have carried out land reform, reduced inequalities and made efforts to improve the welfare of rural masses have tended to be successful at reducing fertility rates (Murdoch, 1988). Landlessness is high in India, with percentages of agricultural landless households estimated to be 15 percent. Even more important is the proportion of smallholder households, whose landholdings are too small to provide a sustainable livelihood, with the percentage being about 40 percent (U.N., 1995). Therefore a necessary step in order to slow the impetus for population growth is to undertake social and economic reforms to raise the status of the poor and their standard of living.

Indias NEP which will most likely, widen inequality and income gaps. The economic reforms could also result in higher prices of necessities which will be market determined, instead of controlled by the authorities, which will place an additional burden on the poor. The lack of emphasis on rural planning and paucity of funds to do so will make it harder to arrest the population growth rate, corresponding benefits in employment and income generation, GDP growth rate may be offset to an extent by the increased population. Consequently government expenditures will also rise in this regard. A larger population will place even greater pressure on the natural resource base in India and create demand for more cropland, agricultural products and demand more services, effecting the agricultural transition and exacerbating rural to urban migration.

Agricultural Transition

About 70% of Indias population is still agricultural and rural based. Over the last four decades India has more than tripled food production, due to green revolution inputs of fertilizes, pesticides and better seeds. As figure 6 below, illustrates cereal production has increased from 85 thousand tons in 1961, to 200,000 tons in 1989, this has been accompanied by a greater percentage increase in fertilizer consumption.

Figure 6. Cereal Production and Fertilizer Consumption.

Source: World Resources Database 1995

With the increasing intensity of agriculture however, cropland has been losing fertility at an increasing pace as fallow periods necessary for soil to regenerate are overlooked. Soil degradation such as salinization, loss of nutrients and erosion seriously affect 85 million hectares of land(World Resources, 1995). Since the total amount of cropland has not declined it can be inferred as cropland has been abandoned, new marginal forest areas have been brought into forest production, thereby accelerating the loss of forests. As noted earlier, population pressures have fragmented family plots and increased intensification of agriculture. Therefore if the poor own land it is unproductive and they lack the credit to improve it. Large farmers may take over small plots, since credit is readily available to them, these farmers tend to practice capital and input intensive agriculture which displaces marginal farmers. Marginal farmers will be hit hardest by the NEPs goal of removing subsidies and may intensify unsustainable and environmentally destructive farming practices. To the extent that land fragmentation is not matched by the introduction of intensive and environmentally sustainable agricultural techniques, the farmers with exceedingly small plots will be forced to mine their land, by shortening fallow periods, cutting remaining trees, or by migrating and engaging in ecologically destructive practices of land extensification on marginal lands.

The thrust in the current NEP is to promote application of green technologies, therefore there is an implicit thrust towards favoring large farmers in the NEP. The focus on promoting exports of farm products will also favor large farmers and provide an incentive for large factory farms. The government is also removing procurement quotas for grains and staples. An implication of this is the non availability of grains for the domestic market. For example, despite 91-92 being a bumper year for wheat harvests and India growing more wheat than the U.S and Canada combined, loosening of restrictions led to hoarding by farmers and traders despite the high prices offered by the government. The government eventually had to import 2.5 million tons of wheat from the U.S. and Canada at high cost(Gupta, 1994). Given the NEPs goal of removing all subsidies and letting the market determine prices, this does not bode well for the poor who cannot afford to pay high prices for necessities. Although the per capita availability of food has increased, from 1975 to 1989 the total proportion of households with adequate nutrition has remained the same 50 per cent of agricultural workers are still malnourished. From this it can be inferred that food resources are being appropriated by the affluent section of society, evidenced in the sharp rise of consumption of meat, poultry and dairy products.

On the flip side application of better agricultural technologies could improve water efficiency, introduce modern soil conservation procedures and genetic technology and help raise agricultural outputs, which might lead to declining prices. However, intensifying agricultural production by applying modern capital intensive farming techniques will likely, lead to widespread rural unemployment.

Urbanization Transition

The urbanization transition is driven in India by the dual forces of rural to urban migration and existing population growth in cities.

Population pressures in rural areas as well as declining productivity of agricultural lands and shrinking plots drive migration. Since the average urban citizen manages to earn more than his rural counterpart, migration is looked upon as a viable means of escape from a desperate rural situation and a way to repay debts. India has the second highest number of urban dwellers in the world at a total of 220 million or 26 % of the population. According to projections made by the World Resources Institute in figure 7, Indias urban population is going to increase steadily with a corresponding decline in the rate of growth of rural population reflecting the transformation from a predominantly agrarian to a manufacturing industry based economy.

Figure 7. Rural vs Urban Population. Source: WRD 1995

Public health spending per capita is over 6 times higher in urban areas than in rural areas (World Resources, 1995). The urban poor also have greater access to social services, such as health care, than their rural counterparts which acts as a magnet driving urbanization. Increased urban pressure could amplify the urban problems of congestion and pollution. Most of Indias cities are already near full capacity or have exceeded it and a third to a half of residents live in slums, squatter settlements or the pavements. Most urban areas already face shortages in drinking water, energy, garbage disposal (World Resources, 1995). The spread of the plague in 1994 which was concentrated in large cities highlighted the role urban areas play in the spread of diseases.

The contribution of Indias urban sector to net domestic product rose from 29% in 1950-51 to 60% in 1990-91(World Resources, 1995) Most of the employment in manufacturing, trade, commerce and transport is concentrated in urban areas while the rural sector is largely agricultural. In India the planning process is heavily biased in favor of urban areas to the detriment of rural areas, borne out by the pattern of allocation of resources, industries are generally not located in rural areas unless they pollute. The availability of employment opportunities in urban areas will attract rural populations especially since the goal of the NEP is to increase jobs in urban sectors and shift the employment pattern from agricultural to industrial. Urban populations also increasingly determine the countries political goals and the shape of its policies. Not surprisingly the greatest demand for change and continued reforms comes from the urban middle class, who stand to benefit most from these changes.

Forestry and Toxicity

The demographic, agricultural and urbanization transitions in turn will affect the forestry and toxicity transitions. Forested areas which covered 40 percent of the land area in 1947 has declined to 19 percent. Although forests are currently not shrinking, degradation is a serious problem, denuded wastelands cover 130 million hectares(UN, 1995) which may have been degraded cropland abandoned in favor of converting forests into farmland. As more land is degraded and abandoned due to the increasing intensity of agriculture, more forestland will be brought under cultivation. These lands are vulnerable to erosion and cause floods exacerbating problems elsewhere. Population pressures in rural areas place demand on forests for fuelwood and grazing. Indias forests can sustainable provide an estimated 41 million cubic meters of fuelwood per year, yet demand is estimated to be 240 million cubic meters. As Figure 8, below shows even exponential growth in fuelwood production cannot produce enough fuelwood, to satisfy demand.

Figure 8. Actual Fuelwood & Charcoal Production and Projections Using Curve Fits

Source: World Resources Database, 1995

This demand has increased in the wake of the reforms following increased prices of commercial fuels such as kerosene. Studies show heavy demand for fuelwood in cities (U.N, 1995) consequently forest cover surrounding urban areas is being reduced. Fuelwood is also being diverted from the rural areas where was a non commercial product to urban markets. Shortages in rural areas induce illegal collection without consequent replanting. In addition 25 percent of Indias 400 million livestock graze in forests which have a estimated capacity of only 31 million. Urban areas also create more demand for timber and paper, As Figure 9, below, shows from 1980 to 1990 paper production rose 105 percent accompanied by a significant increase in wood production (World Resources 1995).

Population growth increasing the intensity of agriculture which further leads to urbanization will only serve to increase pressures on forests.

Figure 9. Sawnwood and Paper Production in Thousand Metric Tons.

Source WRD 1995

Urban areas also create a demand for energy which results in large hydroelectric projects, intensified coal production and consumption which release pollutants. Suspended particular matter and sulphur dioxide constitute a major portion of the atmospheric pollutant load in many cities in India and cause respiratory problems especially among children, for example 3 out of 5 people in Calcutta are estimated to suffer from respiratory diseases related to air pollution. Urban and industrial growth emit greenhouse gases and other pollutants, emissions of carbon dioxide, a greenhouse gas have increased dramatically, in the past two decades. Levels of suspended particulates in most cities consistently exceed WHO standards. Most urban settlements in India exist without proper sanitation and waste disposal methods other than the nearest river. According to a survey conducted by the Central Pollution Control Board in 1988, of 212 cities with populations of more than 100,000 only 71 had sewer systems. of the 6.5 billion liters of sewage generated daily in the 12 major metropolitan areas, only 1.5 billion were collected. (World Resources, 1995).

Figure 10. CO2 Emissions. Source: WRD 1995

One of the challenges India faces over the next several decades is how to speed economic growth without exhausting the resources upon which growth relies. Environment health is of importance to Indias future. Economic growth may create capital to invest in environmental protection, better technology and efficiency can make a positive contribution. For example cookstoves can improve fuelwood efficiency, thereby alleviating pressures causing forest degradation and reducing demands on womens time which could be spent on being educated and learning marketable skills. Health hazards associated with burning biomass fuels which expose millions of women to high levels of harmful substances will be lowered by adopting cookstoves and other devices like solar cookers. India currently has the largest solar cooking program in the world, having sold over 250,000 by 1993(UN, 1995). However, India needs modern environmental management techniques and environmental laws need to be enforced. A comprehensive Environmental act was promulgated in 1986, compliance, however has been lax and most state governments have not shown much interest in enforcing regulations. Regulatory agencies also tend to be understaffed, underfunded and vulnerable to political and monetary pressure.

Critical Issues

It is only when people can satisfy their needs, have control over the resource base and have secure tenure to land that the long term requirements of environmental protection can be satisfied. In practice environmental values and their associated social costs are often regarded as secondary considerations, to be shifted onto other parts of society or future generations. In India the opportunity costs of resource saving technologies tend to be prohibitively high for the poor, whose production and maintenance strategy is shaped, instead to derive short term benefits from the available natural resources. The costs of resource depletion and degradation are externalized and sacrificed by both industry and the poor, alike. Rural families are characterized by high fertility preferences, faced with limited access to capital, improved technology and other production inputs, they can often exercise effective control over only one input, their own family labor.

Because the same factors may be responsible for both high fertility and environmentally unsustainable resource use practices, their identification is important for the search of policy responses that may effectively integrate environmental, economic and demographic concerns. Governments can alleviate or exacerbate the stresses farmers experience in maintaining their livelihood, through pricing, monetary policies, land reforms, access to institutional credit, development of infrastructure and provision of health, education and contraceptive services. These policies can exert considerable environmental impact by altering the use of land based resources. These same policies can influence fertility behavior through their effects in the costs of and returns from children.

The environmental effects of the different transitions India is undergoing have not been experience or have only been dimly perceived in the past, a number of their components cannot be fully anticipated until they actually occur, at which time it may be too late to counteract them. Hence there is a challenging task to choose an appropriate long term strategy when standard short term solutions such as market forces may not be able to provide sufficient insurance against the risks associated with the various transitions.

Analysis and Policy Recommendations

The Indian economy is going through a critical transition at the present. How India emerges from this transition will have broad implications for its populace and will determine the face of modern India. India badly needs modern technology, the efficiency it brings and resultant competition to its complacent industries. The infrastructure in India is inadequate and demand has far outstripped supply in many sectors such as energy generation. With a huge and ever expanding population India needs to husband its resources, discourage wastage and promote their effective usage, which modern technology has evolved to do.

Based on Indias past performance and widening income distribution gap, increasing inequalities and inflationary tendencies it can be inferred, the past economic model was not working well. In this regard the NEP is a much needed shot in the arm. Rapid economic growth and efficient industrialization is possible through outward oriented policies for trade because they encourage efficient firms and discourage inefficient ones. Creating a more competitive environment for both private and public sectors promotes higher productivity and growth. producing a favorable effect on poverty alleviation.

Some surface indicators however, do not seem encouraging, India is currently caught in a debt trap which is eating up most of its current expenditures with the result the government cannot play a role in the economy and protect the poor from market fluctuations. Due to exports not keeping pace with imports the trade deficit has widened, creating problems repaying debt,. How India handles the debt trap will determine whether it follows Brazil and Mexicos form of development or Koreas. Unfortunately India is going through its transition at a time when most world economies are not growing and are in recession and are themselves looking for markets. Most of Indias imports since 1991 have tended to be of consumer goods, foreign companies seem keen on exploiting Indias large middle class of 300 million who can afford to buy consumer goods. Even U.S. trade literature touts Indias huge market not its potential for investment (U.S. Dept. of Commerce, 1995). Therefore a short term solution might consist of, not eliminating tariffs completely and restricting import of consumer goods for the time being until the foreign debt and balance of payments deficit is resolved. Otherwise the burden of paying for the consumption of the well off Indian classes will fall on the Indian government in the form of increased foreign debt burden. While foreign technology and help in needed areas like energy generation, infrastructure should be welcome it is premature to throw open the Indian market to firms bent on exploiting it.

India also needs to be wary of foreign capital. Foreign capital can create great social costs if it dominates the countries productive resources. By benefitting only the wealthy and foreign investors, it can accentuate inequalities and expose poor to market fluctuations beyond their control. The poor often end up paying for capital which they never wanted, benefitted from and only made their condition worse and purchasing power drop. India should not forget that foreign capital does not seek to democratize nations but seeks the highest possible returns. Therefore a path should be laid out that offers opportunities to direct capital investment in socially meaningful ways without jeopardizing national sovereignty and public and environmental health (Adapted from Cervantes, 1993).

Structural issues may not also be resolved by a market friendly approach. Many countries which have relied on market forces for growth including Korea and Japan, implemented radical land reforms before they embarked on a high growth path. Privatization of social services came after a long period of government operated services, after people were able to pay for them(Sinha, 1994). The free market operates efficiently within a given structure of the economy. If a given structure is highly unequal the market will only reinforce it. Since the market takes care of effective demand only, it does not respond to the needs of poor people if not backed by purchasing power. So far economic growth in India has resulted in increasing concentration of economic power and widening inequalities, elitist oriented production structure, declining growth of employment, rising prices and growing social tensions. The NEP based on trickle down economics and the purchasing power of the top 30 percent of the population does not reverse this trend. It will have an immediate impact on 200 million people the other 700 million will see only pain in the beginning.

Therefore the government has to balance liberalizing the economy with some measures to protect the poor and employment generation schemes which it intends to do. However, due to the resource crunch there has been a near stagnation in the governments outlay for social services for the past two years. The government therefore has to increase revenues and take care of foreign debt. This will be a hard task considering interest on debt consists of 50 percent of current expenditures. Other countries such as Israel and Malaysia have successfully negotiated debt write-off from the IMF and India could try to the same or negotiate more favorable terms. Due to political pressure the government has not been able to reduce expenditures by closing sick public sector units and increase revenues through broadening taxes. Unless these measures are carried out they may lead the government to increase borrowing and postpone spending on critical items like population planning, poverty alleviation and ecological regeneration.

The large number of unemployed people is also a serious problem especially since this number will increase as sick public sector firms are closed. It is estimated the stabilization program will create extra unemployment of at least 8-11 million people who may not be absorbed by new enterprises(Ghosh, 1994). The NEP is bound to create greater inequalities in the short run and greater unemployment problems since new technology tends to be more capital intensive than labor intensive.

A focus on employment generation and a feasible strategy for devising the same seems to be missing, in the NEP. Generating employment for 700 million people is not possible without having a labor intensive mix of technology. The NEP is geared to do just the opposite. In a poor country the composition of growth may have greater relevance than the rate of growth. Since the principal constraint in India is capital, investment should be allocated in areas where the amount of capital used per unit of output is low, as Table 1 shows, agriculture, therefore becomes the primary candidate for a higher share of investable resources. (Ghosh, 1994).

Table 1. Capital Output Ratios Under 5 Year Development Plans

	1950-55	1955-60	1960-65	Annual Plans	1965-70	1970-75	1975-80	1980-85
Agriculture	2.48	2.51	4.37	1.96	3.63	3.35	4.75	6.56
Manufacturing	5.52	7.49	6.67	29.76	11.64	8.73	6.96	7.63

Source: Ghosh, 1994

In the field of rural and agricultural development there is hardly any change from the approach of treating them as appendages to the main development program. Given that 70 percent of Indias population is rural based and that is where the highest incidence of poverty is, this is a serious lapse. Spending on rural industries has remained stagnant. which has followed the example of earlier plans of treating rural areas as incidental to the planning process. The view of the NEP seems to be that rural and agricultural jobs are not productive consequently, there is a focus on encouraging rural to urban migration. In the words of Indias finance minister Manmohan Singh and architect of the NEP earlier industrial growth failed to attract the poor away from rural areas. With 70 percent of our society still dependent on farm and rural sector jobs, India is one of the most stagnant societies in terms of movement of labor towards more productive industrial jobs. Therefore the faster pace of job creation in the NEP would shift workers from less productive rural jobs to more productive urban jobs (Singh, 1994).

Inferring from this statement the intention of the NEP seems to be shifting rural and agricultural populations to urban areas and replacing traditional subsistence agriculture with capital intensive agriculture. The industrial infrastructure would therefore have to absorb the bulk of India's population which
might
not
agriculture. The industrial infrastructure would therefore have to absorb the bulk of Indias population which might not

be possible. This also has alarming implications for other transitions, although population growth may decrease as a result of increased access to health services and contraceptives and greater value of female labor, urban squalor would be greatly increased. Epedimiological risks would certainly increase as squatter settlements boom. The toxicity and forestry transitions would be impacted as emissions and outflow of sewage and wastes would increase and become concentrated spatially. The already overburdened health, sanitation and infrastructural facilities would collapse. Demands for energy would increase and lead to more pollution. As noted earlier government expenditures on the average urban resident are much higher than the rural counterpart, therefore government expenditures would greatly increase. Since urban populations tend to be more aggressive, pressures on the government for changes could increase accelerating the rate India takes through its key transitions. This would further lower the adaptive capacity of society and determine the trajectory and final outcomes of the transitions.

So far the government seems to be taking a slow consensus based approach to reform. The slow rate of movement through the transition may be critical in enhancing Indian societies adaptability to change and may ensure negative effects are dealt with. The trajectory India takes through its economic transition will be determined by Indian policy makers who at the very least are conscious of the need to be re-elected. Their response to this factor will determine the outcome of the transitions India is facing.

The IPAT Paradox

Impact (I) on the environment is based on the interaction of population (P), affluence (A) and technology used (T). I = PAT (Ehrlich, 1990). The impact on the environment is related to the number of people and the amount they consume. Simply put a large number of poor people will place pressure on limited resources and have a large impact on the environment. This impact, however, is lessened if they are poor and they are relatively poor thereby consuming less. Technology plays a role in determining impact, traditional labor intensive technologies and advanced capital intensive technologies which produce more from a given resource with less pollution, have the least impact. In between are the, intermediate cheaptechnologies in vogue throughout the developing world which have the most impact and cause wastage.

Affluence causes a large impact on the environment. Rich people consume more per capita than poor people, place more demand upon resources and industrial processes. Satisfying demands by the affluent classes will drive the industrial system and use more natural resources for energy and raw materials emissions of pollutants from industrial processes would be expected to increase. As Figure 11 shows there is a link between increased GDP and fuel production which causes pollution. In India commercial fuel production and consumption have closely mirrored increases in GDP.

Figure 11. Energy Trends vs GDP Source WRD 1995

In order to decrease the fertility rate and arrest population growth India first needs to increase affluence. In other words income inequalities need to be lessened and people need to be made affluent in order to remove the incentive to have children. Affluent people however place more demands upon the environment an have more impact than per capita than poor people. Thus India is caught in a catch 22 situation solving which needs a multi-pronged approach. Rather than pinning all expectations and hopes on market reforms it might be wise to take a lesson from the example of Kerala a state in South India which has made remarkable strides in areas such as health care, education and population control. Over several decades, the state government carried out land reform, mandated education through the tenth grade, instituted a minimum wage and the right of labor to organize and built the most extensive medical facilities in India. The results are impressive: despite a per capita income of about $ 300, many indicators such as literacy, infant mortality, and life expectancy are close to industrialized countries with far higher per capita incomes. More importantly, it also has the lowest fertility rate with an average of just 2 children per woman which is replacement level.

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CHAPTER SEVEN

ALLENN HAN

ENERGY RECOVERY FROM LANDFILL GAS

It may be garbage to everyone else, but to us, its gold.

-Mr. Campbell, plant manager for GSF, Allentown, Pennsylvania

Introduction

Social expectations in current times show a growing support for conservation programs such as curbside recycling, conservation education, and alternative energy sources including reclamation. Much of the state and federal government is following suit through grants, tax breaks, and other such incentives. One such practice is the recovery of landfill gas for energy use. Methane gas comprises almost half of the gas generated from landfills. Since methane is highly combustible and has qualities similar to the common natural gas used in many homes and businesses across the country, the recovered gas may be used as an alternative or recycled form of energy. This project will examine a few of the basic facets required to develop such a technology in the United States with the intention of creating a general protocol to apply toward any part of the world. There will be four main areas of concern including construction and operation, economic analysis, social impact, and global feasibility.

Construction and operation considerations will include factors such as location siting, physical restraints, maintenance, and the ability of the landfill to adapt to fluctuating situations such as population.

More emphasis will be placed upon the two important areas of economics and social impact. The economic analysis will prove to be extremely important in that the cost effectiveness may well determine the feasibility of such a project. First, it is necessary to determine whether sufficient funding can be met to cover capital costs. If the capital cost can be met, the operational cost will then take precedence.

Social impact will play a major role in many decisions. How will it affect the community and their perceptions? What are the local health concerns and how will they be discovered and addressed? Property value will be of great concern to many home and business owners surrounding the location. Politics will enter heavily into the decision of both the construction and operation of the landfill. How will this affect peoples attitudes toward other such projects as incineration and hazardous waste? If government funded or supported, the publics opinion of the government in general and all its other projects, related or not will probably change. Whether it is for the better or for the worse will depend upon their attitudes toward the landfill project and how it is handled. Thus there will be the question of how to increase public awareness, understanding, and communication. This may prove to be the central issue of social impact.

Finally there will be an attempt to extrapolate the results to apply to various situations around the world. This will be done in order to obtain a clearer answer to the ultimate question, is widespread use of this growing technology both feasible and acceptable? This section will pull together the issues and results from the other three areas and will use the transition theory proposed by William Drake in Towards Building a Theory of Population Dynamics: A Family of Transition as an aid to policy-makers. This theory states that a period of upheaval occurs when a set of related variables do not switch from being parallel in a simultaneous fashion. The transition occurs as the remaining variables catch up with the variable already changed (Drake, 1993). There will also be an attempt to create a loose protocol for deciding whether a recovery system can be built and how to begin building it.

The price of black gold and the incentive to find an alternative fuel

Just last year, for the first time in history, oil imports to the

United States accounted for more than half of the nations oil consumption with every update in 1995 breaking a new historical record. The Clinton administration has declared rising oil imports a threat to national security (Myerson, 1995). It has been demonstrated that increasing the world price of oil from $28 dollars a barrel to $50 dollars a barrel would cause a greater loss to the U.S. than to any other country, thus implying an embargo against the U.S. would be very successful. A look back through history at the two oil price shocks of the 1970s has proven that dependence upon imported oil is costly and that an increase in imported oil will also increase the risk of disruption. This disruption can be measured through the price of the energy. Figure 1 shows the price of oil peaking during the oil crisis of the mid 70s then dropping down to the approximate level the United States is experiencing today. Perhaps the most startling depiction, is the tremendous amount of fluctuation of the price of oil compared to that of natural gas, which has remained relatively constant throughout the past decades. High oil imports, therefore, put the United States at the mercy of such fluctuations. One way to steady this behavior is to increase domestic production of oil in an attempt to decrease the sensitivity to outside market disturbances.

figure 1 (Source: World Resource Database, 1995)

However, domestic production of oil has been on a decline despite the fact that 90% of all new exploratory drilling is done by the U.S., and with 75% of the estimated total recoverable oil already discovered, a breakthrough is not in sight (Folkerts-Landau, 1984). The data in figure 2 shows energy consumption out growing energy production. The deficit, so far, has been compensated through increasing the amount of energy imported to the U.S. . However, further projections show that, given current trends, the U.S. will still fall short of filling the deficit in the future, even with the inclusion of imports. Later data analysis will show that, to compound the situation, there may be a transition headed towards the reduction of the production of oil as a fuel source.

figure 2 (Source: World Resource Database, 1995)

exponential fit for all data

figure 3 (Source: World Resource Database, 1995) exponential fit for all data

The prevalent attitude with the lawmakers is to get away from importing energy. It is a policy based upon this previous data, which effects may all be elegantly summed through a simple application of chaos theory (figure 4). Arlinghaus et al. has proposed a chaotic method to view population-environment dynamics, which may also apply to this situation. When data is plotted alongside the line y=x (at which input equals output), the intersections of these two lines, or fixed points, will become either attracting or repelling points, depending upon the area of interest on the x-axis.

figure 4 (Source: World Resource Database, 1995)

exponential fit for energy import data

Figure 4 depicts such a relationship. During the mid 60s, the import trend passed a benchmark, an attracting point. At the moment, the United States is between two fixed points. If the stress to increase oil imports were removed, the trend would naturally tend to decline towards the mid 60s level. However, there is a threshold of irreversibility at which point, the natural trend would be to increase out of control towards infinity. If this point, only twenty years away at the year 2015, is breached, imports would become extremely difficult to harness. Therefore, measures must be taken to bend the import curve away from this point in hopes that the future intersection will never occur. To accomplish this, the energy deficit must thus be filled by alternative sources. The administration is currently searching for ways to encourage domestic energy production. Methane recovery is one such method that may be utilized in asserting a little energy independence. Scott Skill, executive director of National Bioindustries Association has forecast, landfill gas could supply 5% of U.S. natural gas needs, and thats a profoundly large number, and one of the ways this country is going to cut its trade deficit (Peterson, 1995). Figure 5 proves a transition towards increased natural gas usage is feasible. It has happened in the past. During a twenty year stretch from 1960 to 1980, United States energy consumption underwent a successful natural gas/coal transition. Coal use dropped dramatically, but an equally dramatic increase in natural gas usage picked up the slack.

figure 5 (Source: Annual Energy Review, 1993)

Examination of the transitions in United States energy production show that this phenomenon may already be underway (figure 6). There have been many transitions in the past four decades when, at various times, each of the big three energy sources (coal, oil, and natural gas) enjoyed a stay at generating the most energy. However, upon further inspection, it can be seen that oil production has followed a very steady overall decline. Although coal quite recently experienced an increase in production percentage, it, too, is starting to decline. Natural gas is the lone rising major energy source and will soon rank first in percentage of energy production.

figure 6 (Source: Annual Energy Review, 1993)

Energy production from waste, such as methane recovery systems, is increasing along with this trend, implying its contribution to natural gas production will be significant (figure 7). Future policy changes, such as ones presented later on, may bend this curve into more of an exponential shape.

figure 7 (Source: Annual Energy Review, 1993)

What is methane gas?

Methane is the primary component of natural gas and landfill gas and can be generated by the anaerobic (oxygenless environment) bacterial decomposition of organic waste (figure 8). This gas is insoluble in water and lighter than air so it will tend to rise up and out of a landfill into the atmosphere (Lafond, 1992). Methane is emitted primarily by anthropogenic sources which account for about 70% of all global emissions. Landfills are the largest anthropogenic source in the United States with the equivalent of 6750 MegaWatts of electricity generating capacity escaping to the sky last year; enough to power more than four million homes (Hogan ed., 1993).

figure 8 (Source: Chestnut, 1991)

Since methane can be produced through the decomposition of organic materials only, it is important to characterize a potential sites garbage content when determining if a landfill energy recovery project is feasible. Composition varies slightly from site to site within a country, and may greatly vary from actual country to country (figure 9).

figure 9 (Source: Qian, 1995)

In the United States, approximately three quarters of municipal waste is organic. Due to the advent of widespread recycling, the organic content of garbage will continue to rise as glass, metals, and aluminum are separated from the waste stream. Figure 10 depicts this forthcoming transition towards a more organic composition with organic content rising sharper than the inorganic composition.

figure 10 (Source: Qian, 1995)

So why retrieve landfill gas?

On the mildest and most local level, it is considered a plain nuisance, causing the unpleasant odor so much associated with decomposing garbage. There is also a much more serious health issue. Aside from the release of harmful volatile organic carbons (VOCs), the methane which comprises the majority of landfill gas is obviously extremely combustible and possesses the insidious ability to migrate underground (Lafond, 1992). Quite recently, a Madison, Wisconsin, apartment exploded when a tenant lit a cigarette, with the most plausible explanation being traveling gas from the nearby landfill (Eldred, 1986). Local vegetation may also be affected. Not too long ago, the ground was bare at the Carne Landfill in New Jersey. The plants would take up the methane in their roots and die. However, ever since the recovery project began, there have been definite signs of spring growth all around (Peterson, 1995). On a slightly grander scale, smog can be created given the proper atmospheric conditions, along with acid rain. And on the grandest global scale, both carbon dioxide and methane are major greenhouse gases. Methane is pound for pound more potent than carbon dioxide, responsible for roughly 18% of the total contribution to radiative forcing, a measure of global warming. Atmospheric methane concentrations have risen sharply at about .6% per year and have more than doubled in the last two centuries. The good news is that much of these effects can be avoided through the reclamation and combustion of landfill gas. Generators used for this purpose are very efficient and are able to combust these compounds breaking them down into components having little or no effect on the environment (Carolan, 1987). Aside from producing this clean-burning methane, the reclamation displaces the coal or petroleum that would generally be used in its place (Hogan, 1993). Similarly, the local community benefits by retaining revenue that would otherwise have been used to import the energy from an outside source (Lafond, 1992. Naturally, this would also work on a macroscopic level. The EPA is recognizing these benefits and are pushing for future regulation requiring the collection and monitoring of landfall gas. More and more landfill owners and operators are realizing that while they may not reap royalties, the activity is still positive. (Carolan, 1987).

Part I: Construction and Operation

Siting

Siting a landfill is perhaps the most complex and certainly the most time-consuming step in constructing a landfill. At present day, 50% of all landfills catch their repose in rural areas, while 25% are placed on industrial land, and the remaining 25% on other properties. However, while a fill may be located well outside a city, urban growth often catches up and overgrows the host community, thus changing its site into residential land (Atwater, Dec 1989). There is such a variety of facets to the decisions, it is difficult to find an equitable approach. One method put forth by Swallow et al in his study, Siting Noxious

Facilities, seems to give a fair general overview combining approaches across several disciplines. A sound method should address both technical and sociological concerns. The technical side should include expert advise regarding engineering, safety, and environmental criteria (Swallow, 1992). It is important to make an attempt to foresee the unexpected. The Seattle Midway Landfill was a model site until toxins were illegally dumped into it (Eldred, 1986). The sauce-political approach should emphasize public access to the decision-making process. Swallow proposes a three-stage approach. Stage 1, the first stage, examines which sites have the physical requirements for a waste facility. This includes the availability and cost of the land, hydrology, topography, and climate. Care must be taken to balance these factors since some of the preferred criteria are contradictory. Case in point, the site should be in close proximity and accessible to the primary waste-producing urban center. However, it is generally best to locate far from residential neighborhoods. This stage produces a long list of possible sites that will further be narrowed by stage 2, social suitability. This section involves the education of the public and determination of long term effects on the community. Issues unearthed at this stage will be delved into further in the discussion of social impact. This is arguably the most important consideration. All concerns are debated at this point and a short list is created of perhaps two or three communities. It is noteworthy that it is also at this juncture that many solely economically-based selection models break down. The final decision is made at third stage. The basic concern is finding an acceptable compensation package. It many cases, the compensation to the host community is so alluring, the final selectees will auction for the right. An obvious drawback to this system is the ample room available for political manipulation. This can partially be avoided by clearly announcing beforehand , the criteria set for both the long and short lists (Swallow, 1992).

How is methane retrieved?

Methane production begins approximately one or two years after waste placement. The lag time accounts for the amount of time taken to deplete the oxygen in the fill so that anaerobic methanogenesis may thrive. A series of blowers and compressors create a vacuum inside the landfill. This pressure funnels the gas into perforated pipes which, in turn, head toward the cleanup facility where the gas is filtered and heated to remove the moisture (Qian, 1995).

What to do once it is recovered

Once retrieved, landfill gas can be used in one of three ways. It can be cleaned and compressed to pipeline quality, then sold to a natural gas distributor. The cost to upgrade gas is quite expensive, but the landfill is able to sell it directly to a power company without having to identify a specific customer. A second option combusts the gas in an on location generator. The energy is then generally used for maintenance needs on the site itself. The third, and most profitable option, if it is available, is to sell it to an industrial plant as medium grade boiler fuel, which contains about half the energy value of pipeline natural gas used residentially. Ideally, the medium grade fuel customer would be located no more than five miles away (Hogan, 1993). Fluctuations in both demand for energy and seasonal waste generation may be handled by mixing in mined natural gas when needed (Lafond, 1992).

Estimating methane output (figure 11)

There are numerous methods used to estimate the generation of landfill gas. A simple equation derived by the EPA in a 1993 report to congress on Opportunities to Reduce Anthropogenic Methane Emissions in the U.S. offers a quick, handy recipe.

For landfills over 1 Mg:

methane (m3/min) = 8.22 + 5.27 W

where W = amount of waste measured in Mg (106 grams)

For landfills under 1 Mg:

methane (m3/min) = 7.43 W

where W = amount of waste measured in Mg (106 grams)

For each of the above equations, it is standard to assume a 85% efficiency (Hogan, 1993).

figure 11 (Source: Hogan, 1993)

Note: There is a significant amount of uncertainty in determining the exact amount of waste generated in a country, thus a range of estimates is often given when depicting trends for large areas, such as the United States.

Part 2: Economics

Ultimately, the profitability of a landfill gas recovery will depend largely on the price of energy at which the site is located (John, 1995). These recovery systems are highly sensitive to fluctuations of market energy prices. At an expected price of 5"/kilowatt-hour (kWh) in the year 2000, it is profitable to recover methane from more than half of all U.S. landfills. A penny less per kWh, and it would feasible to recover gas from just 15% of all landfills. A penny more, however, and the figure rises to 75%. Currently, prices range from 2"/kWh to 10"/kWh, with an average of 6"/kWh (Hogan, 1993) (figure 12). As common sense dictates, recovery works best where energy prices are high or where there is a population boom requiring power companies to find more power (Eldred, 1986). It may be useful to seek out locations with population dynamic transitions showing a simultaneous population boom and energy transition toward natural gas or alternative fuel.

figure 12 (Source: Hogan, 1993)

The low, average, and high estimates correspond to the possible charge for electricity of 4"/kWh, 5"/kWh, and 6"/kWh, respectively. As is apparent, the sensitivity of these recovery projects is extremely high. Currently, the United States is on the path following the high estimate.

The economic future of landfill gas generation is bright. New federal tax credits are increasing the value of gas for many landfills. Specifically, the Energy Policy Act of 1992 extended the Section 29 tax credit for non-conventional energy production until the year 2008. The credit is approximately equivalent to 1"/kWh.

An additional savings may be redeemed through the cost of reducing carbon dioxide (CO2). Since CO2 is a major greenhouse gas, it is advantageous to reduce CO2 emissions. The estimated cost of doing so is approximately $15 per ton. Since this recovery process not only reduces methane emissions, but CO2 emissions also, an additional savings of about 2"/kWh may be attached. Plus, the savings from displacing the fossil fuel that would otherwise have been used to create the energy totals to approximately .6"/kWh (calculating 1.5 lb CO2 avoided per kWh).

The overall savings from the Section 29 tax credit and the cost effectiveness of reducing CO_2 is about 3.5"/kWh. This assistance is significant noting the sensitivity of the recovery system to energy price (Hogan, 1993).

Estimating collection system cost

Again, the 1993 EPA report to congress provides a handy equation for estimating cost.

Collection System Capital Cost = W.8 * $470,000

where W = amount of waste measured in Mg (106 grams)

Operational and maintenance cost = 10% of Capital Cost

includes 6% for labor-related cost (such as wages and overhead)

+ 4% non-labor-related cost (such as administrative and insurance)

(Hogan, 1993).

Estimating generator cost

MW = methane (m3/min) * .1765

Capital Cost = $1,200,000 per MW

Operational Cost = 13% of Capital Cost

(Hogan, 1993)

Part 3: Social Impact

Property Value

Property value depreciation is often one of the reasons for host community opposition to the siting of a new waste facility (Atwater, Dec 1989) Landfills affect many environmental and social characteristics, all of which are generally reflected in the property value of a home. Issues of concern to home owners include the scenic view (or lack thereof), quiet, safety, health, risk, nuisances, social impact of a stigma on the community, environmental change, government property value, the unfairness of one area being impacted while other surrounding neighborhoods enjoy benefits, loss of confidence in the government, and retardation of residential development (Atwater, Sept 1989). The December follow-up study to the September property value study surveyed homeowners with respect to their objections to a landfill (table 1). The shear nuisance of the landfill was the major concern. However, all the impacts are theoretically inherent in the property value.

Facility Impacts on Neighborhood	Proportion of Residents with Negative Beliefs
Nuisances	66 %
Health Risks	45 %
Property Values	41 %
Community Image	41 %

table 1 (Source: Atwater, Dec 1989)

One way to compensate homeowners for a perceived loss in property value is to offer property value guarantees. A property value guarantee ensures the homeowners of the hypothetical fair market value of the home as if the landfill never existed. The guarantee is valid even to the point where the landfill owner will buy the house if it is not sold within nine months. A study by Atwater and Zeiss on the effect of landfills on property values examined 15 case studies covering a variety of both rural, urban, and suburban locations. The results were surprising in the sense that they could find no strong correlation between the landfill and its host community. Out of the 15 cases ranging equally from rural to suburban to urban communities, 6 cases showed a decline in property value, 8 cases showed no effect, and one case exhibited an actual increase in property value. Of the landfills studied with recovery systems, they found waste-to-energy plants that use the latest technology and are operated cleanly did not impact on residential property value or development. Property value guarantees, although unnecessary for monetary compensation, were found useful for the simple fact that they acknowledged community concerns (Atwater, Sept 1989) However, in a follow-up study and survey, only 50% of the people polled found property value guarantees acceptable compensation, therefore, it is only a marginally effective public relations tool (Atwater, Dec 1989).

How to Communicate with the Host Community

Many landowners agree that demonstrating concern for proper environmental management is the proper way to position the industry with the public. Therefore, reclamation projects such as energy recovery in its essence, can create good public relations (Carolan, 1989). The education of and communication with the host community is both the major and most volatile component of the landfill creation process. In the past, siting was generally dictated through a economical-political process. The public did not have much input into the events that would affect them. This brought about such issues as environmental racism which generally targeted poorer communities that were not able to object to waste facilities placed in their district. This process can be greatly improved by creating a dialogue between the landfill owners and the public. An excellent case study of such a dialogue is the siting of the Maricopa County Landfill in Arizona which incorporated town meetings and liaisons as a communication link. Four hundred angry residents attended the first meeting. The county received the message and immediately expanded the site selection using frequent town meetings to obtain suggestions from the public for possible locations. A hierarchy was also created through the establishment of advisory and steering committees. The districts elected official, Carole Carpenter, made sure the county was given adequate information, the advisory committee was alerted to all decisions, and the media was well informed. This was crucial to ensure that facts were always in tact and residents could still gather information if they were unable to physically attend the meetings. Carpenter encouraged the airing of all concerns, debates are just part of the process to arrive at a consensus about a landfill site that is not only environmentally sound, but socially acceptable (Landfill Siting..., 1986). Twenty-four original sites were narrowed down to seven, which the advisory committee carefully analyzed. When it came time to make the final site selection at a town meeting, not one person objected. The meticulous system worked, and the Deputy County Engineer noted, we werent getting anywhere until the people got involved in the study. Through public meetings, they learned about landfills, and they educated us about what was important to their neighborhoods and them (Landfill Siting..., 1986). The process was time consuming, but as Carpenter explained, the public involvement process takes time, but people should recognize a year or so is not a long time to go through a successful process for siting and starting up a landfill (Landfill Siting..., 1986) This siting method, which closely follows the method proposed by Swallow et al, should be widely implemented with careful consideration that the town meetings not be used as persuasion by either side, rather as an informational session and dialogue. Any scientific experts involved should be careful to simply explain the situation rather than justify any proposed decisions (Kaminstein, 1990).

How to compensate a host community

Every discussion with the host community, particularly during the final selection, will include a compensation package unique to the concerns of the public. There are four logical, sequential steps that may be used to describe this compensation. Step one is prevention. This includes technical safeguards against accidents or malfunctions. The use of buffer zones between the landfill and the community has also become a popular additional prevention technique. The second step is control. This mainly accounts for the construction of the landfill and include various liner, filtration, and monitoring systems (Atwater, Sept 1989). A resident of the Seattle Midway Landfill community, Denny Clark, was worried about his children growing up near the site, but now applauds the owners for aggressively installing monitoring probes and measures to vent the methane gas (Eldred, 1986). The third step is mitigation. If an accident should occur, it is important that proper corrective measures be quickly implemented (Atwater, Sept 1989). The three mile island accident is an example of successful mitigation. The property value of the surrounding community did not decrease, despite the highly publicized mishap. This has generally been attributed to the expectation of government assistance, the absence of visible damage, and the very visible influx of troops of cleanup workers (Atwater, Dec 1989). Finally, step four is compensation in the form of cash or services (Atwater, Sept 1989). An increasing number of landfills are developing public parks on inactive landfill sites. As part of the deal to accept the landfill, the Palm Beach Landfill in Florida has created an enormous park to meet the growing needs of adult recreation. It includes twelve miles of cycling paths, a thirty-three acre waterway for canoeing and fishing, along with horse trails, a model airplane field, and even a golf course. The distinguishing characteristic is the ninety-foot lookout mound from which pedestrians can spot local landmarks including the neighboring active waste-to-energy facility (Palm Beach..., 1995).

Part 4: Global Feasibility

Barriers and policies to overcome them

1. Low electricity prices

In general, methane recovery is only feasible from large, urban landfills. The exact size, however, depends largely on the electricity price. Unfortunately, landfill energy projects are highly sensitive to fluctuating prices. A small dip in cents per kWh translates into a large dip in profits. By the same token, fortunately, landfills are highly sensitive to fluctuating prices. This implies that a mild government tax break or incentive program, such as Section 29, can be used to augment the profitability and thus neutralize the detrimental effects of low market prices. The current U.S. tax policy is adequate for encouraging landfill recovery projects. The tax structure has already kept the average adjusted charge for electricity from energy recovery projects at 6"/kWh. Thus, 75% of landfill methane can theoretically be recovered. Any increase in the tax break would be a step into diminishing returns.

2. Potential liability for financial backers and system operators

In the United States, under CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act), the owner and operator of a landfill may become solely responsible for the costly cleanup if hazardous conditions should occur. This scares away many investors who are needed to assemble the high capital cost. This may be handled in three ways. Governments may fund research for the development of cheaper cleanup technologies in order to reduce the amount of the liability. New insurance structures may be looked at to provide better, more affordable coverage. Also, legislative action may be utilized to spread out the liability cost among more of the responsible parties.

3. Siting and Permitting Concerns

Energy recovery landfills have the best chance of success if they are sited close to an urban center experiencing a population boom. However, the permitting standards are also stricter around these areas. It can be very costly to meet the permitting requirements. One way this may be overcome is to develop more efficient low emission technologies such as fuel cells, which chemically convert methane directly into usable energy bypassing the reactor, thus making it easier to meet the standards. This can be achieved through governmental funding of both public and private research projects. The opposite approach is to grant waivers or provide special permitting for environmentally beneficial projects that can prove a high benefit-to-cost relationship.

4. Perception of high risk

Most alternative energy production technologies are viewed as unproven and risky. This high risk perception may be voided by publicizing the reliability and profitability of methane recovery projects already in existence. In the case of the United States, an outreach program could be developed to provide information on the over one hundred successful U.S. projects already in existence today.

5. Development cost of technology

The high cost of technology hinders the development of new, more efficient technologies. Again, the government can fund and develop both private and public research programs.

6. Lack of information

A landfill may be a prime site for methane recovery, yet the owner may simply be unaware of the recovery option. Or, if aware of the option, may not have the know-how to implement it. For instance, 85% of the landfills in the U.S. are owned by local governments whose only responsibility is to adequately store municipal solid waste. Since it is not their primary concern, they may be unaware of the ability to take the process one or two steps further. An outreach program can be developed by the government to provide publicity and technical information on the construction and operation of a waste-to-energy landfill (Hogan, 1993). This also brings in the issue of public versus private management. Smaller plants are particularly sensitive to the performance and efficiency of the management. Many vendors argue that private managers are better equipped to handle emergencies. Public management may become too bogged down in bidding contracts which can be slow and political. However, advocates of public ownership argue that it is best to keep a local landfill under local control. A publicly owned landfill can also theoretically be run at a lower cost since it would be a non-profit operation (Carolan, 1987).

By Section of the World

Waste in developing countries is expected to increase at a much faster rate than the industrialized countries. This trend is attributed to projections of higher population growth rather than an increase in per capita consumption (Hogan, 1993). Transition theory may be an incredibly powerful tool used to help site energy recovery projects around the world. Through the examination of indicator variables, it can be determined which areas are primed for this technology. General trends can be depicted to determine if there is a need for the energy, if enough gas can be generated to make it economically feasible, and if the physical building blocks exist. Perhaps the most important contribution transition theory can offer to this application, is the ability to time when these variables will occur in the proper combinations. Knowing when sites may be ready to accept this technology is extremely valuable when creating policy, and determining how to spend funds and when. A few examples of this technique will be applied to several test countries in the following section. Three transitions will be examined. The first plots energy consumption and production to determine if there is an energy deficit to be filled, such as the extreme case of the United States. The second transition checks if the country is in the midst of an urban boom. As has been stated, these projects are best situated around areas experiencing rapid urban growth and a natural gas demand. The third relationship takes another step past the urban boom to determine if the infrastructure is in place to allow recovery projects. It is not enough that the project creates energy, the energy must also have a path to flow to the consumers. To determine the state of the infrastructure for natural gas, natural gas production is plotted. If there is a boom in natural gas production, the country will most likely have the means to distribute the energy, This underlines another asset of the transition theory as a tool. Transitions with indirect relationships can be used to express a variable that may otherwise be difficult to obtain.

Africa and the Middle East

Municipal solid waste (MSW) generation is .7 kg per person per day (Hogan, 1993). There is a need for greater technological development before recovery systems can be installed. Energy recovery requires the control granted by a sanitary landfill as opposed to the smaller, simpler dumping landfills which are more frequently found in this geographical area. More effort also must be diverted into creating markets for the end product of an energy recovery system, including the infrastructure required to provide it. At this point, resources should be used to improve waste handling and landfill design before methane recovery can be considered.

Asia

MSW generation is .6 kg per person per day. Asia is responsible for 16% of the global generation of methane from landfills. Some countries are upgrading their collection methods by using compacting trucks and covered containers. This would decrease the amount of scavenging and increase the amount of waste placed in landfills. In addition, the increasing population will also increase the amount of waste. However, economic constraints and a history of slow waste management development indicate that the use of sanitary landfills will not significantly increase in the near future. Efforts should be made to develop recovery systems for the sanitary landfills that do exist and will grow in volume.

figure 13 (Source: World Resource Database, 1995)

Figure 13 shows Indias energy deficit. Although relatively small, the gap is significant and is showing growth. Now may be an opportune time to begin developing technologies to prevent the gap from exploding.

figure 14 (Source: World Resource Database, 1995)

India does not seem to currently be in a rapid urban transition. Therefore, areas of densely packed population, which is ideal for energy recovery from landfills, may not be increasing at a fast enough rate to make this technology feasible.

figure 15 (Source: World Resource Database, 1995)

However, India does show an incredible boom in natural gas production, along with an exponentially increasing urban population, albeit fairly steady compared to the overall population. Therefore, now may be the time to begin planning for widespread recovery.

Europe

MSW generation is .6 kg per person per day. Europe is responsible for 20% of the global generation of methane from landfills. Some countries such as the Netherlands, Denmark, and Germany plan to increase recycling and incineration which would decrease the volume placed in landfills. However, the technology is in place to implement methane recovery and many of the Western European countries in particular have the infrastructure available to distribute the recovered energy. Many of these countries such as England are actively researching recovery techniques. Although no Eastern European country currently has a gas recovery system, there is tremendous opportunity for widespread implementation. Sanitary landfills or open dumps are the exclusive methods used for handling waste in most of these countries (as opposed to incineration). A growing number of these countries, such as Poland, are phasing out open dumps in favor of sanitary landfills. Natural Power, a U.S. based company is currently working with Kiev, Ukraine to develop a recovery system. Other such outreach programs to Eastern European countries could prove to be successful.

figure 16 (Source: World Resource Database, 1995)

The former U.S.S.R. has kept its energy transition fairly steady. it is not in a desperate situation right now, at least as a whole (figure 16).

figure 17 (Source: World Resource Database, 1995)

However, it is starting to experience a slow urbanization which may accelerate in the near future (figure 17).

figure 18 (Source: World Resource Database, 1995)

Although the urbanization is relatively slow, the gas fuel production has skyrocketed (figure 18). Therefore, the former U.S.S.R. has the means, but not yet the demand. It should be recommended at this time that work is pursued to create markets for landfill energy and that the state of sanitary landfills be improved and updated to meet standards required for recovery.

The Americas

MSW generation is 1.8 kg per person per day. The Americas are responsible for half of the global generation of methane from landfills. Sanitary land filling is the predominant method for waste disposal. There is a great number of growing urban areas with the demand and infrastructure necessary to distribute the energy. Municipal solid waste generation is also expected to increase making this section of the world best primed for widespread implementation of this technology, particularly in the North American countries. South America has fewer gas to energy systems, but is showing vested interest and a willing for commitment to this technology (Hogan, 1993).

figure 19 (Source: World Resource Database, 1995)

It has already clearly been shown that the United States desperately needs to become energy independent. There is no urban boom, but there is a slight, erratic rise in gas fuel production (figure 20, 21).

figure 20 (Source: World Resource Database, 1995)

This is a good example of the limitations of transition theory for this application. The data show a tremendous need, yet the United States is experiencing neither an urban boom nor a steady explosion in natural gas production. Yet, the United States is the prime candidate for this technology. In this case, transition theory gave too vague a trend. Further exploration reveals that the rise in organic content of the waste and the extremely high per capita waste production will compensate for the lack of rapid urbanization. This is a case in which transition theory shows a mild propensity , but more research must follow to determine the exact extent.

Australia

MSW generation is 1.1 kg per person per day (Hogan, 1993). There are few highly urbanized areas in Australia with landfills large enough to make a recovery system profitable. However, the technology and infrastructure are in place for the few landfills which are potential candidates.

figure 21 (Source: World Resource Database, 1995)

If India is almost primed for an energy recovery system, the former U.S.S.R. must wait and prepare, and the United States analysis gives a lukewarm result, then Australia is on the other end of the scale. It is actually experiencing increasing exports as its production outruns its consumption (figure 21). There is no urban boom (figure 22). In fact, there is even a slight divergence between total and urban population.

figure 22 (Source: World Resource Database, 1995)

figure 23 (Source: World Resource Database, 1995)

Again, Australia does have the know-how and equipment, there is just very little demand (figure 23).

The future of landfills in the U.S.

The state of landfills in the Unites States may mirror prospects in many of the other highly industrialized countries, and may be an indicator of the far future of countries in the later stages of industrial development. As the average landfill size increases, as will be the case according to a recent EPA report to congress, energy recovery will become more profitable and feasible. With the Section 29 tax break in place for at least another thirteen years, an average rate of 5"/kWh is reasonable. At this rate, about 750 of the current landfills in the U.S. can profitably recover methane and produce about 4000 MW of energy. To reduce the air pollution, the EPA will soon require all landfills to collect and combust the gas produced (Hogan, 1993). In addition, the growth of recycling programs and attitudes change the composition of municipal solid waste. Much of the plastic and metal, which do contribute to methane generation, will be removed from the waste stream while the organic content, which does contribute to methane generation, increases. This means landfills will become more efficient producers of methane (Peterson, 1995).

Conclusion

figure 24 (Source: World Resource Database, 1995)

In a time where world population is starting to become a concern for many areas of the world if not all areas, more must be done to meet the exponentially growing needs of this world community (figure 24). Landfill gas recovery is a technology that can actually harness urban growth and transform it into a positive force.

figure 25 (Source: World Resource Database, 1995)

As figure 25 indicates, this technology will most likely first impact the Americas and Europe. These two areas have both the highest amount of technology and are both major sources of methane emissions, a good match. It is up to these nations to research and refine the system so that other sections, such as Asia, may follow suit when the time comes. Asia has a high methane emission output, it simply needs the technology to make this recovery economically viable.

The world can no longer depend on the diminishing oil and coal reserves for its future energy needs. Alternative energy sources are available and can be made feasible in the near future. In all likelihood, oil and coal will not be replaced by one single new energy source that can be globally transported and used in a similar fashion. Rather, they will most likely be replaced by alternative local energy sources specific to the unique characteristics of each area. Landfill energy will never be a major global source of energy, but will surely be a major local source of energy with more and more communities benefiting every year.

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Appendix

Some successful examples

Landfills remain a largely untapped natural gas reserve capable of producing large amounts of energy. Although a general global approach was taken in this paper, methane gas recovery systems are extremely sensitive to the surrounding environmental, economical, and socio-political conditions. Therefore, the benefits are harvested locally. Each particular site will have its own set of nuances and the feasibility of each site must be determined individually. Here are some examples of locally successful landfills:

Handling fluctuations in supply and demand - Racine Landfill, Wisconsin

The surrounding community of this eight acre site is highly susceptible to seasonal fluctuations in energy demand, yet the rate of waste generation is fairly steady. To compensate, the designers incorporated a system to simultaneously combust landfill gas and raw natural gas piped in from an outside source. Therefore, if more energy is needed, more natural gas can simply be added. The system also burns off hazardous waste solvents further reducing air pollution. The design has won the Wisconsin Governors Award for Energy Innovation and the National Energy Conservation Award from the U.S. Department of Energy (Lafond, 1993).

The longevity of energy - Burnsville Landfill, Minnesota

The Burnsville Landfill creates 3.2 MW of energy meeting the energy needs of the 2000 surrounding community homes. Although this landfill is closed, estimates show that Burnsville can depend on landfill electricity for another twenty years (In Minnesota..., 1994).

A growing resource - Amityville Landfill, Pennsylvania

A recovery system was added to the active Amityville Landfill. Originally designed for 1 MW of electricity, it expanded two years later to 1.5 MW. Currently, the landfill produces 2 MW of electricity with future plans to add yet another generator (Chestnut, 1991).

Paying for itself - Riverview Landfill, Michigan

Electricity produced at the Riverview Landfill is sold directly to the Detroit Edison electric company. Thus, the landfill operator does not need to be concerned with finding a specific customer for the end product. Within two years, the landfill owner recovered the capital cost and proceeds are now being added to Riverviews cash flow (Alperovitz, 1994).

A community improves their local economy - Glendale Landfill, California

Says John Cosulich, supervising engineer, Its a win, win situation all the way. The treated recovered gas from the Glendale is currently being sold to the city at a 12% discount from what it used to pay for imported natural gas. Not only does the discount improve Glendales cash flow, the locally generated energy as opposed to the imported energy improves the economy of the town (Lou Chen, 1994).

Enough energy to spare - Puente Hills Landfill, California

This is the biggest methane gas recovery project in the country. Despite the capital cost of 33 million dollars and an annual operating cost of 3.6 million dollars, this site generates a revenue of 8.7 million dollars every year (John, 1995).

Into the future, Not just for homes anymore

Next year, during the 1996 Summer Olympics, Atlanta has plans to shuttle athletes throughout the city in natural gas-powered buses. EPA restrictions will encourage automobiles to have near zero emissions in the near future. Compressed natural gas cars are one of major solutions (Peterson, 1995).

CHAPTER EIGHT

MICHAEL LANDWEBER

MALARIA AND AIDS: THE EPIDEMIOLOGICAL TRANSITION IN THAILAND

Introduction

Malaria and the Acquired Immune Deficiency Syndrome (AIDS) do not seem to have much in common on the surface. Malaria is transmitted by mosquitoes; AIDS through contact with bodily fluids. A parasite causes malaria; AIDS results from infection with the Human Immunodeficiency Virus (HIV). Malaria is curable; AIDS is not. But it is the similarities with which this paper is concerned: namely, both diseases have created major epidemiological headaches for health professionals around the world, and both diseases are preventable.

In terms of the health situation in Thailand, these two diseases represent the past and the future. As recently as the 1950s, malaria was the number one cause of mortality in Thailand. According to most estimates, HIV has spread throughout the country to such an extent that AIDS will probably become the top killer by the year 2000. The juxtaposition of these two diseases will also be utilized to show that the policy implemented through the control programs for malaria can become a groundwork for dealing with a potentially bigger challenge in AIDS.

In a broader context, this paper will describe the two epidemiological transitions seen in Thailand. The first, a shift in the major causes of mortality from infectious to degenerative diseases, has already been successfully completed. Malaria will be used as a specific example to illustrate this change. The second transition has not yet occurred, although it has begun. The sole reason for this predicted shift -- from degenerative diseases back to infectious -- will be the rampant spread of AIDS. However, it must be noted that this is not a foregone conclusion, though based on present statistics and actions taken, it is a very probable one.

Transition Theory

The starting point for this study is the theory of transitions put forward by William Drake in his paper Toward Building a Theory of Population-Environment Dynamics: A Family of Transitions. The basic premise states that changes within societies, or segments of societies, can be viewed in terms of transitions in which a certain aspect of the group in question begins in a state of relative stability, passes through a turbulent stage marked by change and instability, and finishes at a new level of relative stability markedly different from the starting point.

For this paper on the health situation in Thailand, the epidemiological transition from Drakes paper will be used as a framework.

The epidemiological transition describes the changing source of mortality and morbidity from infectious diseases occurring primarily in the younger age groups to degenerative diseases in older age groups. This is the traditional way in which this particular transition has been viewed. For most countries, passing through this transition marks an important step along its developmental road. Within the theory of transitions, however, it is important to remember that not all shifts are in a positive direction. Every transition has the potential to be reversed, or at least to change in a way that negates the previous change. This, unfortunately, seems to be what will occur in Thailand in terms of the epidemiological transition. Although the reasons for the two transitions are completely different, the result will be the return to infectious diseases as the leading causes of mortality, rather than degenerative diseases. And again, it will be the young who will be struck down as opposed to those who have lived a full life.

The First Transition

As a nation, Thailand is extremely aware of the state of its health. The government has long kept tabs on the various causes of mortality and morbidity, and has actively pursued control programs for many of the worst offenders. In the case of malaria, it will be shown later just how effective such effort can be. In 1987, a commission released a report on the health priorities for the country. Within this document, the successful passage through the epidemiological transition was noted:

Since the last decade, Thailand has been faced with a different trend of health problem. The acute infectious diseases have been declining in both number and severity. On the contrary, most non-infectious diseases have been steadily increasing.

A second report written four years later commented that the health transition in Thailand began as early as 1975 when the top ten leading causes of death changed from the three top-ranked infectious diseases to three non-communicable disorders.

But, before providing data on the transition and its success, consider some statistics about Thailand itself. Situated in the heart of Southeast Asia, Thailand currently has a population of around 57 million and a population density of approximately 114 people per sq. km. Currently, the population is growing at a rate of around 1.27 percent annually. The country is divided into four distinct regions: 1) Central, which includes Bangkok and is the most heavily populated; 2) North, a mountainous region that is home to Chiang Mai as well as many indigenous hill tribes; 3) Northeast, which borders Cambodia and Laos and is relatively dry; and 4) South, which has an abundance of coastline and islands popular with tourists. Resting in the tropical zone, Thailand has two distinct seasons, rainy and dry, although the temperature variation is minimal. Most of the population still engages in agriculture to make a living.

In showing the success of the epidemiological transition, it is useful first to examine another common transition (see Fig. 1). The demographic transition is characterized by a drop in

Fig. 1: Graph of the demographic transition of Thailand (Source: World Resources Database)

the crude death rate followed soon after by a drop in the crude birth rate. Looking at the comparison for Thailand of these two variables, it appears that this trend has already occurred. There are many possible explanations for the success of this transition. Often the drop in crude death rate is marked by a combination of a decrease in death rates for infants and children under five, and an increase in the life expectancy for the general population. In a society that relies heavily on agriculture, as is still the case in Thailand, the birth rate corresponds to the need for individual families to have surviving children to work in the fields or the rice paddies. Thus, when infant mortality is high, the birth rate is also high to compensate for the loss of children and maintain the ability of the family to produce the crops necessary to survive. Conversely, as the infant mortality drops, in some cases so does the birth rate. In this way the demographic transition is directly linked to the epidemiological one.

In Thailand, the demographic transition has indeed coincided with a marked decline in the infant mortality rate and an increase in life expectancy (see Fig. 2). This, in turn, has occurred at the same time as the death rates for many childhood diseases have fallen. From this, it is not unreasonable to infer that as families see more of their children survive, one of the societal results in Thailand has been a move toward having fewer children. The purpose of this argument is to show that the successful demographic transition can be used as a factor in determining the success of the epidemiological transition since the variables in each play upon the progression of the other.

Beyond their application to the demographic transition, the variables in Fig. 2 illustrate directly the results of the successful epidemiological transition, if not the transition itself. Clearly, as the shift has been completed away from infectious diseases that mainly kill the young, the statistics for infant mortality and deaths for children under five years of age have fallen dramatically. At the same time, life expectancy has increased as the mortality rates begin to be dominated by diseases and conditions that characteristically strike the elderly.

This methodology so far may seem indirect. After all, if one wants to chart the epidemiological transition, it might seem sufficient to put the death rates for infectious diseases on a graph with those for degenerative diseases. Unfortunately, the availability of disease statistics for Thailand make this straightforward approach nearly impossible. For the most part, the statistics for this study were obtained from two sources: the World Health Organization and the International Medical Foundation of Japan. Although each of these organizations received their numbers from the Thai government originally, there are still occasional discrepancies between the two. Whenever possible, this paper will refer to statistics taken directly from Thai government reports. However, since most statistics were gathered from the aforementioned secondary sources, discrepancies will be noted when they are deemed important or necessary.

Fig. 2: Comparison of life expectancy and mortality of children under five in Thailand. The left axis corresponds with life expectancy; the right axis corresponds with mortality - Under 5 and mortality - infant. (Source: World Resources Database).

One other peripheral set of statistics should be acknowledged prior to considering the disease statistics. Health facilities are widespread throughout Thailand, and this has been a major factor in the successful epidemiological transition. Thailand is divided into 73 Provinces, which in turn are broken down into 621 districts, which further segment into 6283 tumbons. As of 1985, 86% of the districts had a major hospital; however, every tumbon had a health center. This extensive coverage will become important when looking specifically at the containment of malaria and AIDS. Additionally, the widespread access to health care accounts for the percentages of 1-year olds who have had certain immunizations (Fig. 3). Of course, this immunization strategy influenced the epidemiological transition since these diseases rank among the major childhood illnesses.

Fig. 3: Percentage of children receiving major immunizations in Thailand. (Source: World Resources Database).

Mortality Statistics

It is immediately clear (Table 1) that the leading causes of death in Thailand have shifted from infectious diseases to degenerative diseases over the past forty years. One distinction between infectious and degenerative diseases that is often made involves degree of preventability. Infectious diseases -- such as malaria, tuberculosis, pneumonia, etc. -- are often labeled as more preventable than their degenerative counterparts -- heart disease, cancer, cirrhosis. However, this is a troublesome distinction since it can be said that many degenerative diseases are preventable. To clarify, preventable in this case refers mainly to societal and governmental variables, such as access to health care, sanitary facilities and clean water. This is still not adequate considering that environmental factors that are subject to government intervention are often considered causes of many degenerative diseases. However, for this study, it will suffice to leave the distinction fuzzy, but noted.

Rank	1950	1960	1970	1980	1990
No. 1	Malaria 195	Gastroenteritis 38.7	Accidents 27.2	Accidents 35.9	Heart Disease 49.6
No. 2	Tuberculosis 65.5	Tuberculosis 34.7	Tuberculosis 20.8	Heart Disease 31.4	Other Accidents25.3
No. 3	Gastroenteritis 65.1	Pneumonia 32.5	Diarrhea 17.6	Cancer 23.6	Cancer 22
No. 4	Pneumonia 39.4	Malaria 30.2	Heart Disease 15.3	Tuberculosis 14.3	Diseases of the Digestive System 18.4
No. 5	Dysentery 32.8	Heart Disease 19	Pneumonia 14.8	Pneumonia 10	Transportation Accidents 15.2

Table 1: List of the top five causes of mortality in Thailand over the years. The number below the cause indicates the number of deaths per 100,000 population. A note of further clarification: on this chart

the term malignant neoplasms has been changed to cancer. The source designated these particular death rates as malignant neoplasms of other sites. The reason for this distinction is unclear. In 1990, the death rate per 100,000 for all malignant neoplasms, or all types of cancer, was 39.3, which would move it to second on the list for that year. (Source: International Medical Foundation of Japan).

Another interesting comment about the leading causes of death revolves around the increased prominence of accidents. In fact, by 1987 injuries as a category -- which includes accidents, homicides and suicides -- accounted for more deaths than either infectious diseases or degenerative diseases. However, this is not directly relevant to the epidemiological transition.

The table of leading causes of death shows a marked decline in death rates of some of the major infectious diseases. Tuberculosis, for instance, fell from 65.5 deaths per 100,000 population in 1950 to 14.3 deaths per 100,000 in 1980. By 1990, it had dropped out of the top five, but Figure 4 illustrates that its mortality rate has continued to decline. Similarly, the death rates for pneumonia plummeted over the years. Malaria demonstrates the most striking example of the control of an infectious disease and will be discussed in detail later.

The table also illustrates the increase in degenerative diseases. It is unclear whether or not a significantly higher percentage of people contract these diseases now or whether the higher rates

Fig. 4: Mortality rates for selected causes in Thailand. Data for 1987 was generated using statistics from other years and trends. (Source: International Medical Society of Japan).

are simply a function of an increase in the older population prone to such ailments. The important factor to note is the increased prominence of degenerative diseases among the leading causes of death. Still, heart disease in 1990, which was responsible for 49.6 deaths per 100,000, cannot be compared to malaria in 1950 at an incredible 195 deaths per 100,000. This is another sign of the successful epidemiological transition. No longer does a single disease run rampant through the society, causing great numbers of deaths. Mortality in post-transition Thailand has become widely distributed with no single cause reigning supreme, but with degenerative diseases at the forefront.

However, despite the dramatic improvement in death rates for infectious diseases, morbidity rates still remain quite high in Thailand. Again, malaria is probably the clearest example of the success of controlling mortality, while being unable to conquer morbidity. In the tropical climate, it has proven extremely difficult to eradicate infectious diseases. It might be more accurate to say that the epidemiological transition in Thailand concerns the control of infectious diseases as a source of mortality. However, as the following discussion of malaria control over the past fifty years will show, infectious diseases may never be effectively limited as a source of morbidity.

Malaria Control in Thailand

In 1949, malaria accounted for 205.5 deaths per 100,000 population in Thailand, killing 38,046 people. By 1992, the death rate had fallen to 1.8 per 100,000 population for a total of 1,051 dead. These tangible results have been the result of better access to health care, which in turn has led to an increased distribution of anti-malarial drugs. Before tracing the course of malaria control programs in Thailand over the past few decades, it must be noted that the number of cases of malaria have not marked the same continual decline as the death rate statistics. In fact, morbidity for malaria has fluctuated since the mid-seventies (Fig. 6). The reasons for the difficulty in maintaining low levels of morbidity will become evident during the recounting of the history. However, the morbidity statistics do highlight the difficulty of obtaining accurate statistics about malaria. The World Health Organization recorded consistently higher numbers of cases than the Japanese medical association. There are many reasons why this might occur, all of which are factors in the spread and continued prevalence of the disease. One organization might be including cases from among the large number of workers who enter Thailand from neighboring countries to work. Additionally, migration of Thai workers within the country makes it difficult to obtain an accurate count, since many of these people end up traveling in areas where malaria is highly endemic. One other possibility may involve the problems of determining the number of cases within the indigenous hill tribes of the Northern region.

The ecosystem of malaria consists of three interacting organisms: human beings, mosquitoes and the parasite that causes the disease. The parasite is carried by the mosquitoes, which in turn infect human beings. Mosquitoes can also receive the parasite from infected people, thus increasing the diseases chances of spreading. Thailand has 62 species of mosquito that are capable of transmitting the disease; however, two species are the primary carriers. Because of its extensive rainy season, Thailand has many areas that become ideal breeding grounds for the insects. There are three types of parasites that are predominant in Thailand. Of these, increasing attention is being paid to P.Falciparum, which has shown high levels of resistance to many of the known treatments for the disease. Malaria has been eradicated in the major cities of Thailand. However, in rural areas throughout the country, malaria remains a problem.

Thailand began a concerted effort to control malaria in 1930 when the first Malaria Unit was formed in Chiang Mai to perform surveys, distribute medication and educate the general populace. In 1949, the first spraying of DDT inside houses occurred in Chiang Mai province in an effort to control the mosquito population and thus prevent transmission of the disease. At the same time, the distribution of anti-malarial drugs increased for use as both prophylactics and treatment. This two-pronged approach of attacking both the parasite and the mosquito, which is followed in

Fig. 5: Mortality rates for malaria. Data for 1987 was

unavailable. (Source: World Health Organization, 1949-1985; International Medical Foundation of Japan, 1986-1992).

Fig. 6: Malaria morbidity statistics for Thailand. The vertical axis represents the number of cases; the horizontal axis represents the year. (Sources: International Medical Foundation of Japan and the World Health Organization).

most malaria control programs, yielded positive results almost immediately, as noted by the World Health Organization:

Encouraged by the rapid reduction of malariometric indices in the pilot project area with residual insecticidal spray, the Government of Thailand decided to launch a nation-wide malaria control programme which was extended in a phased manner. Along with spray operations, for purposes of evaluation, malariometric surveys were carried out at quarterly intervals, and termed as a surveillance system. In addition, malaria mortality statistics were also collected.

This widespread household spraying did in fact have an immediate effect on the prevalence of malaria cases. One interesting question that will not be covered in this paper is the effect on the Thai population of having a toxic insecticide such as DDT sprayed inside homes. However, ignoring the possibility that the insecticide might be harming the general public, Thailand pressed ahead. In 1965, the government implemented a malaria eradication plan for the nation with the goal of conquering the disease altogether.

Their optimism proved to be premature. In a single year, between 1969 and 1970, the number of cases of malaria increased by 42 percent. There are many reasons for the increase, but perhaps the two most important reflect the adaptability of the mosquito and the parasite. Before spraying became widespread, mosquitoes usually fed on people inside their homes. Soon after spraying it became evident that the mosquito population was avoiding the DDT-sprayed houses, yet continuing to bite people outside where there was no concentration of insecticide. At the same time, the parasite was displaying an increasing rate of resistance to the prevalent treatments.

Throughout the seventies, morbidity continued to fluctuate, even as the mortality rates continued their downward trend. In 1982, a new health plan for the nation included the aim of integrating malaria control into primary health services. The result has been a cohesive local approach that covers the entire country.

Spraying was done by the village spraymen. Blood slides were collected by the health centre staff, by malaria volunteers and health volunteers. There is one malaria volunteer in each village in addition to health volunteers. Health education was being done by health communicators. There is one health communicator for a group of 10-15 houses.

Such an organized and pervasive approach holds the key to the second transition and eventually control of AIDS.

Controlling Human Behavior: Prelude to the Second Transition

As has been mentioned, reducing morbidity of malaria has posed a far greater challenge than reducing mortality. While the adaptability of mosquitoes and parasites play a major role in this challenge, the human factors are more important to examine for this paper. The government can -- and, in Thailand, does -- provide access to health care and medication, offer household spraying, and educate the public about the disease. But it is the responsibility of the general public to take advantage of these services. One factor in the continued morbidity is the refusal of many to have their houses sprayed, or to sleep under a mosquito net or near a mosquito coil. If the people do not follow the advice of the health professionals, it makes controlling the disease more difficult.

In the case of malaria, other human factors also contribute to the spread and perpetuation of the disease. Migrancy is a common occurrence in Thailand as a significant segment of the population moves around from place to place to work. These people not only lack immunity to local strains of parasites, but also introduce new strains into the area. Therefore, migrant workers are likely to become infected in the new area as well as help to infect the local population. This problem is compounded by foreign workers who introduce parasite strains from other countries. Another problem occurs with the improvement of the infrastructure and what might be called economic progress. Two examples are the building of dams and deforestation for timber. The first increases the breeding grounds for mosquitoes; the second brings the human population into contact with mosquitoes and parasites previously out of range. Both increase morbidity. One final challenge to malaria control are refugees, a common phenomenon among the often politically unstable countries of the region. For example in the early 1980s, Thailand became home to half a million people fleeing Cambodia. Although mosquito controls were implemented at the refugee camps, an increase in malaria was almost inevitable with the mixing of local and foreign parasites.

So what are the policy implications of the history of malaria control and what path should be followed in the future? It has been shown that control of morbidity is a nearly impossible proposition. Mosquitoes are a fact of life in Thailand; the only way to get rid of them would be to completely destroy their environment. No one is advocating razing the forests; at least, not for the purpose of mosquito control. Morbidity will fall naturally, and already is, as the economic progress of the country begins to reflect itself in higher employment rates, less migrancy and better housing. The best policy route, besides continuing education on avoiding being bitten by mosquitoes, is to follow the road already taken toward better health service nationwide.

It is the difficulty of controlling human behavior that leads to the second epidemiological transition in Thailand and AIDS. Malaria has human behavioral factors involved in its spread, but reducing the mortality rate does not rely on controlling these. For malaria, the government can afford to concentrate on those areas on which it can have a definite impact, while allowing behavior control to be a secondary concern. The second transition, however, requires that Thailand take exactly the opposite approach:

One cannot compare AIDS to diseases such as cholera and malaria, which currently claim the lives of more people. AIDS reaches further into society than these diseases because (a) it affects people during their most productive years in which they are typically responsible for the care and support of both children and elderly parents; (b) transmission of the virus generally goes unrecognized; and (c) no cure is available, and probably will not be during this century.

Instead of treating those who have the disease as the first priority, AIDS must be prevented from spreading by changing the behaviors of the populace that lead to the transmission of HIV. AIDS cannot be cured once it is contracted; people with the HIV almost inevitably will develop AIDS. It is crucial to stop the transmission at the source.

The Second Transition: AIDS

One of the most interesting, and terrifying, aspects of AIDS is the speed with which it is able to spread through a population, if the conditions are favorable. As will be shown, Thailand has proven extremely hospitable to the HIV virus. Unlike malaria, health officials know exactly when the first AIDS victim appeared in Thailand and are able to trace the entire course of the disease to date.

The first case of full-blown AIDS was reported in Thailand in August 1984. The patient was a 28 (sic), bisexual male and had just returned from the United States where he had spent 2 years. He was hospitalized there and then returned home where he received additional care. He died by the end of 1984. Due to this alarming event, serological investigations of the high risk group were begun that year.

The second reported case, in December 1984, was a homosexual foreigner who returned home after a short period of stay. In 1985, 4 more cases were reported. Three are foreigners, who had acquired infections abroad. The only Thai patient was a 27 year old bisexual male who had contracted the disease from a German who visited Thailand every 2 to 3 months. The patients female partner was also infected and was classified with HIV as ARC (AIDS-related complex).

As was the case in many countries, the initial appearance of AIDS led to stigma. In Thailand, AIDS was viewed as a foreign disease transmitted through homosexual contact. However, at the same time, the health community in Thailand proved itself less short-sighted than some countries, acknowledging that the disease would spread.

Asymptomatic carriers are more likely to spread the disease. Without serological examination, they do not differ from the general population. The total number of asymptomatic carriers is not known, however, the average incidence of seropositives among the high risk population (i.e. homosexual/bisexual men, female prostitutes, persons who received blood transfusions and intravenous drug abusers) in four seroepidemiological surveys conducted in Bangkok and Pattaya ranged from 0.6 to 2.4 percent. This nod to the HIV virus showed the willingness to admit that the disease was hidden among the population.

By 1988, the government had recorded a total of 3,138 carriers of the HIV virus, 38 of whom had developed symptoms of some sort. Clearly there were many more: by 1994, more than triple that number had full-blown AIDS (See Fig. 7). The Thai Ministry of Public Health estimated that between 500,000 and 600,000 Thais were infected with HIV by 1993. Projections have been done that estimate that, without significant changes in behavior among the populace, there will be between 3.4 and 4.3 million Thais infected by the year 2000. This is a staggering prediction considering that within ten years of being infected with the HIV virus more than 67 percent of people are expected to develop AIDS and die within the next two years. Using this framework and the Ministry of Public Healths current estimate of HIV carriers, it can be inferred that by the year 2003 an additional 335,000 people will develop AIDS and probably die by the year 2005. Even dividing this number of deaths over 10 years would still mean approximately 33,500 deaths a year or a mortality rate of 55.8 per 100,000. Referring back to the leading causes of mortality shows that AIDS will clearly take over as the leading killer, even without the truly apocalyptic predictions.

Fig. 7: New cases of AIDS reported in Thailand annually. Cases of AIDS-related complexes -- conditions linked to the HIV virus and its weakening of the immune system -- have not been included, since statistics for these are sketchy and unreliable. (Source: International Medical Foundation of Japan and the World Health Organization).

Although Thailand currently appears to have the worst AIDS problem within Asia, it must be noted that South and Southeast Asia as a whole currently sits on the brink of a major health crisis. Cases throughout the region have been increasing at an exponential rate (see maps). According to the World Health Organization, as of the middle of 1993, more than 1.5 million people in the region were infected with HIV. Because AIDS strikes those in their prime working years, the epidemic is also expected to have a devastating effect on the economic growth that has skyrocketed throughout the region in recent years. This topic, however, is to large to be handled satisfactorily in this study.

As noted, the first cases of AIDS were attributed to homosexuals and foreigners. Following the lead of other countries, Thailand first focused their efforts on gay men, prostitutes and intravenous drug users. The last two groups in particular have been responsible for much of the spread of the disease, although it is now clear that the disease is spread primarily through heterosexual contact (Fig. 8). However, to understand why the heterosexual population became the focus of transmission so rapidly, two societal issues must first be addressed: the drug problem and the thriving sex industry.

Map 1.

Map 2.

Map 3.

Map 4.

Drugs, particularly opium, have always been present in Thailand. The Golden Triangle area, which encompasses the far northern part of

Thailand as well as parts of Burma and Laos, currently accounts for a large portion of the heroin trade worldwide. In the early 1980s, Thailand saw a sudden increase in heroin addiction, particularly among young men living in urban areas. In terms of AIDS, the most important factor was the sharing of needles used to inject heroin. One study showed that in Bangkok in 1982 between 82 and 92 percent of heroin users took the drug intravenously. In 1988, a seroprevalence survey of drug users was taken at clinics in Bangkok. The first survey taken between January and March determined a rate of 15.6 percent HIV-positive; just six months later that already high rate had risen sharply to 42.7 percent.

Recognizing the problem, drug clinics, particularly in Bangkok where the number of addicts was highest, began to integrate AIDS awareness and prevention into their programs. Demonstrations on how to properly use condoms and clean needles with bleach became common. The clinics now provide a number of treatment options ranging from a 45-day detoxification course. . . to promoting safer ways of administering heroin (e.g. by smoking), to meditation to reduce the need for a chemical high.

While the drug problem has posed serious challenges in the control of AIDS, by far the most serious obstacle to limiting the spread of the disease is Thailands widespread sex industry. Most intravenous drug users are found in Bangkok and parts of the north. Prostitutes are found virtually everywhere in Thailand. Some estimates on prostitution place the number of sex workers in Bangkok between 100,000 and 200,000 with as many as 800,000 for the entire country.

Fig. 8: Method of transmission in Thailand of HIV based on the category of the person who causes the infection. Abbreviations: Het.-Heterosexual; Hom.-Homosexual; Bi-Bisexual; IDU-Intravenous Drug User. The term vertical refers to children who have been infected through their mothers. (Source: Thai Ministry of Public Health, 1994).

A survey done in June 1991 found that 24 percent of brothel prostitutes were HIV-positive. The same survey showed that in northern provinces, which do not include Bangkok, this rate was over 40 percent.

Attitudes toward sex and prostitution in Thailand pose the biggest threat to controlling the AIDS epidemic. Thai men regularly go to prostitutes for sex. One survey showed that 44 percent of Thai men lost their virginity with a prostitute at an average age of 18. Another group of surveys found that 75 percent of all Thai men have had commercial sex at least once in their lives, 16 percent within six months of the survey. Many of these men contract the virus and then go home to their wives. This connection between commercial sex and infection between spouses illustrates another aspect of prostitution in Thailand:

The circle may be especially vicious because of a peculiarity of Thai prostitution. There are many male prostitutes as well as female ones. The men who service foreigners tend to be heterosexual by preference, and often have wives and girlfriends (some of them prostitutes too) to whom they pass the virus. This creates a frighteningly wide channel of transmission between the homosexual and heterosexual pools.

Two other factors increase the frequency of transmission within families. First, homosexuality does not carry the stigma in Thailand that it has in Western countries; many married men will have sex with male prostitutes. Also, prostitutes who charge lower rates and cater to average Thai men, rather than rich locals and foreigners, tend to have a higher incidence of the HIV virus. According to a government seroprevalence survey done in 1991, only five percent of prostitutes charging high rates were HIV-positive, as compared to 20 percent of those charging low rates. These lower paid prostitutes are also more likely to engage in sexual activity with more clients in a single day than higher paid sex workers.

All of this leads to one of the more tragic aspects of the AIDS situation in Thailand: the infection of children through their mothers. One prediction posits that as many as three million children will be born to HIV-positive mothers during the onset of the next century; of these, one million will probably die of AIDS while the rest will probably end up orphans. This, in turn, will place an incredible economic burden on Thailand as a whole.

Because of the danger involved, the most obvious policy route would appear to be a nationwide crackdown on prostitution. Brothels operate very openly in Thailand and arrests for prostitution are infrequent at best. There are two reasons for this: corruption and tourism. The first is seen mostly on a local level. The sex industry provides an economic engine for many segments of the country, from which many local officials and businesses profit. Breaking this cycle of corruption is a daunting prospect.

Policy toward prostitution on the national level does not help matters either, since it is intertwined with the booming tourist industry. Thailand has become one of the most popular tourist destinations in Asia, helped in part by the lure of the sex industry. It is a telling coincidence -- or possibly not a coincidence -- that 1987 was declared Visit Thailand Year, and 1989 officially became the Year to Combat AIDS. Patphong Road, one of Bangkoks foci for the sex trade, is often visited by busloads of tourists. Two-thirds of the visitors to the country as of 1992 were male, and there still are organized sex tours from Japan, Taiwan, South Korea, Australia, the United States and Europe. The foreigners create two problems: the possibility of bringing HIV with them from their home country, and the likelihood that they will export it back with them. Though it is not certain how many of these tourists actually engage in sexual acts with prostitutes, the surge in tourism still initially made the Thai government reluctant to discuss the problem of AIDS, for fear of scaring away foreigners and their money.

Despite the governments early reticence, the full scope of the problem has now been acknowledged, including its connection to tourism. The Thai government has initiated a full-scale plan to combat AIDS, including public service announcements and condom distribution. The government distributed 70 million condoms in 1991 alone. Another aspect of the program has been to increase the scope and availability of testing for the HIV virus. However, reports are mixed as to whether or not condoms are used in commercial sex. In the minds of foreigners and Thai men, Thai women, especially prostitutes, are expected to be subservient and eager to comply with their wishes. Brothel owners propagate such thought with the bottom line being that the decision to use a condom rests with the client, not the prostitute.

The Effects of the Second Transition

It is clear that if drastic changes are not made in behavioral patterns that AIDS will become a major cause of mortality in the coming years. In fact, based on number of people starting to come down with full-blown AIDS, it seems that it is already inevitable that many will die: the key now is to keep some control over the situation. In looking at AIDS in terms of a second epidemiological transition -- the shift back to infectious diseases -- the basic nature of the disease must be acknowledged. AIDS weakens the immune system. This, in turn, increases the vulnerability to opportunistic infectious diseases. Although the death rates for other diseases, such as tuberculosis, have not yet increased, it is to be expected that they will as the number of AIDS cases goes up. This will lead directly to the second transition.

The effects of this transition on the country will be widespread. Domestically, a shortage of labor, both in quantity and quality, may occur with an increase in AIDS. High rates of absenteeism brought on by illness will certainly be disruptive to companies. Finding workers to replace those that have died will be difficult and costly. Health care costs will skyrocket as more and more people begin to get sick. There will also be great expense, both sociologically and financially, due to the large number of children whose parents will die. Looking at many of the variables that this study used to show the successful completion of the first transition, the U.S. Department of Commerce made projections for the year 2010 with and without AIDS for Thailand. It predicts that, if the disease runs the course it is currently on, infant mortality will more than double and child mortality will quadruple. Life expectancy at birth will fall from around 75 years to closer to 45. Finally, the population growth rate will go from being positive to negative.

Predicting the number of people who will die of AIDS in the coming years is a particularly difficult proposition. There are too many factors that affect the spread of the disease and too many unknowns among the current population (i.e. the number of HIV-positive Thais). However, Figures 9 and 10 show the results of using two basic methods of creating projections on the current number of AIDS deaths. As can be seen, the two projections differ wildly. The linear projection presents an unrealistic picture of the future, with AIDS deaths rising slowly, but steadily, over the next two decades. Although it is probably too drastic, the exponential projection in Figure 10 is also, unfortunately, more accurate. The projection only works until the year 1998, after which the number of AIDS deaths for the nation exceeds the total population. It should be noted that this dire prediction is based on the number of deaths for 1990-92. The curve would undoubtedly be even steeper if data from the last two years was available since the number of deaths will have gone up. This projection is not useful as a pragmatic tool for dealing with the epidemic logistically. It is nearly unthinkable that more than 20 million people, nearly half of Thailands population, will die of AIDS in 1998. However, this curve is extremely important to note because of the rapid increase that takes place in a very short span of time. Up until the projection for this year, the curve is

Fig. 9: Linear projection of AIDS deaths based on 1990-92 statistics. Year one corresponds with 1990; year 21 is a prediction for the year 2010. (Source: International Medical Foundation of Japan).

Fig. 10: Exponential projection of AIDS deaths for Thailand based on 1990-92 statistics. Year 1 corresponds to 1990; year 9 corresponds to 1998. The projection for deaths in the year 1999 exceeded the population of Thailand, and therefore has not been included. (Source: International Medical Foundation of Japan).

relatively flat. Suddenly, in 1996, the number of deaths skyrockets. While the reality will not mimic these particular numbers, it is almost certain to mirror the trend. As has already been shown through the dramatic increases in both the number of cases of HIV and full-blown AIDS, within the next two decades the curve seen in the exponential projection will become the unfortunate reality.

However, another type of projection is more useful in terms of setting a timetable for policy within Thailand. Using a logistic curve fit with an upper limit, it is possible to avoid the pitfalls of the exponential and linear graphs. By setting an upper bound, the projection maintains a limit without sacrificing the ability to view the general trend, which in the case of AIDS and HIV infection is quite dramatic. In order to do these projections, it must be noted that two statistical references were needed. For the projection of HIV infections (Fig. 11), the two data points used were the Thai government estimate of 500,000 cases in 1993 and the projection cited of a possible 3.4 million people with the virus by the year 2000. The graph of AIDS deaths (Fig. 12) was extrapolated from the same numbers, using the 67 percent formula cited earlier. Of course, it must be acknowledged that basing a projection on numbers acquired, respectively, from an estimate and a projection gleaned from other sources is not the ideal situation. Still, while the actually numbers may be debatable, the trend shown can not be ignored.

The upper limit for the two graphs provided was set at 7 million, a rather arbitrary doubling of the HIV infection statistic for the year 2000. Although these are the only projections included in this paper, a number of other options were calculated using upper bounds ranging from 5 million to 56 million, the entire population of the country. It is important to consider the upper limit set as a worst case scenario, the total number of people that might contract the disease. In experimenting with the limit, an interesting phenomenon was found. Regardless of the worst case scenario envisioned, the HIV projections showed that it would come to fruition around the year 2010, give or take a few years. In other words, no matter how many people are believed to be at risk from contracting HIV, the projection predicts that with the current trend very nearly all of them will have it by the year 2010. Not surprisingly, the AIDS graphs with various limits also showed striking similarity in shape and end point, predicting that deaths will peak around the year 2020. Though it is impossible to say how many people will contract HIV or eventually die from AIDS, these projections provide policy makers with a framework in which to plan for the epidemic at hand.

Fig. 11: Logistic projection of HIV infections in Thailand with an upper limit set at 7 million. Year 0 (not shown) is 1993. Year 33 is 2026.

Fig. 12: Logistic projection of AIDS deaths in Thailand with an upper limit set at 7 million. Year 0 (not shown) is 1993. Year 31 is 2024.

Conclusion

Unfortunately, the outlook for Thailand from a health perspective is bleak. As was mentioned earlier, the second transition is not a foregone conclusion, but the statistics make it appear very likely. To make matters worse, death rates for AIDS in Thailand still barely register among the leading causes of mortality -- only 248 people died of AIDS in 1992. Of course, the low number of deaths in itself is not a bad thing, but it presents a misleading picture of what is really happening. Just as the number of cases has shot up dramatically in the past couple of years, so will death rates in the next two or three, as seen in the projections. It is inevitable because AIDS is incurable. There is always the hope of a cure, a medical breakthrough. Currently, the World Health Organization lists over 150 experimental drugs and at least 13 vaccines undergoing testing worldwide. A cure would almost immediately end the epidemic, assuming it was not reserved for those able to pay for it, and make the second transition nothing more than a theory. But this type of dream -- and currently it is just that -- combined with the low death rates in Thailand serve to do nothing except become misleading arguments against drastic action.

So what are the policy implications for AIDS? For this, the first place to look is at the malaria control program. Every tumbon should have an AIDS volunteer, just as there is a malaria volunteer. This person, or group of people, should be responsible for making sure that all local sex workers are educated about AIDS, that condoms are widely distributed and that regular testing occurs. Thailand has already proven itself capable of providing health services nationwide. Now AIDS education and treatment must become part of primary care just as malaria has.

The second policy implication will be far more difficult to enact, let alone enforce: a change in attitude toward sex and women among Thai men. Brothel owners must allow prostitutes to insist on condom usage. Thai men must be convinced not to patronize brothels or, at least, not to engage in unsafe sex. Changes such as these do not fall easily into a government plan of action; it is nearly impossible to legislate respect for women. One way to obtain greater control over the spread of AIDS within brothels would be to legalize prostitution and then regulate it. This would undoubtedly be a controversial proposition, though there are probably fewer societal impediments than in other countries. If the government were enabled to license and monitor brothels, it would also be able to mandate condom usage and limit the number of prostitutes allowed to work. Of course, as is always the case, governmental control would bring a whole new set of problems without necessarily solving the original ones.

There is one guarantee. Attitudes towards sex among the general population will change, just as they did in the homosexual and drug user communities in Thailand, as people begin to see those around them die. Unfortunately, in Thailand that may be the only way that sexual habits will change and the AIDS epidemic will be slowed. Sadly, it seems, based on this, that the second epidemiological transition will occur with devastating consequences. This is what the Thai government must be prepared for, the worst case scenario as seen in the logistic projections. While it does everything in its power to try and convince people to change their behavior, the government must be ready to deal with the health crisis that will come if it fails to achieve this original goal. The timetable can be seen in the graphs (Fig. 11 and Fig. 12). The attempts at prevention must be fully implemented immediately because it is in the next ten years that the majority of HIV infections will occur. Looking ahead, policy makers must plan for a dramatic increase in the number of AIDS sufferers between the years of 2010 and 2020. This is not too far in the future, and all sectors of the government must have plans to deal with the problem in the event that the worst case scenario should come to pass.

Notes

References (a) (b)

CHAPTER NINE

ELIZABETH J. LOMBARD

LESSONS ON IMPROVED COOKSTOVE DIFFUSION: INDIA, KENYA AND CHINA

Introduction

The diffusion of fuel-efficient biomass stoves throughout the developing world began in the early 1980s and was largely justified as a "demand side" solution to the fuelwood crisis (Barnes et al., 1994). Although limited numbers of improved stoves had been promoted worldwide since the 1950s, these were concerned mainly with reducing health problems related to wood smoke exposure (Chege, 1993). By the 1970s, however, with annual human population growth rates peaking at over three percent in developing countries, and stocks of renewable resources such as fresh water and wood rapidly declining, problems related to population-environment interactions began gaining the attention of policy-makers. The fuelwood problem was placed on many national agendas. Over half of the world relied on fuelwood for home energy. Numerous studies reported that villagers spent greater amounts of time searching for firewood and increasingly resorted to the burning of dung and crop residues for domestic energy -- tell-tale signs of fuelwood shortage (Agarwal, 1986; Barnes et al., 1994; Mellor, 1988). Rural communities such as those in mountainous regions of Nepal and Peru, and arid countries in the Sahel, were depleting their surrounding fuelwood stocks at alarming rates in order to supply household energy needs (Mellor, 1988). Total fuelwood demand was exacerbated by the oil crisis of the 1970s when many poor urban dwellers, previously using kerosene and natural gas to cook, reverted to woodfuel (including charcoal) use in response to the rising cost of petroleum (Chege, 1993). As the Table 1 illustrates, by 1980, fuelwood scarcity affected major regions throughout Sub-Saharan Africa, Asia and Latin America.

Besides the direct concern that decreased stocks of fuelwood would lead to a widespread rural energy shortage, the fuelwood situation was regarded as dangerous for other reasons. Excessive fuelwood consumption was believed to be a major cause

of local deforestation, leading to a cascade of ecological problems such as soil erosion and species extinction. Furthermore, because fuelwood shortage caused an increased

Table 1: Fuelwood use by selected ecological regions: 1980

(in cubic meters per cap. per year)

Region	Need	Availability	Fuelwood status
Sub-Saharan Africa			
-arid	.5	05 - .01	Acute scarcity
-mountainous	1.4 - 1.9	.5 - .7	Acute scarcity
-savanna	1.0 - 1.5	.8 - .9	Deficit
Asia			

-mountainous	1.3 - 1.8	.2 - .3	Acute scarcity
-indo-gangetic plains	.2 - .7	.15 -.25	Deficit
Latin America			
-Andean plateau	.95 - 1.6	.2 - .4	
Acute scarcity			
-semi arid	.7 - 1.2	.6 -1.0	Deficit
-arid	.6 - .9	.1 - .3	Acute scarcity

reliance on crop waste and dung to supply household energy, concern arose that farmers were returning less biomass to the earth, thereby lowering soil fertility and agricultural output (Barnes et al., 1994).

Wide-spread rural diffusion of fuel-efficient cooking stoves, therefore, was seen as a promising way to reduce overall fuelwood demand -- since an average 75 percent of biomass energy is used for cooking -- and allow rural communities to restore their fuelwood stocks until they made the transition from woodfuel to other fuels (see Diagram 1 and Graph 1).

Diagram 1.

Graph 1.

With great enthusiasm, programs were launched by national governments, international development organizations such as UNICEF, the Food and Agriculture Organization (FAO) and CARE, dozens of smaller aid organizations, and private companies. By the mid-1980s, over 100 improved cookstove programs were underway in more than 60 developing countries (see map entitled Improved Cookstove Projects: Selected Countries).

As early as 1983, however, feedback on cookstove projects was not encouraging. After initial introduction of stoves to rural areas, dissemination was not spontaneously taking place as predicted. The seeming advantages of fuel-efficiency did not appear to be an adequate incentive for the local purchase of new stoves, even with subsidies. Moreover, many new stoves did not meet local needs, did not live up to their laboratory efficiency rates, and did not hold up to the rigors of daily use. Within months, many dissatisfied households abandoned their improved stoves and returned to their previous way of cooking -- over a three-stone fire, or with other low-efficient traditional stoves. By 1986, fewer than 12 of the more than 100 woodstove projects world-wide were believed to have distributed or sold over 5000 stoves (Agarwal, 1986). A 150-page report by the International Institute for Environment and Development (funded by the World Bank, United Nations Development Programme, and several other foundations) seemed to seal the cookstove coffin by questioning the basic value of most projects worldwide: The wrong stoves were promoted for the wrong reasons in the wrong way, (Brown, 1985, Foley, 1983).

Map 1.

Nevertheless, in its 1994 review of stove programs throughout the world, the World Bank reaffirmed the value of cookstove projects, and the capacity for cookstove diffusion to take place:

The social, economic, and environmental benefits of promoting improved stoves under suitable circumstances are quite large, and the existing successes demonstrate the usefulness of well-managed programs. (Barnes et al., 1994).

In order to explain this attitude transformation toward cookstove programs -- stemming from the failures of many cookstove projects in the early 1980s followed by their rebound in the last decade -- I will focus on three countries where dissemination of cookstoves has been greatest: India, Kenya and China. Because these countries represent three disparate approaches to cookstove program design and implementation -- resulting in poor dissemination in India, moderate dissemination in Kenya, and overwhelming success in China -- they offer important lessons to present and future efforts to spread fuel-efficient cooking technology throughout the developing world. I will not address whether improved cookstove diffusion does, in fact, reduce woodfuel demand or improve environmental conditions. Rather, I will focus my discussion narrowly on the elements of successful and failed cookstove dissemination efforts by presenting case studies of the aforementioned countries.

India

Indias fuelwood shortage, serious 20 years ago, has now reached critical heights. Indian per capita consumption of woodfuel has held steady for the past 2O years while its total population has grown by nearly two-thirds (see Graph 2).

Graph 2.

A sharp increase in the price of commercial fuels (kerosene, coal and charcoal) over the last 15 years explains the persistent use of fuelwood for cooking among urban poor, while fuelwood scarcity in rural areas has caused many families to turn to the burning of dung and straw for household energy (see Table 2).

Table 2: Fuelwood Prices in Selected Indian Cities

FUELWOOD PRICE IN RUPEES, PER TON

CITIES	1960	1986	1992
Ahmedabad	90	740	1191
Bangalore	47	657	1135
Bombay	84	1232	1812
Calcutta	93	1040	1585
Hyderabad	66	667	917

Today, India still relies on woodfuel to satisfy 24 percent of its total energy consumption. The World Resources Institute report for 1994-95 indicated that Indias forests can sustainably provide 41 million cubic meters of fuelwood per year, although current annual demand for wood stands at 241 million cubic meters (World Resources Institute, 1994). In the village of Gujarat, India, it takes an average of 3 hours per day to collect wood for a family of 5; one family member --usually a child -- often spends all of her time outside the home completing this chore (World Resources Institute, 1994).

Hoping to abate this national thirst for woodfuel, the Indian National Programme on Improved Chulhas (stoves) was launched in 1983 (Barnes et al., 1994). Administered by the central bureaucracy, as well as in six regional offices (and in numerous state and district offices), the program aimed to disseminate hand-made clay and mud stoves (equipped with chimneys) in order to double the fuel-efficiency of traditional three-stone fires and reduce indoor air pollution (Barnes et al., 1994). The government took a campaign approach to dissemination, implementing an aggressive country wide effort, with special emphasis on rural India. Ten-day demonstration camps were held to motivate and involve villagers, local government functionaries and students in the rapid diffusion effort (Agarwal, 1988). Local women, especially, were targeted for the building and marketing of chulhas (Chege, 1993). A major component of the diffusion strategy was the provision of a government subsidy to all households purchasing an improved stove. A minimum 50 percent subsidy was available, reducing the cost of new stoves from $10 to $4.30 (Kammen, 1995; Barnes et al., 1994).

As a result of this massive campaign, India quickly disseminated improved stoves to about 8 million households. However, fundamental weaknesses in this approach gradually became apparent. Because it involved multiple levels of government bureaucracy, program administration was cumbersome and fractured (Kammen, 1995). Furthermore, the program lacked an adequate budget for consistent monitoring and evaluation so that problems were not detected and corrected early on. Lastly, the program was quickly diluted, being only one of several national campaigns occurring at the time.

Presence of a large government subsidy also presented its share of problems. Because the government automatically paid builders for half the cost of stoves, producers incentive for construction was directed more toward the government than toward the needs of the consumer (Barnes et al., 1994). Producers took a less aggressive role in marketing than would private entrepreneurs, and were cued to follow overly-general government specifications for stove construction, rather than tailor stoves to meet the particular needs of the community. Consequently, local stove construction was often hasty and technically faulty. Many stoves did not accommodate the household cooking pot or crumbled under excess heat. In two Indian villages, inadequate training of students (of urban background) resulted in the construction of numerous chimneys that expelled smoke within the house (Sarin and Winblad, 1983).

Moreover, many of the stoves simply did not provide the promised savings in household woodfuel consumption. Its very hard to get the critical dimensions for efficiency without highly-trained craftspeople, explained John Lippert of Volunteers in Technical Assistance (VITA), a US-based development organization involved in stove dissemination until

1987 (Brown, 1985). Similar cookstove projects in areas such as Central America and Nepal, where stoves were constructed from mud, sand and clay by poorly-trained individuals, also attained efficiency and continuation rates much lower than predicted (Barnes et al., 1994).

The heavy government subsidy for cookstoves also squelched efforts by private entrepreneurs to disseminate their own improved stoves as they could not compete with the government price. As will be illustrated in the cases of Kenya and China, commercialization of improved stoves is key for long-term, self-sustained cookstove dissemination.

Another flaw in the Indian program was its failure to target regions where fuel shortages were especially acute, or where woodfuel was an expensive commodity, such as in urban settings. Many rural households could not afford or were not willing to make even the modest $4 investment, especially if they could gather fuelwood for free; the purchase of a new stove, especially in the eyes of men, did not seem to provide adequate return. Attempting diffusion in impoverished, non-critical zones wasted precious financial resources for Indias cookstove program, and discouraged program implementers (Barnes et al., 1994).

In sum, the Indian effort at cookstove diffusion progressed rapidly at first, but, riddled with administrative, technical and marketing mishaps, resulted in poor wide-spread dissemination. By 1990, the average discontinuation rate for improved cookstove use in India was 50 percent -- among the worst globally. Today, approximately one in 40 Indian homes is equipped with an improved woodfuel stove (see Figure C).

Nevertheless, faced with worsening population pressures and fuel shortages, India remains determined today that improved chulhas can play an important role in mitigating woodfuel demand. The government has modified its top-down strategy, and has begun to integrate some of the successful aspects of cookstove programs that will be enumerated in the remaining discussions on Kenya and China.

Kenya

With few domestic sources of energy such as coal or petroleum, approximately 80 percent of Kenyas total energy consumption is in the form of traditional woodfuel (WRD, 1994). With higher rates of total fertility and per capita consumption of traditional woodfuels than either China or India, Kenyas woodfuel crisis risks progressing at a much more rapid pace (see inset of map entitled Total Fertility Rate: Cookstove Countries, and Graph 3). As a proxy measure for fuelwood shortages in Kenyas arid regions

Graph 3.

(representing 80 percent of Kenyas total land area) the fuelwood gap in neighboring Sudan illustrates the grave woodfuel situation in arid East Africa (see Table 3):

Table 3: Woodfuel Gap Forecasts for Sudan (million cubic meters of tree stock)

	1980	1985	1990	1995	2000

1. Forest stock	1994	1810	1539	1145	607
2. Forest growth	44	40	34	25	14
3. Woodfuel consumption	76	88	102	121	141
4. Woodfuel gap (3-2)	32	48	68	96	127

By 1983, rural women in Kenya were traveling on average 3.5 hours per day to collect wood. Facing high woodfuel prices, but having no cheaper fuel alternative, urban Kenyans spent an estimated 20 percent of their average annual income on household fuel (Kammen, 1995).

In the early 1980s, the Kenya Renewable Energy Development Project, a collaborative effort between the U.S. Agency for International Development and the Kenyan government, was created. Over the next 15 years, the project used a cyclical refinement process to design and disseminate appropriate cookstoves for Kenya. Their first fuel-efficient stove -- capable of burning both wood and charcoal -- was modeled after an improved metal stove developed in Thailand (Kammen, 1995). Since many Kenyans had traditionally employed metal cookstoves for years (made from scrap metal by local artisans), it was assumed that the switch to the modified Thai Bucket would be a smooth one. After minimal field testing, therefore, this first generation stove was disseminated to villages throughout rural Kenya.

Consumer response to this new stove was equivocal. First, the stove had a narrow base, making it unstable for heavy pots, especially with rigorous stirring. Second, the laboratory-designed stove did not match the size of Kenyan pots and pans fitted for the traditional metal stove. Third, the stoves ceramic and vermiculite liner proved too efficient: it retained so much heat that the metal exterior fatigued and structural segments cracked easily (Barnes et al., 1994, Kammen, 1995).

Map 2.

Furthermore, like India, efforts to diffuse new cookstoves in Kenya were focused in rural areas, where people could ill-afford the initial cash outlay for a stove, and had little monetary incentive to save wood.

Early monitoring and evaluation of cookstove projects, however, picked up on the poor diffusion rates much more quickly than in India. Consequently, the Kenya Renewable Energy Development Project began to develop a second generation of cookstoves. Enlisting feedback from womens organizations involved in community health and environmental protection, as well as focus groups from several regions, a new stove, the jiko, was recast in the mid-1980s. The jikos hourglass shape provided greater stability at the base of the stove. Its insulative liner -- extending only within the upper portion of the stove --prevented the overheating and cracking typical of the previous version. Finally, its mouth accommodated a greater variety of pots (Kammen, 1995).

Next, the Kenyan cookstove program began working with private craftspeople to ensure on-going, mass production of the jiko. As one analyst described, Project managers debated whether to give the job to the formal or informal sector -- and ultimately decided to involve both, (Chege, 1995). A loose consortium of artisans engaged in traditional stove production was selected to manufacture the metal cladding of the new jiko, and existing pottery companies began producing the more complicated ceramic linings (Chege, 1993; Kammen, 1995). Mass production and competition brought down the price of the jiko, making it affordable to more Kenyans.

Finally, surveys were conducted to determine the strongest potential markets for the jiko (Barnes et al., 1995). The stove was targeted specifically for urban dwellers who faced unavoidably high fuel costs and who did not rely on fire for uses other than cooking. The new stove, while costing between $2 and $5 (approximately two to three times as much as the traditional metal stove), provided a total yearly savings of about $64.70, paying for itself in two months (Chege, 1993; Kammen, 1995; Barnes et al., 1994). Moreover, purchase of jikos by highly visible organizations such as schools, businesses and churches helped to spark interest within the general population (Kammen, 1995). Additionally, possession of a new jiko became a symbol of status among lower-income Kenyans, increasing cultural diffusion of this technology throughout and beyond the city.

The design changes of Kenyan cookstoves, coupled with new marketing strategies as well as training programs on production, use and maintenance, have made huge strides in the stoves acceptance. Diffusion of the jiko currently stands at approximately 20,000 per month (Chege, 1993). Because of its success, moreover, the jiko has been disseminated in several other East African countries -- Sudan (28,000), Tanzania (54,000), Uganda (25,000) as well as Zambia and Burundi (Kammen, 1995).

The diffusion of a third generation of improved cooking device tailored for rural Kenya is currently underway. With the assistance of numerous womens groups in the rural regions (forming an alliance called Maendeleo ya Wanawake -- womens development), government and aid organizations have designed a cheap and simplified version of the jiko -- the Maendeleo (Kammen, 1995)., This innovation is essentially the ceramic portion of the jiko without the metal frame. It is placed directly over an open fire, and accommodates large pieces of wood. (This is a major advantage to rural women, many of whom do not have the tools or inclination to chop wood into fine pieces for small, portable stoves). While less efficient than the jiko (attaining 15 to 35 percent efficiency versus the jikos 20 to 40 percent efficiency), the Maendeleo still requires 25 percent less wood than a three-stone fire, and costs the consumer between $.80 and $1.20 (Kammen, 1995).

To be expected, diffusion of improved cookstoves in rural Kenya, as well as in rural India, will progress slowly as long as fuelwood is a free commodity and womens time is not monetized (see Figure B). With increased womens education and entrance into the labor market, however, rural husbands may be more willing to invest in time-saving technology for their wives, knowing that the time they save will be used to earn family income (see map entitled Education of Women...Cookstove Countries).

China

Chinas motivation for initiating a national cookstove program was rooted less in a concern over fuelwood shortage, and more in a desire to reverse households rapid conversion to coal as their fuel of choice (Smith et al, 1993). With the liberalization of the rural economy in the early 1980s, average family income steadily increased in the countryside, bringing with it a general desire to climb the energy ladder. Mass ascension from woodfuel to coal use caused nation-wide supply shortages of coal, especially to large industry .

graph

As part of its strategy to mitigate coal demand, the government devised a plan to disseminate highly-efficient biomass stoves so that woodfuel consumption would become cheaper than coal use. The Chinese National Improved Stoves Program was initiated in 1982. In the following 10 years, over 125 million improved cookstoves and parts reached homes in China; today 7 out of 10 rural households possess stoves that are at least 30% more fuel-efficient than older stoves (World Resources, 1994) making the Chinese program the most successful worldwide (see Chart below).

chart

The Chinese government played an important but limited role in cookstove dissemination. First, the central government restricted itself to providing up-to-date research on cookstove technology and identifying areas of greatest potential for stove adoption. Local rural energy offices took charge of technical training, implementation, standards for manufacturing production, and program monitoring (Kammen, 1995; Barnes et al., 1994). Second, with direct contracts between the central and county governments, the program bureaucratic entanglement (Barnes et al., 1994). Third, government subsidy of improved stoves was extremely limited ($.84 for every stove costing $9) and was directed toward stove producers -- to provide assistance with construction training, administration, and promotion support -- rather than toward consumers (Barnes et al., 1994). Most rural Chinese, considerably wealthier than their counterparts in Kenya or India, were able to lay down the initial funds for this investment in fuel-efficiency.

With design, production and sale of the improved stoves occurring at the ground level, stoves were created to suit the local community. Improved brick and mortar stoves (with accompanying chimney) replaced older models. For those families unable to purchase completely new stoves, insulative parts (such as mortar and ash) were sold as packing around the stoves circular opening where the wok sits (Kammen, 1995). Stoves in the cold Northern States were designed for the dual purpose of cooking and heating. Stove design also took into consideration attractiveness and convenience (Barnes, 1994).

Although it began with a custom-built approach, the Chinese cookstove program is gradually moving to mass-production of stove parts, in order to increase profit margins for private manufacturers, as well as reduce the cost to the consumer. This approach, it is hoped, will assist in the long-term sustainability of Chinas cookstove program and allow the improved technology reach the poorer and more remote populations (See Figure A).

Conclusion

The experiences of India, Kenya and China offer valuable lessons to other countries engaged in cookstove dissemination. First the overwhelming success of Chinas cookstove program, and eventual improvement of the Kenyan effort attest to the fact that fuel-efficient stoves are indeed popular among select populations. Such populations -- usually urban -- already purchase fuel, and thereby stand to benefit directly from fuel-efficiency. In some of the most successful cookstove programs, such as in Kenya and Rwanda, consumer payback for the stove investment has occurred within only a few months (Barnes et al., 1994).

Figures A, B, and C.

Market surveys should be undertaken before improved stoves are disseminated; as India learned, precious funds should not be wasted on attempting diffusion in regions where it is likely to fail.
Low-potential markets typically include impoverished rural areas where fuelwood is still free or accessible, and where fire is used for many

purposes other than cooking (such as lighting, heating, smoking meat, and as insect repellent) (Munslow et al., 1988; Barnes et al., 1994). For these populations, separate fuelwood/energy approaches may be necessary, including tree nursery programs, agricultural interventions, and other indirect methods to improve overall economic prospects, to monetize womens labor, and to address land-use management practices (Munslow et al., 1988).

Second, to the greatest extent possible, stoves should be modified versions of traditional stoves and should be durable, attractive, and user friendly. Extensive pilot testing, involving the input of actual consumers and local artisans, should precede stove diffusion.

Third, as illustrated in China, the government should play an important but narrow role in cookstove dissemination. The national government may provide technical research on cooking technology, and spread knowledge about improved cookstoves (information, education and communication), while local governments see to production quality, and local monitoring and evaluation (Barnes et al., 1994; Munslow, 1988). Government subsidies, as India discovered, usually cause stove producers to neglect consumer needs, resulting in inferior stove quality and less aggressive marketing. Hence they should be avoided, or replaced with opportunities to attain credit for the purchase of a stove. Donor agencies may also assist in the above-mentioned roles, but only if their support is sustained (at lease 5 years) and coordinated with other public and private cookstove diffusion efforts (Barnes et al., 1994).

Finally, for long-term success, commercial enterprises involving local experts should become the primary producers and disseminators of cookstoves. As with the Kenyan program, mass producing stoves and their parts, as well as using local scrap material, helps to lower costs. Conversely, mass campaigns and folk construction to disseminate cookstoves, as Indias program illustrated, are not conducive to the sustained production of high-quality stoves. Applied to similar projects in other countries, these lessons may further the rebound of cookstove dissemination throughout the developing world.

APPENDIX

bar chart

Improved cookstoves in Kenya, Chaina and India

Improved Stoves	Efficiency (%)	Cost ($US)	Dissemination
Jiko	25-40	$2 to $5	1 million plus
Maendeleo	15 -35	$.80 to $1.20	100,000
Chinese brick and mortar	20-40	$8 to $9	125 million
Indian mud & clay chulha	10-40	$8 to $10	8 million

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CHAPTER TEN

ALICE NABALAMBA

NATIONAL PERSPECTIVES AND PRIORITIES: A COMPARATIVE STUDY OF URBANIZATION IN UGANDA AND TANZANIA

Background:

This paper seeks to examine the urbanization transition and its relation to population and environment dynamics in Sub-Saharan Africa. The study will focus on two countries that have had similar experiences in many respects but also offer important differences in their ideological approach to development. Uganda and Tanzania had very similar experiences particularly prior to their independence in early 1960s. They were both under British colonialism (Tanzania having become a British colony in 1916), had predominantly agricultural economies and inherited a common market (The East African Community of which Kenya was also a member).

Interestingly, after independence, the two countries that had experienced a similar past, each took on a very different approach to economic development. In both cases, the focus was on nation building, social change and economic independence for the good of the general population. Uganda initially pursued market-based economic policies that placed a premium on individual incentives and basically promoted the colonial approach to economic development. In the late 1960s, the state adopted mixed economic policies that promoted import and export protectionist measures but still with a capitalist approach.

Tanzania, on the other hand took a different direction of intent. After five years into independence, Julius Nyerere, Tanzania's leader, lost faith in the development institutions inherited from colonialism. In 1967, Tanzania adopted the Arusha Declaration on Socialism and Self-Reliance, marking a clear retreat from previous aid-driven politics characteristic of the other East African nations. The declaration entailed the abolition of private enterprise, the nationalization of private agricultural and industrial enterprise, and the reduction of the countrys dependence on external financing.

Development according to Nyerere meant that people and not money were the motor force of social transformation. Development in this case meant initiating communal village settlements (Ujamaa Villages) in rural areas using local materials and simple technology. Government support to meet basic human needs, notably food, education, water and transportation would then be provided within these confines. This new socialist program had no industrialization agenda to speak of, and it was invariably anti-urban. In Nyerere's opinion, it would be unfair to focus development programs on urban centers since peasant production was the sole genuine source of marketable surpluses and thus national wealth.

Nyerere's program is the most notable national spatial restructuring system in Sub-Saharan Africa. Originally a voluntary resettlement effort, by 1970, financial and technical assistance had been added as rewards for moving into the Ujamaa villages. By this time, only 9 percent of the population lived in the communal villages , thus by 1973, the government of Tanzania initiated a policy of forced resettlement --namely "Operation Tanzania". Becker, Hamer and Morrison, 1994, have commented that this operation was remarkably successful in redistributing population within and between territories. D. Oluwu (1990) adds that the program succeeded to the extent that it brought together scattered families into village settlements and enabled the government to reach the largest possible number of people. However, the consensus among others that have studied the program is that it was a failure from the point of view of agricultural productivity, infrastructure allocation and administrative management. It was also a very costly program. Thus one of its intended objectives--controlling growth of urban areas--was not achieved.

Uganda, on the other hand, saw urbanization as a fundamental prerequisite to modernization and thus national development. In all the country's five year development plans following independence, there was considerable discussion on the costs of urbanization. The planning position was that investing in the rural areas where the population was highly dispersed brought with it special costs, particularly in the provision of social amenities (educational and health services). Yet a high concentration of population such as in urban areas would permit economies of scale in transportation, communication and provision of other social services. To the Uganda government, the debate over allocation of resources for urban or rural programs was a budgetary concern rather than one of humanistic reasoning.

In addition, Uganda envisioned market oriented economic policies as the means of facilitating Africans to enter the urban business sector (that had been previously dominated by Asians and Europeans), and a means to redistribute income and wealth. Tanzania saw equitable income distribution, particularly in favor of the rural peasantry as more important than economic growth within the inherited colonial economic structures. Tanzania focused on rural based development to counter urbanization. With this same socialist agenda, Tanzania introduced another difference among her East African counterparts (Kenya and Uganda). Tanzania moved fast and far ahead of them in terms of arresting potentially volatile ethnic tensions that would otherwise result from regional inequalities. The Ujamaa village program allowed interaction among the various ethnic groupings from various regions. In addition, the introduction of Swahili as the national language, helped to down play all previous ethnic and language differences. Yet Ugandas failure to develop a program geared toward regional development to encompass regional differences triggered ethnic tensions of the magnitude we saw in the country throughout the 1970s and 1980s.

These comparisons are important because they provide a starting point for understanding the urbanization transition, which for the purposes of this discussion can be traced back to the time of independence (1960s). Since the 1960s, a significant amount of literature has been generated on urbanization trends in Sub-Saharan Africa. Many authors have attributed the problems related to urbanization to Africa's obsession with "urban bias" policies. Michael

Lipton (1977) in Why Poor People Stay Poor, critiques development theories and practice, by charging that their authors are responsible for problems related to urban biased development in many Third World countries. What Lipton really meant was that those that are informed by these theories in their practice, for instance international advisors on national planning, have stressed the importance of investment and production in export-oriented sectors (that are urban based for the most part) and industrialization and have encouraged heavy capital expenditures for urban infrastructure, such as ports and airport facilities, highways, communication systems, urban hospitals and educational institutions.

Nevertheless, the debate on the implications of urbanization continues. There those that believe, especially amongst political economists that urbanization in and of itself is a positive sign of economic growth. There are also political consequences in that it has been proven to create a middle class in societies such as Uganda and Tanzania where there was none prior to independence. Perhaps what is still not clear is the causal correlation between levels of urbanization and economic development. In other words, does increased urbanization lead to high per capita incomes or does increased economic growth lead to urbanization? It would seem from Lipton's argument that economic growth particularly if national government policies are targeted for urban areas, occurs first and once the conditions in the urban areas become attractive, they then encourage rural-urban migration. In the meantime, because national budgets particularly in Africa can only be stretched so far, rural areas are neglected. Indeed, proposals for rural development by national advisors have focused on a limited number of projects such as large scale irrigation and other land questions which in some instances have rendered large populations landless. The focus on export-oriented sectors invariably implies that the emphasis in many countries is on national economic performance with no consideration for the human capital that is responsible for economic growth. This urban focus translates into rural underdevelopment. Again, because the chances of survival seem some how better in the city, mass emigration from rural areas becomes everywhere the norm.

Demographic Transition:

Now that we have established the background to the factors that influenced modern urbanization transition in Uganda and Tanzania, we need to put the concept in the context of population and environment dynamics. In addition to tracing the urbanization transition in these two countries, it is also the intent of this paper to identify symptoms of a deteriorating urban environment and to see if there is a direct link between these problems and the process of urbanization. In order to completely grasp these phenomena, there is need to look at urbanization in Uganda and Tanzania in the context of the larger demographic framework of the two countries.

E. Kalipeni, 1994, informs us that the high population growth rates currently witnessed in Africa are primarily due to Africa's position in the second stage of the demographic transition. In this stage, crude death rates have suddenly decreased while birth rates have stubbornly remained high and sometimes experience an increase.

Technological advancement in the medical area as well as economic growth are the reasons for this shift. We can safely say that both Uganda and Tanzania have experienced a dramatic decline in crude death rates including infant mortality rates particularly since the turn of the 20th century. These changes have had significant influence on population growth in both rural and urban areas in Tanzania and Uganda as well as other Sub-Saharan African states. (see fig 1 and appendix I). For many countries, the population has more than tripled in the last forty years and in a few cases, it has quadrupled.

FIGURE 1

Source of Data: World Resource Database, 1994/95, New York, NY, 1994.

There have been two schools of thought on the subject of high population growth rates both of which have had some impact on public policy in Uganda and Tanzania. The neo-Malthusian tradition, deeply rooted in the Western development thinking argues that population growth is detrimental to development, in that it will outrun world resources and finally lead to misery. The Worldwatch Institute under the directorship of Lester Brown have notably paid significant attention to hunger in Africa. In their series On the State of the World (1990-95), they point out that the food shortages so prevalent in Africa are an indication of the consequences that the world will be faced with unless nation states take immediate action in terms of regulating population growth. This argument also implies that population growth rate is currently far greater than the potential increases in food production.

The second school of thought comes from a contrary tradition, largely anti-Malthusian. The debate in this case has been led by Third World structuralists who argue that population growth can in fact make positive contribution to economic growth and development. Population growth, they contend, can have beneficial effects on stimulating demand and encouraging technological innovation to accommodate the new growth. It is this tradition that has greatly influenced African leadership in the recent past. For many decades, African leaders generally encouraged population growth. The reasons have ranged from population and people being a development asset to a way of replacing populations lost during the various catastrophes experienced in the late 19th century and early 20th century. The anti-Malthusian tradition thus explains why neither Uganda or Tanzania has had a population control program until recently.

Uganda :

Up until 1992, the Uganda government did not have an explicit population policy and as such lags behind many Sub-Saharan African countries in national debate on issues of population growth. In fact in the 1966-1971 second five year development plan, the nation was less concerned with population pressure as a potential problem . Apart from the mountain regions of the eastern part of the country, elsewhere, population density was low. But the 1980 population census and the Atlas of African Affairs, 1980, both indicated an uneven pattern of population growth and concentration around the Lake Victoria region. The Lake Victoria region occupies the three largest urban conglomerations of the country (Kampala, Jinja and Masaka--see map 1) including the most productive agricultural region of the country. Today, however, there seems to be heightened concern in many African nations about the region's growing food deficits, increased external dependency (apparent in the size of Africa's foreign debt), growing poverty, low GNP per capita incomes and growing urban problems. These concerns are all directly related to the population question thus require a systematic program to deal with them.

According to the World Bank country study, 1993, Uganda's population growth rate was estimated at 3.10% between 1990-1995 and if the current total fertility rate of 7.3 children per woman were held constant, then the country would experience an increased growth rate of up to 3.8% annually between 2010 -2015. A United Nations projection for 1988 places it at 3.58 percent while the World Resource Database - 1994/95 (WRD) places it at 3.00% in the same period (see fig. 2).

FIGURE 2

Source of Data: World Bank, 1988, United Nations, 1989, World Resource Database, 1994.

The UN and WRD data sources, however, also predict a slight drop in the growth rate between 1995-2000 or after 2000 to 3.51% and 2.68% respectively, and a relatively higher drop after 2015 indicating that Uganda is entering the last demographic transition state. The estimated fertility rate of 7.3 per woman, places Uganda among countries with the highest fertility rates in both Sub-Saharan Africa and among Third World nations in general. Increasing crude birth rate between 1970 and 1995 is equally worrisome. (see Fig 4)

FIGURE 3

Source of Data: World Resource Database, 1994/95: New York, NY, 1994

FIGURE 4

Source of Data: World Resource Database, 1994/95, New York, NY, 1994.

Tanzania:

Tanzania, like Uganda has had no official population policy. However, the countrys second five year plan which initiated the Ujamaa program had implicit demographic and redistribution effects. By 1979, "Operation Tanzania" had successfully redistributed 79 percent of Tanzania's mainland population into Ujamaa villages. Other aspects of the development programs that had specific population content are those that related to health (including maternal and child health), education , rural development and spatial redistribution because at independence, the main obstacles to national development were seen as poverty, ignorance and disease.

However, the Ujamaa program, failed as a rural development policy and in 1977, it was officially ended. The program failed partly because it became apparent after a few years that the economy could not support the plan objectives. In addition, the program failed to redistribute population evenly countrywide. Most of the resettlement took place in the northern and western (lake regions) and in the central (mountain region). Secondly, the program failed to control population movement between rural and urban areas as was intended. Prior to 1967, Tanzania's annual rural-urban migration rate stood at 7.05 percent. During the "operation Tanzania" program,--1970-1978, the rate dropped only slightly to 7.01 percent indicating that the program did not significantly improve rural conditions nor did it have a major impact on urbanization trends. During the same period, there is evidence of only 1 percent annual rate of out migration from urban areas to the countryside.

Urbanization Trends:

Although Uganda and Tanzania embarked on deliberate policies that initially affected urbanization trends, both countries are still highly rural societies (see Fig. 5). This fact would seem to indicate that there were other variables that accounted for urbanization trends that we are witnessing in both countries besides the specific programs each adopted. In Tanzania, as previously noted, the Ujamaa program failed as a rural development policy and invariably led to an increase in movement of population from rural to urban areas. In Uganda on the other hand, urbanization did not occur as quickly as the government intended. By 1995, less than 20% of Uganda's population resided in urban areas while close to 30% of Tanzania's lived in cities. Nevertheless, the urbanization transition in Africa as a whole is only recently emerging from its early stages.

FIGURE 5

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Source of Data: World Resource Database, 1994/95, New York, NY, 1994

It has been suggested that the region is experiencing runaway urbanization. But there is no indication that the urbanization trend is any different from what other regions experienced during their urbanization transitions. The forces driving urbanization are identical. The difference, is that these forces are stronger in Africa than in most other places. In particular these forces (that can be traced back to the time of independence) include increased fertility rates, population movements, deteriorating agricultural productivity and growth in government labor force. In addition, urban growth in Uganda and Tanzania has disproportionately concentrated in capital cities and the principle industrial centers.

In Tanzania, based on the 1978 population census, a significant proportion of net-migration into the country's urban centers is recorded in Dar-es-Salaam, the national capital. Like in most other African states, growth in Dar-es-Salaam is five times greater than in the next largest city and 50 percent of Tanzanias urban population is concentrated here. There is even evidence of negative growth in some of the smaller towns perhaps due to migration to larger cities such as Dar-es-Salaam or back to rural areas (during the Ujamaa program).

Natural population growth in Tanzania's urban centers is also an intriguing phenomenon. The general assumption that fertility rates are lower in urban areas and generally higher in rural areas has been proven otherwise in Tanzania, particularly in Dar-es-Salaam. Data provided by the 1989 United Nations case study on population policy for Tanzania suggests that fertility increased between 1967 and 1978, with the total fertility rate rising from 6.6 percent to 6.9 percent and that crude birth rates rose from 47 per 1000 to 49 per 1000 in the same period. In urban areas such as Dar-es-Salaam, fertility rate increased from 4.3 percent in 1967 to 5.7 percent in 1978. This is also true for other towns such as Dodoma and Arusha (see table 1)

TABLE 1

Urban Growth in Tanzania:

Estimated Total Fertility Rates (TFR)and Crude Birth Rates (CBR)/1000 for selected towns:

based on National censuses of 1967 and 1978.

City/Town	1967		1978	
	TFR	CBR	TFR	CBR
Dodoma	6.9	48	7.4	52
Arusha	7.1	51	7.6	48

Tanga	6.9	46	7.1	47
Dar-es-Salaam	4.9	33	5.7	48
Tabora	5.5	40	6.2	45
Kigoma	5.9	43	7.1	52
Mwanza	6.9	49	7.4	51

Source of Data: United Nations: Population Policy Paper Number 22, New York, NY, 1989

an indication that perhaps rural norms had been transferred to urban areas as rural-urban migration occured. Life expectancy in urban areas was also much higher than in rural areas during the same period

In Uganda, prior to 1971, the country's social indicators were comparable, if not better than, most countries in Africa. The country's economy was 90% agricultural based. The various regimes that governed the country between 1971-1985 radically reversed the economic and social progress the country had attained since independence. The civil strife that ensued following the first military take over in 1971, and the civil war that broke out following the elections of 1980, were largely based in the most productive part of the countryside--the region surrounding the country's capital (see map 1). This led to a decline in agricultural contribution to national Gross Domestic Product. Industrial productivity did not increase eitherand the country increasingly depended more on foreign assistance .

With the deteriorated agricultural productivity, particularly in the 1970s and 1980s Uganda's urban population growth rate began to surge resulting primarily from rural-urban migration but also from population natural increase in urban areas. In addition, the military regimes of the 1970s and 1980s were characterized by large armies, which could be seen in the size of military barracks many of which were built during this period around the capital. Every regime recruited large numbers of military cadets from the countryside (particularly northern Uganda) who made the city their permanent home. These regimes were also characterised by large civil service bureacracies all in an attempt to legitimize the regimes. Inevitably, these policies are directly responsible for the rapid increase in urban population particularly in the Lake Victoria region. The growth, however, concentrated in the country's capital, Kampala as was the case in Dar-es-Salaam. Kampala's share of national urban population increased from 38% to 52 percent during this period. At the same time, as the countrys economic fabric deteriorated due to mismanagement, there was a decline in urban social services leading to a destruction of the urban infrastructure. It is estimated that during this period, GDP declined by 25 percent, exports (primarily agricultural products) declined by 60 percent, and imports except for military hardware declined by 50 percent. The large increases in defense expenditures led to further increase in foreign capital borrowing. Priorities of the 1960s decade that focused on providing for urban growth became insignificant as expenditures on important sectors such as education, healthcare, urban services were being reduced in favor of defence expenditures to maintain the 1970s and 1980s military regimes.

Impact of Population Growth on the Urban Environment:

The impact of population growth on the urban environment is still debatable in some circles. For instance the Ugandan government initially perceived population growth in urban centers as a prerequisite to modernization and eventually national development. Some economists have argued that urbanization in and of itself is not a negative indicator. It is in fact a positive sign on economic growth. Recently, however, there is growing indication that too much urbanization may not necessarily produce desired results of economic growth. In fact the situation in Uganda and Tanzania as will be seen later, indicates that economies of these two countries are incapable of supporting large numbers of urban population, let alone rural populations. The rate of urbanization assumes an equivalent level of job creation, housing supply, health care, educational and transportation facilities. Many African governments have not been able to reproduce economies with these qualities as was the case in the industrialized and industrializing nations. Thus the question of the role of population growth on urban environmental degradation has to be seen in light of state ability to provide the necessary infrastructure to support its urban populations.

Uganda:

The World Resource Database (1994/95) as well as the 1993 World Bank study on Ugandas social sectors provide a very dismal picture of the changing urban environment. The problems are two fold--increased urban population growth that is concentrated in the largest city, Kampala, and structural neglect. Ugandas urban population nearly doubled in the past thirty years, yet growth in the national economy has not kept the same pace. As previously noted, the countrys economic performance took a downward spiral during the 1970s and 1980s. Government resources to support population growth shrank as export earnings declined. National budgetary figures show that fewer resources have been devoted to providing and improving existing social or physical infrastructure in the last 20 years. The most visibly affected areas are access to clean water, garbage collection, sanitary and sewage facilities, and housing shortages (see table 2). These are very serious problems that can no longer be ignored as they have come to define urban centers of Uganda.

TABLE 2

Access to Safe Water and Sanitary Facilities in Urban Areas

	Safe Water		Sanitary Facilities	
	1980	1990	1980	1990
Uganda	45%	60%	40%	32%
Tanzania	X	75%	X	76%

Source of Data: World Resource Database, 1994/95: New York, NY.

The problems are more pronounced in the countrys capital, Kampala where 52 percent of the urban population resides, and the industrial hub of Jinja, where no major infrastructure improvement has taken place in the recent past. (see figure 6) The authors of the 1993 World Bank country report write that although the country is well endowed with fresh water and its resources, increased human activities both in city and countryside --deforestation, poor farming practices, industrial pollution and demographic pressures--have disturbed the equilibrium of the water cycle through increased run-off with minimal recharge to the underground and surface water reserves, thus impairing water quality. As a result it is estimated that only 60% of the countrys urban population has access to safe water supply, a situation made worse during the civil upheaval period. In the rural areas the percentage of population that has access to clean water within reasonable distance is even lower (because there are no water treatment plants). The World Resource Database (1994/95) also indicates that access to sanitary services has declined in Ugandas urban centers from an estimated 40 percent in 1980 to 32 percent in 1990. (see table 1) These numbers indicate an alarming condition of urban areas in Uganda, particularly in the larger cities.

FIGURE 6

Source of Data: United Nations, 1988, New York, New York

Tanzania:

As the case in Uganda, the declining urban environment in Tanzania is a combination of rapid population growth rate as well as government declining expenditures on new infrastructure and or maintenance of existing ones. The pervasive deterioration of urban infrastructure rose out of national policies that had been paved with the best intentions: the goal was to create a conflict free society (with equitable income distribution, avoiding exploitation of the rural sector by investing heavily in urban centers, and by avoiding the big city phenomenon). Even when the 1970s rural policies failed, and it was clear that urbanization was inevitable and on the rise, the government did not invest in new infrastructure beyond that the colonial government left behind. In 1980s, Tanzanias urban centers were characterized by shortages of basic necessities, rising poverty, and massive inflation. The WRD 1994/95 report does not provide data on access to safe water and sanitation facilities for 1980, but the figures for 1990 indicate that there is still a serious problem in many of Tanzanias urban centers. In the last two decades, Tanzania has become increasingly dependent on foreign financing for its development projects implying poor economic performance. The country's priorities are now being made based on the overall needs of the country as opposed to specific needs of a city or region. In other words, resources are spread thinly across the various national social sectors. One indicator of Tanzania's dismal economic situation is that once a net exporter of food in the 1960s, the country now spends a significant amount of its resources importing food items.

Perhaps the most alarming problem in Tanzania is the growing concentration of the population in very few areas. According to the United Nations Population policy study of 1989, 60 percent of Tanzanias population is concentrated on 20 percent of the land.

Conclusion:

Unfortunately, in most African states, the urban environment is in a state of crisis. The problems are clearly related to infrastructure deficiencies as noted in Uganda and Tanzania but most importantly to population growth that cannot be absorbed by national economies. These problems are noticeably high outside the core areas of the cities (Central Business District) and are not only affecting the urban environment, but also productivity of urban areas. It is estimated that by 1980, at least 50 percent of Africas urban population lived in slums with no basic services (water, sanitation, healthcare, etc.) The city size inherited at the time of independence has grown many fold as new immigrants arrive and natural population growth expands, and yet, no accompanying infrastructure investments have been made in the same proportions for most countries.

This paper has attempted to explain these problems in relation to the urbanization transition in two countries--Uganda and Tanzania. We began with a background of national policies that both countries adopted immediately after independence and their impact on population growth and urbanization trends. We discussed the theories that influenced national leadership in their effort to formulate population programs. We have also discussed urban population growth in the two countries as well as the impact of urbanization on the urban environment.

The paper has tried to show that there is a relationship between population growth and environmental degradation. In both Uganda and Tanzania, the data indicated that there is a causal relationship between concentration of population densities in a few urban areas and the environment. Yet the two countries have made no major attempts to integrate a population policy in national economic planning. Today, all demographic indicators point to a continued high population growth rate with prospects of rise in urban areas and certain other regions of both countries. The possibility of decline in population growth as well as the improvement of the urban environment will occur only if there is a deliberate government commitment to reducing population growth. Likewise, urbanization growth will have to be dealt with in terms of the overall national population structure.

Policy Implications:

Local Programs:

In 1992, the Uganda government in its rehabilitation and development plan stated that a national population policy would be formulated. The document states that:

> ....*Government is keenly aware of the importance of population factors in socio-economic development. Of particularly concern is the effect of population increases on the health status and welfare of the people, especially amongst the most vulnerable groups such as mothers and children. In this regard, Governments long term objective is to promote the health and welfare of the population by reducing the prevailing high levels of morbidity, mortality, and fertility to ensure a balance between population growth, socio-economic development and the quality of life of the people.*

However, the discussion of a national population policy has been made in very broad terms with no specificity. At the present time, the country lacks an organized family planning program along the lines of some leading African countries such as Zimbabwe. In view of the urgency to reduce the countrys high birth rates which are directly responsible for the high population growth rate, there would be need to address the crisis with a strategy with a long term effect that targets the reproductive sector of society. With this strategy the country will be able to deal with several other problems including poverty at both individual and household level, reproductive choice, reduction in the number of children born to HIV infected parents (who would die and leave behind orphans), maternal and child health, and rapid population growth. Attempts do deal with population problems with economic measures have only partially been successful and they have been very short term strategies.

In Tanzania, we have seen that coercive measures to control growth in urban areas were not successful. There were no counter measures to control growth in rural areas. Several years later, the Tanzanian government attempted to relocate the capital--Dar es Salaam to Dodoma (in the center of the country) in the hope of diversifying development and relocating business and therefore people. Strategies such as this, however, are very expensive for countries that have many other pressing priorities. In addition, they only resolve the high urban density question, but not the root cause of the problem--natural population increase.

External Programs:

It is expected that urban growth rate will begin to stabilize around the year 2000 in both countries. (see Fig. 8)

FIGURE 7

FIGURE 8

Source of Data: World Resource Database, 1994/95, New York, NY, 1994 and United Nations, 1988, New York.

Several reasons can be identified as contributing to the decline in the urbanization trend. First, WRD and UN data indicate that as we move into the Twenty-first century, overall population growth rate for Tanzania and Uganda will begin to decline (see Fig 1, 2, 7). This will have an impact on urban population growth resulting from natural increase. Secondly national economies of both countries are shifting into directions that are beginning to have an impact on the urban population. Since the early 1980s, upon the advisement of the World Bank and the International Monetary Fund both Uganda and Tanzania governments adopted Structural Adjustment economic programs (SAPs) that were designed to restore economic structures of countries that were experiencing poor micro and macro economic performance (depictable in their large external debts as well as large deficits). The SAPs have had several effects. They have forced governments to shrink their large bureaucracies, encouraged decentralization of government and other business functions from capital cities to secondary centers and have resulted in reduced government role in parastatal bodies (state owned corporations). Besides the large bureacracies, parastals were another major strain on national governments in terms of their large resource consumption in form of surplus workforce, marketing and distribution expenditures.

The SAPs were also designed to resucitate Africa's declining agricultural sector in order to absorb those populations that the public sector would have eliminated. It is expected that as a result of the decentralization effort, more jobs will open up in other towns thereby attracting unemployed populations from capital cities. While migration behavior cannot be precisely predicted, the long term expectation resulting from the SAPs is a reduction in rural-urban migration as people find more remunerative activities in the agricultural and rural sectors.

Monitoring and Evaluation: Towards Comprehensive Planning:

In order to reduce birth and fertility rates, there are several areas that must be tackled at the same time. For instance, developing literacy programs that would target women and at the same time increase their employability in productive sectors could be a starting point. When women are employed in market productive sectors, it is expected that they will begin to view reliance on their off springs as sources of household labor in a different vein. The people of Uganda and Tanzania have long been aware of the increasing cost of maintaining a large family, but the economy has not been able to provide an alternative.

National programs that promote equal opportunity to education need to be developed. The Uganda government has been working on such a program for the last five years and it is expected that by 2005, all children in Uganda will have access to primary school education. Not only does society need basic education, there is also need to target those areas that have a direct link to peoples lives, such as environmental education. Even in this area, a national policy needs to include women at the forefront. African women are in direct contact with the natural environment on a daily basis, such that understanding the causes of degradation is very important to safe guarding it. In many communities, they find themselves with the responsibility of passing on new knowledge to their children and to society as a whole. Thus farming techniques and other ways of reproducing life in ways that would sustain the ecosystem would have to be introduced to women.

There are no easy solutions to population and environmental questions. Local and external intervention programs discussed above are merely experiments for which concrete effects may never be realized. Many domestic and foreign entities would have to be involved in determining long lasting solutions to the problems created by the interaction of population and the environment. At the same time, the various entities would have to integrate their determinations in order to develop comprehensive plans that would have sustainable effects. In addition, the programs developed need to have the capacity to be monitored on a regular basis so that ideas can be sythensized, failed ideas rejected and new ones added. The national economies of both Uganda and Tanzania are incapable of managing the complex nature of population and environment dynamics, thus the international community needs to intervene from time to time. Intervention needs to be constructive and not coersive as has been the case in many places. Constructive intervention would, for instance, constitute technological expertise to monitor progress of and improve specific population and environmental programs.

APPENDIX I

	Population in Millions			Average Annual Population Change		
	1950	1990	1995	1980-85	1990-95	2000-05
Angola	4.13	9.19	11.07	2.63	3.72	3.05
Benin	2.05	4.62	5.40	2.82	3.11	2.91
Botswana	0.39	1.24	1.43	3.40	2.92	2.69
Burkina Faso	3.65	8.99	10.35	2.50	2.81	2.69
Burundi	2.46	5.49	6.34	2.80	2.88	2.53
Cameroon	4.47	11.52	13.28	2.83	2.83	2.84
Central Afr. Rep.	1.31	3.01	3.43	2.58	2.62	2.31
Chad	2.66	5.55	6.36	2.28	2.72	2.47
Congo	0.81	2.23	2.59	2.82	3.00	2.67
Cote d'Ivoire	2.78	11.98	14.4	3.86	3.68	3.28
Djibouti	0.06	0.44	0.51	4.46	3.01	2.88
Equatorial Guinea	0.23	0.35	0.40	7.22	2.55	2.41
Ethiopia	19.57	49.83	58.04	2.12	3.05	2.84
Gabon	0.47	1.16	1.37	4.01	3.31	2.64
Gambia, The	0.29	0.86	0.98	3.01	2.60	2.34

Ghana	4.90	15.02	17.45	3.58	3.00	2.81
Guinea	2.55	5.76	6.70	2.23	3.04	2.86
Guinea-Bissau	0.51	0.96	1.07	1.87	2.14	2.12
Kenya	6.27	23.59	27.89	3.56	3.35	3.12
Lesotho	0.73	1.75	1.98	2.78	2.47	2.39
Liberia	0.82	2.58	3.04	3.17	3.32	3.08
Madagascar	4.23	12.01	14.16	3.06	3.29	3.06
Malawi	2.88	9.58	11.3	3.42	3.31	2.42
Mali	3.52	9.21	10.8	2.85	3.17	2.91
Mauritius	0.49	1.08	2.34	1.09	1.00	2.68
Mozambique	6.20	14.20	16.36	2.27	2.83	2.87
Namibia	0.51	1.44	1.69	2.94	3.18	2.91
Niger	2.40	7.73	9.10	3.36	3.26	3.02
Nigeria	32.94	108.54	126.9	3.20	3.13	2.95
Rwanda	2.12	7.03	8.33	2.87	3.40	3.09
Senegal	2.50	7.33	8.39	2.81	2.70	2.59
Sierra Leone	1.94	4.15	4.73	2.32	2.66	2.54
Somalia	3.07	8.68	10.17	3.2	3.18	2.99
South Africa	13.68	37.96	42.74	2.58	2.37	2.07
Sudan	9.19	25.2	28.96	3.11	2.78	2.65
Swaziland	0.26	0.75	0.86	3.07	2.68	2.64
Tanzania	7.89	25.99	30.74	3.28	3.36	2.99
Togo	1.33	3.53	4.14	2.93	3.18	2.93
Uganda	4.76	17.56	20.41	2.72	3.00	2.68
Zaire	12.18	37.39	43.81	3.18	3.17	2.98
Zambia	2.44	8.14	9.38	3.58	2.84	2.56

Zimbabwe	2.73	9.95	11.54	3.22	2.97	2.48

Source of Data: World Resource Database, 1994/95, New York, NY, 1994

APPENDIX II

Map 1: Urbanization in Uganda: Major Cities

Map 2: Urbanization in Tanzania: Major Cities

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NOTES

CHAPTER ELEVEN

DIANE OCONNELL

COSTA RICA AND THE FORESTRY TRANSITION: A MODEL FOR DEVELOPING COUNTRIES

Introduction

Tropical forests are disappearing at alarming rates. During the 1980's, approximately 4.6 million hectares of tropical rainforest and 6.1 million hectares of moist deciduous forest annually were converted to other land uses (Sizer, 1995). The loss of tropical forests is greatest in Asia (2.2 million hectares per year), followed closely by Latin America (1.9 million hectares per year). The reasons for tropical deforestation are very complex, and are linked to local needs of the community, national policy, and international markets. Solutions to tropical deforestation will require a complete analysis of all of the reasons for loss of this habitat. Government policies may be a part of the solution to reducing the loss of tropical forests.

Costa Rica has experienced rapid rates of deforestation during the 1960's and 1970's. The national government responded to this environmental crisis by creating a widely-praised system of national parks, biological preserves, and other protected lands to slow down the deforestation rate. As a result of government policies, Costa Rica's deforestation rate has stabilized, and today there is little net loss of forests. Costa Rica is viewed as an international leader in conservation efforts and biodiversity preservation. However, Costa Rica still suffers from deforestation outside of the protected areas, threatening the edges of the protected areas and creating biogeographical islands of protected forests. In addition, the rapidly growing population may pose another threat to the remaining forests. The challenge for the national government of Costa Rica is to direct policy measures to the current deforestation outside of protected areas. If this challenge is not met, Costa Rica may one day be completely deforested outside of pockets of protected forests.

Physical Geography of Costa Rica

Costa Rica is a small country (19,730 square miles [51,032 square kilometers]), slightly larger that the state of West Virginia, and is located approximately 10 degrees north of the equator. The physical geography results from the complex relationship of many variables, including the tropical location, topography, and prevailing wind direction. The topography consists of two parallel mountain ranges which are tectonically active. The highly urbanized Central Valley or Meseta Central located between these mountain ranges is actually a tectonic depression (Dorn, 1989). Costa Rica is geologically young, and the volcanic soils are more fertile than the expected leached tropical soils. Prevailing winds come from the east, which bring large amounts of precipitation to the Caribbean coast (up to 200 inches per year), and lower amounts of precipitation to the northern and central part of the

Pacific coast. The tropical location and the varied topography result in an amazing biological wealth; some estimates indicate that Costa Rica contains approximately 5 percent of all of the world's species of plants and animals (Baker, 1995). This biological wealth is closely linked to the variety of forests found in Costa Rica, including tropical rainforests, tropical wet and dry forests, and montane forests.

Forestry Transition

All societies are dynamic, and experience change in all or some of the following sectors: demographic, energy, urbanization, technological, educational, agricultural, and forestry. Transition theory provides a model to describe changes in sectors over time to understand the relationship between human population and the environment (Drake, 1993). When analyzing a sector longitudinally, there is a critical period where the rate of change is particularly fast, and the society must accommodate this change. The society may be vulnerable at this point, and have difficulty adapting to the change (Drake, 1993). A further complication occurs when societies experience rapid change in multiple sectors at the same time. Then, the potentially harmful impacts of one transition can be exaggerated by the presence of other transitions, and the society must cope with multiple changes simultaneously. Public policy can intervene to mitigate the negative impacts of rapid change in multiple sectors, if the society can identify these critical areas. A period of stability often follows this rapid change. The equilibrium that is achieved is dependent upon the way the society manages the period of rapid growth (Drake, 1993).

Transition theory is particularly applicable to countries experiencing rapid population growth. Often, changes in many sectors are related to either human population growth or changes in settlement patterns. Rapid population growth often directly affects the educational, agricultural, forestry, energy and urbanization sectors. Besides affecting many sectors in the society, rapid population growth has a major impact on the environment. For purposes of analysis, it may be desirable to examine one transition; however, transitions from different sectors are intimately linked, and it is difficult to completely separate one from the others.

The forestry transition describes changes in forest cover over time. At the beginning of the forestry transition, a large percentage of a region is forested. During the critical period of the transition, deforestation rates are exceptionally high. Forest cover eventually stabilizes at a lower total area of forest cover than at the beginning of the transition. The rate of deforestation is determined by many variables, including local demand for forest products and land, and international demand for forest products. Forests are a renewable resource, and the forestry transition is complicated because regeneration of forests often occurs simultaneously with deforestation. However, regenerated forests frequently do not contain the rich biodiversity of the original forests because non- native or mono-species often replace the native species. The forestry transition is further complicated because of the difficulty of obtaining longitudinal data on forest cover and the lack of universal agreement on definitions for forest cover and deforestation.

The forestry transition for Costa Rica is illustrated in Figure 1. Forest declined rapidly from 1961 to the early 1980's, while the land in permanent pasture increased dramatically. The country was in a very vulnerable stage during this period of extremely high rates of deforestation. Deforestation rates were 7 percent per year during this period of rapid change, versus 2 percent for the other time periods (Sader, 1988). This high deforestation rate between 1977 and 1983 indicates a significant loss of primary forest.

Continuation of this rate of deforestation would have eventually resulted in complete deforestation of the country. However, stability is reached by the early 1980's, and there appears to be little change of forest cover since that time. The amount of land in cropland has remained almost constant. Costa Rica has completed the forestry transition, and has reached a stable point where total deforestation rates are relatively low. However, deforestation does occur, and the following section explore the reasons for historical and current deforestation in Costa Rica.

Causes of Deforestation in Costa Rica

Deforestation results from both direct and indirect factors. Direct factors emanate from the local area, while indirect ones can be attributed to global factors (Honadle, 1995, p. 90). Direct factors include social variables, such as population growth and change in migration patters; economic variables, such as growth of transportation corridors and employment opportunities; and political variables, such as national land policies and government subsidies. In addition, physical variables, such as type and accessibility of forests, play an important role in the rate of deforestation. Indirect causes for tropical deforestation result from international market needs (Honadle, 1995, p. 92). Indirect factors include world demand for tropical products, such as hardwoods, fruit, and palm oil, and the world demand for beef. The indirect factors are frequently linked to direct factors; for example, global consumer demand for bananas increases the amount of land cleared for banana plantations and the local community sees the potential for both employment and revenue from the banana plantations (direct factors). Tropical deforestation is a complex problem that is affected both by other sectors in the society, and by international markets.

Historical analysis of forest cover is often restricted by lack of both the necessary data and longitudinal maps of land use/land cover. Sader and Joyce (1988) used satellite images to complete a longitudinal study of the loss of primary forests in Costa Rica during five time periods: 1940, 1950, 1961, 1977, 1983 (Figure 2). The study focuses on physical variables related to deforestation, including type of forest, humidity, and slope.

Figure 2: The Forestry Transition in Costa Rica.

Source: World Resources Institute, 1994.

Prior to 1940, most deforestation occurred in the tropical wet and dry forests in the northwestern part of the country. These ecosystems have a distinctly dry season, and were cleared for crops and pasture land in the early history of the country (Sader, 1988). Primary forest occupied only 11 percent of the entire tropical dry region as of 1940. Between 1940 and 1950, the highest average annual rates of forest clearing occurred in the tropical dry and montane moist forests (Sader, 1988). During the time period of 1961 to 1977, the highest annual rates of clearing occurred in the montane wet forests, followed by the tropical wet forest. By 1977, the primary tropical dry region was totally deforested. As a result of the loss of the tropical dry forests, the tropical moist forests are now cleared for cattle ranching.

Annual deforestation rates between the years 1940 to 1983 were lowest for relatively dry forested areas, such as montane forests. The more humid areas are less accessible and less desirable for agriculture and pasture use because of high rainfall, rugged topography and rocky soils (Sader, 1988).

Much of Costa Rica is in relief; the majority of the low lying areas are located inn tropical rainy locations. Prior to 1940 and for the period 1940 to 1950, the largest amount of forest cleared occurred in the 31 to 45 percent slope category. Between the years 1961 and 1977, the forest clearing rate increased on the shallow slopes (4.4 percent per year). Prior to 1977, the 0 to 5 percent slope areas were inaccessible Atlantic coastal plains. However, the rate of deforestation has increased in the tropical rainforests adjacent to the San Jose-Guapiles Highway in the 1977 to 1983 period (Baker, 1995).

Social Variables Related to Deforestation

Deforestation is closely associated with a growing population because of the need for additional land for both settlement and agriculture. Costa Rica has a population of 3.3 million people. The birth rate is 26 per thousand, and death rate is 4 per thousand, which results in a 2.2 percent natural increase and a doubling time of 32 years (Figure 3). Costa Rica is in Stage 2 of the Demographic Transition Model, the fastest growing stage of the model. Population growth rate has been dramatic, as illustrated in Figure 4, which shows an exponential curve fit to the population growth for the time period of 1950 to 1995. In 1990, approximately one-third of the population was under 15 years of age, indicating that population growth will probably continue for several decades (World Resources Institute [WRI], 1994). The population may double to 6 million before stabilizing. This growing population places a stress on the country's national resources, including the forests.

Figure 3: The Demographic Transition for Costa Rica.

Source: World Resources Institute, 1994.

Figure 4: Actual and Projected Population of Costa Rica.

Source: World Resources Institute, 1994.

Approximately half of the population resides in the San Jose metropolitan area and the Central Valley. During the 1970's, migration increased to the San Jose metropolitan area in response to a depressed agricultural sector and the promise of employment in urban areas. However, the global recession triggered by the 1979 oil price increase, 1980 increase in world interest rates, and reduced foreign loans, altered migration patterns. In the time period of 1981 to 1982, citizens left the San Jose metropolitan area and moved to rural districts. Between the years 1973 to 1984, population increased 51 percent in rural areas with arable land (WRI, 1994). Population increased on marginal land, also; the population increased 27 percent on land classified as poor and 16 percent on land classified as very poor (WRI, 1994). This migration to rural districts has increased deforestation rates. Since 1984, the population in the urban areas, primarily San Jose and Alajeula, has been steadily increasing (WRI, 1994).

Economic Variables Related to Deforestation

Economic variables that contribute to deforestation include the growth of the transportation network, increased production of crops and beef for export, and the loss of employment on plantations. The development of transportation corridors increase accessibility to previously remote areas, and hasten deforestation. Costa Rica's transportation network grew dramatically during the time period 1977 to 1983. The cumulative distance of primary, secondary and unimproved roads and railroads was approximately 2088 kilometers in 1967 and 5582 kilometers in 1977 (Sader, 1988). In 1977, the mean distance from the nearest road or railroad to a forest was 14.2 kilometers. The greatest distance of any forest location (63.5 kilometers) to the nearest road or railroad is located in the northeast near the Nicaraguan border (Sader, 1988). However, the San Jose - Guapiles highway, which links the capital San Jose to the Atlantic lowlands has opened up this previously inaccessible area (Baker, 1995).

During the 1970's, much of the forest clearing is directly related to the expansion of the cattle industry (Figure 2). The tropical wet and dry forests of the Pacific lowlands are largely deforested today, and the land is in permanent pasture.

Today, it is the expansion of banana plantations, rather than the cattle industry, that is a reason for much of the deforestation. Bananas are a major sources of revenue for Costa Rica, and banana plantations bring the promise of local employment opportunities and increased capital for both the local and national economy. However, these plantations have also caused social and environmental problems, as illustrated by the following example in the Sarapiqui region. The Sarapiqui region is located near the San Juan River close to the Nicaraguan border. The Sarapiqui contains approximately 250,000 hectares, of which 50,000 are protected in biological preserves, 100,000 are in peasant agricultural communities, and 100,000 consists of secondary growth forest, cattle pasture, ornamental-plant or fruit plantation (Vandermeer, 1995). At least five banana companies are planning expansion in this region because of perceived market opportunities in the European Community and Eastern Europe (Vandermeer, 1995). Both the local and national governments encourage the expansion of banana plantations. Costa Rica is a poor country with a large external debt, so companies that promise revenue and employment are welcomed regardless of the problems that may result.

The banana industry brings complex chemical pesticides and fertilizers to the region, reduces the amount of forests, and contributes to local social problems. Pesticides pollute local water bodies and poison plantation workers. Standard Fruit Company used the fungicide DBCP in the region, and approximately 2,000 workers on the plantation became sterile (Vandermeer, 1995). Forests must be cleared for the banana industry. The area in the Sarapiqui dedicated to banana plantations increased from 20,000 hectares in 1985 to 32,000 hectares in 1991, and it is projected to be 45,000 hectares by the end of 1995 (Vandermeer, 1995). Banana plantations may eventually include all of the arable land in the region that is not either protected in a biological preserve or owned by agricultural communities. Frequently, the local work force does not provide enough laborers, and workers are imported from other parts of Costa Rica or from other countries, including Nicaragua and Panama.

When banana prices fluctuate in the world market, or the land becomes unproductive through overuse, banana companies reduce their work force. The unemployed workers can either migrate to the metropolitan areas or try to settle in the region. Unemployed workers that remain in the region need land to grow subsistence crops or harvest products from the forests. However, the local community in the Sarapiqui may have little land to offer the workers, and the only land that is not devoted to agriculture is located within the four biological reserves in the region. One future scenario projects that the landless peasants may be forced to clear the forests in the biological preserves (Vandermeer, 1995).

Protected lands have been threatened by unemployed plantation workers before. After several banana plantations had been abandoned, approximately 800 unemployed laborers and their families moved into the Corcovado National Park, and began prospecting for gold (Bequette, 1994). The rivers of the Corcovado National Park became polluted with sediment and mercury. A court order gave the police powers to evict the workers, but soon other prospectors arrived, setting off armed conflicts between the police and the prospectors. The expansion of industries dedicated to production of cash crops can have a detrimental impact on forests in two ways. First, the land must be cleared for the production of the cash crops. Second, workers imported into the area may clear marginal lands for their own use when work is no longer available on the plantation.

Political Variables Related to Deforestation

Federal policies contributed to the rapid rate of deforestation in the 1960's and 1970's. The 1961 Land Reform law allowed landless migrants to apply to the Agrarian Development Institute (IDA) to obtain a title for unused private land (WRI, 1995). Unfortunately, much of the IDA land was marginal land, and was prone to high rates of soil erosion if deforested. In the 1970's, ownership rights were given to anyone who cleared the land and lived on it for one year (WRI, 1994). Squatters could either claim land after a 10 year period, or sell the cleared or improved land after only one year to cattle ranchers, who immediately took title to the land. Poor and landless individuals could profit by clearing land and selling the land to cattle ranchers.

Much of the deforestation on the Pacific Coast is a result of expansion of the cattle industry. Government policies promoted the beef export industry by allowing subsidized credit to ranchers, and tolerating high delinquency rates (WRI, 1995). People were motivated by these subsidies to enter the cattle industry whether or not the industry was profitable.

Current Rate of Deforestation

The annual rate of deforestation for the time period of 1981 to 1990 is approximately 50 hectares or a 2.6 percent annual rate (WRI, 1994). Costa Rica has the largest annual rate of deforestation in Central America (Sizer, 1995). The annual logging of closed broadleaf forest (1981 to 1990) is approximately 34 hectares per year; 27 percent of which is primary forest (WRI, 1994). A chart showing current land cover is in Figure 4.

Figure 5: Land Use/Land Cover in Costa Rica.
Source: World Resources Institute, 1994.

Government Response to Deforestation

The Costa Rican government responded to the rapid deforestation rates in the 1970's by banning the export of more than 60 tree species and prohibiting deforestation without permits (Baker, 1995). However, efforts by the federal government have not ended deforestation; landless peasants continue to move onto marginal land, and land is cleared for coffee and banana plantations.

In 1970, Costa Rica formed a national park system to protect valuable forests and preserve biodiversity. Approximately 10.27 percent of the total land area is protected and an additional 17 percent is aside as forest reserves, buffer zones, wildlife refuges and Indian reserves (Baker, 1995). The National Park System is in charge of managing 21 national parks, 9 biological reserves, and a national monument (Table 1). The national parks and reserves protect soil and watersheds, and preserve the habitat for approximately 75 percent of all Costa Rican species of flora and fauna (Baker, 1995).

Table 1: Costa Rica's National Parks, Refuges, and Reserves

Arenal National Park	Hitoy Cerere Biological Reserve
Barra Honda National Park	Irazu Volcano National Park
Braulio Carrillo National Park	Isla Guayabo Biological Reserve
Cabo Blanco Natural Reserve	Juan Castro Blanco National Park
Cahuita National Park	La Amistad International Park
Cano Island Biological Reserve	Las Baulas de Guanacaste Park
Cano Negro National Wildlife Refuge	Lomas Barbudal Biological Reserve
Carara Biological Reserve	Manuel Antonio National Park
Chirripo National Park	Marino Belleno National Park
Cocos Island National Park	Palo Verde National Park
Corcovado National Park	Poas Volcano National Park
Gandoca-Manzanillo National Wildlife Refuge	
Guanacaste National Park	
Guayabo National Monument	
Tortuguero National Park	
Barra del Colorado	
Rincon de la Vieja	
Santa Rosa National Park	
Tapanti National ParkOstional	
National Wildlife Refuge	

Source: Instituto Costarricense de Turismo, 1995.

In 1989, the country began to reorganize the National Park System in an attempt to increase the protection of the forests. The national parks, reserves, and national forests are being combined into larger regional conservation units (RCUs) so that wildlife can easily migrate from one preserve to another. The Guanacaste Regional Conservation Unit serves as a model for these megaparks (United National Environment Programme). The other RCUs are: Arenal, Cordillera Volcanica Central, Isla del Coco, Osa, Pacifico Central, Tempisque, and Tortuguero. Costa Rica is widely praised for its system of protected areas. Only five percent of the forests in Costa Rica are not under some kind of protected status. The National System of Conservation Areas will hopefully ensure the long term preservation of one-fourth of the country, and the current administration plans to expand the conservation areas to cover one-third of the total area of the country (Figueres, 1994)

The national government also promotes reforestation by using tax breaks, but the reforestation often results in the development of tree farms that contain non-native species, such as teak. The government grants legal residency status to persons participating in reforestation programs; however, these efforts frequently do not replicate the once complex ecosystems (Baker, 1995).

Costa Rica's Model of Sustainable Development

Sustainable development is not a clearly defined concept; many interpretations can be found to describe sustainable development. The Brundtland Commission summed up the spirit of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (in Hale, 1993). The Jose Maria Figueres Olsen administration views sustainable development as an alternative development paradigm to ensure both economic growth and environmental protection in Costa Rica (Figueres, 1994). Costa Rica is currently experiencing difficulty in many sectors, including the forestry, demographic, energy and urban sectors. Forests outside of protected areas are cleared, the human population is rapidly growing, energy consumption increases 9 percent annually, and the migration to the Central Valley increases (Castro, 1994). The possibility of a reduced standard of living for Costa Ricans has convinced the government to pursue a model of development that differs significantly from the current industrialized model. The national government is using Agenda 21 from the United Nations Conference on Environment and Development in Rio de Janeiro in June, 1992 as a guide for implementing sustainable development policies, and hopes to export this sustainable development model to the rest of the tropical developing world (Figueres,1995; Keating, 1995).

A key motivation for the construction of this new model of development is the desire for preservation of the forests which host the vast biological wealth; as stated by the Minister of Natural Resources, Energy, and Mines: "Biodiversity is a pillar of Costa Rica's sustainable development initiative" (Castro, 1994). The Costa Rican model for sustainable development is impressive in its extent, and attempts to integrate international (extra-regional), regional, national, and local components (Figure 5).

Figure 5: Major Components of the Costa Rican Model for Sustainable Development:

International Component

Ratified Convention on Climate Change (1994)

Statement of Intent for Bilateral Sustainable Development, Cooperation

and Joint Implementation of Measures to Reduce Emissions of Greenhouse

Gases - United States and Costa Rica (September 30, 1994)

Convention on Biological Diversity

Conservation Units can Procure international funding

INBio - Merck Pharmaceuticals, Inc.

INBio - Intergraph

Regional Component

Central American Commission of Environment and Development

protect region's biological diversity (1989)

coordinate preservation of tropical forests

Central American Convention on Biodiversity (1992)

Central American Alliance for Sustainable Development (1993)

Convention for the Management and Conservation of Natural Forest

Ecosystems and the Development of Forest Plantation (1994)

Megaparks (Path of the Panther)

Si a Paz and La Amistad

National Component

Constitutional Reform

Reforms to articles 18 and 15 of the Constitution

"right to a healthy and ecologically sound environment"

Institutional Reforms

Ministry of Natural Resources, Energy and Mines

Policy Reforms

Increased Public Participation

Electricity Tax

Local component

Water districts

Local autonomous groups

Source: Figueres, 1994 and 1995; Keating, 1995; World Resources Institute, 1995, Castro, 1994.

International Component of the Model

An integral part of the sustainable development model is for Costa Rica to forge alliances and agreements with other nations. Opportunities for sustainable development investments and projects, such as the Global Environmental Facility wind power project, are created by international agreements (Castro, 1994). Costa Rica has also adopted the Convention on Biological Diversity and the Framework Convention on Climate Change. Costa Rica is welcoming joint implementation projects, cooperative projects between developed and developing countries to reduce greenhouse emissions (Castro, 1994). On September 30, 1994, United States Vice-President Gore and President Figueres signed a letter of intent for a Bilateral Sustainable Development, Cooperation, and Joint Implementation (United States, 1994). A pilot project will institute sustainable forest management in a national park and buffer zone in central Costa Rica. The project includes funding to police illegal deforestation and purchase privately held land inside the park (United States, 1994).

International non-governmental organizations are welcomed to Costa Rica to help develop conservation programs and provide funding to implement these programs. Costa Rica contains numerous private reserves and a children's reforestation project in Monteverde. Some of these organizations participate in a debt-for-nature swap program that is designed to both protect forests and reduce the country's external debt (Table 2). One example of a debt-for-nature swap follows. The Nature Conservancy bought a portion of Costa Ricas debt from a United States bank at a discounted rate. Costa Rica then paid off the National Parks Foundation with bonds in the local currency, and agreed that the money would be used on conservation projects.

Table 2: Debt-for-Nature Swaps in Costa Rica.

Purchaser	Date	Face Value of debt	Millions of

dollars	Cost($) Funds Generated(million $)			
FPN		2/88	Total	5.4
918,000	4.05			
Netherlands		7/88	Total	33
5,000,000	9,9			
TNC		1/89	Total	5.6
784,000	1.68			
Sweden		3/90	Total	24.5
3,500,000	17.1			
Sweden/WWF/TNC		3/90	Total	10.753
1,953,473	9.602			
Rainforest Alliance/MCL/TNC		1/91	Total	0.6
360,000	0.54			

Source: World Resources Institute, 1992.

Costa Rican conservation units can procure international funding, and manage their budgets separately from the national budget. Costa Rica's National Biodiversity Institute (INBio) recently signed a contract with Merck Co., Ltd, one of the world's largest pharmaceutical companies. INBio will provide Merck with samples of plant and insect species in exchange for royalties from any marketable products (Langreth, 1994). The objective of the agreement is to finance the conservation of biodiversity, and to ensure that Costa Rica receives a small percentage of profits derived from pharmaceutical extracts. Some of the proceeds will help fund the "All Taxa Biodiversity Inventory," a detailed survey that will eventually include all of the species found in the Guanacaste Conservation Area (INBITTA, 1995)

Regional Component of the Model

Central America has a unique political geography; seven small countries share an isthmus that connects two much larger regions. Because of the physical proximity, environmental problems frequently become transboundary problems. These issues require a regional solution, and the governments of the Central American countries have made several efforts to unify the region. During the 1989 Summit at Costa del Sol, the Central American presidents agreed to create the Central American Commission of Environment and Development (CCAD) to protect the region's biological diversity, and coordinate preservation of tropical forests (WRI, 1995). CCAD consists of representatives from each of the seven Central American countries. The charter states that the goal of the organization is to promote "coordinated actions by governmental, non-governmental, and international organizations" (Weed, 1993). The CCAD created a forestry unit that designed a regional Tropical Forestry Action Program (TFAP), to develop guidelines for forest policy (Figueres, 1995). In 1992, CCAD representatives signed an agreement with the United States National Aeronautics and Space Administration to receive regular satellite images to provide information to use to advise member governments on deforestation (Weed, 1993).

As a result of the Convention for the Management and Conservation of Natural Forest Ecosystems and the Development of Forest Plantation, the Central American countries propose to consolidate the management of protected areas, reforest lands, and manage forest growth in secondary forests (Figueres, 1995). The region's national forest service directors and TFAP coordinators met with farmer's unions, forestry industry representatives, and women's groups during the convention to discuss any concerns related to the management of the regions forests.

Transboundary protected zones are being established throughout Central America to protect international forests from squatters and prospectors. These international reserves, often called "Peace Parks," include La Amistad Conservation and Development Initiative, located along the border between Panama and Costa Rica, and the 500,000 hectare "Sistema de Areas Protegidas para la Paz (System of Protected Areas for Peace), also called the Si-a-Paz, reserve along the Costa Rican-Nicaraguan border (Weed, 1990). An eventual goal is to create a Central American biogeographical corridor called the "Path of the Panther." These transboundary parks are rich in biodiversity, and unfortunately are under intense pressure for development (Weed, 1990).

A regional plan called the Central American Alliance for Sustainable Development (alianza para el Dessarrollo Sostenible de Centro America) was launched in December, 1993 by United States Vice-President Albert Gore and the presidents of the Central American countries (Figueres, 1995). The objectives are listed below:

Table 3: General Objectives of the Central American Alliance for Sustainable Development

1. To make Central America a region where peace, freedom, democracy, and development will thrive by promoting a change in personal and social attitudes in support of sustainable development in the political, economic, social, cultural, and environmental domains.

2. To ensure sustainable practices for preserving regional biodiversity.

3. To communicate the Alliances achievements to the international community so that Central American efforts will serve as an example to others.

4. To permanently strengthen societys capacity and increase participation in the process of improving the present and future quality of life.

Source: World Resources Institute, March, 1995.

National Component of the Model

The Costa Rican government is taking steps towards sustainability by implementing constitutional, institutional, and policy reforms. In 1994, articles 18 and 50 of the Political Constitution were revised to confer the "right to a healthy and ecologically sound environment" (Castro, 1994). The Parks Service, Fish and Wildlife Service and Forest Reserves and Protected merged into a new institution: the Directorate of Conservation Units under the Ministry of Natural Resources, Energy and Mines (United Nations Environment Programme). Costa Rica is currently experiencing a nine percent increase per year in electricity demand, and an electricity tax was implemented to internalize the full environmental costs of generating electricity (Castro, 1994).

A national government - non-governmental organization (NGO) commission developed a project to convert up to 2 million hectares of pasture back to woody crops and forest (WRI, 1995). In November, 1994, the Ministry of Natural Resources, Energy, and Mines and the Ministry of

Rural Development inaugurated the 7,000 hectare Horizantes Forest Experiment Station in the Guanacaste Conservation Area (ATBI for Terrestrial Organizations of the Guanacaste Conservation Area). Government and private extension agents provide educational support to help citizens switch from grass to woody crops.

Local Component

The national government plans to integrate local community groups into the sustainable development model. Costa Rica has numerous community organizations, including 2,000 rural development boards, two thousand water control boards, and 100 nongovernmental organizations (Figueres, 1995). These organizations will be informed and hopefully involved in the national government's effort to pursue sustainable development.

Exportability of the Model

Costa Rica is planning to become a pilot project for sustainable development, and create a model that can be exported to the rest of the developing world. But, can the Costa Rican Model be applied to other tropical developing countries? Even though Costa Rica is a poor country and is classified economically as a developing or a Third World nation, Costa Rica has undergone a social and political transformation in the past four decades that differentiates it from the rest of the Third World. Many social indicators place Costa Rica in a developed nation category rather than with developing nations. Table 4 compares relative characteristics of wealth and social indicators for Costa Rica, its Third World neighbors in Central America, and the more developed United States. Advances in education, health care, and urban and rural infrastructure have resulted in a dramatic improvement in the lives of both rural and urban Costa Ricans. Costa Rica has had a strong democratic tradition since its independence in 1821. Costa Rica was the first Latin American country to base its government on free elections and a multi-party system (Wearing, 1993). In 1948, Costa Rica abolished its military, and the government still pursues a philosophy of social and economic improvements for all Costa Ricans. The nation continues to develop democratic institutions, and search for ways to both improve the lives of the people and the quality of the environment. Costa Ricas political system contrasts dramatically with the political systems of its neighbors.

The Costa Rican Model of Sustainable Development has evolved from this history of social transformations and democratic principles. In addition, the country actively seeks international experts to help design programs and restructure governmental agencies. The well educated and healthy Costa Rican population is an asset to the implementation of conservation projects. The country already has a strong environmental educational program. The traditions of dedication to the quality of all citizens and democracy are very different from the experience in much of the developing world. An important question is whether the Costa Rican model can be applied to nations that have not undergone social and political transformations. Because of the unique circumstances in Costa Rica, some of the programs initiated in Costa Rica may be difficult to implement elsewhere in the developing world.

Another potential problem with the model is that it may not stop the high deforestation rates outside of protected areas. The Costa Rican Model of Sustainable Development ultimately relies on a national system of protected lands to save forests; indeed the current administration plans to increase the amount of protected land to approximately 30 percent, and today only 32 percent of the total area is forested. Therefore, almost all of the forests in the country would be under some kind of government protection. Placing land under protected status does not address all of the critical variables related to deforestation. In addition, there can be no guarantee that the sanctity of national parks will not be violated if the local population needs land or forest products. The model needs to incorporate the reasons for deforestation, and attempt a solution to this problem. Deforestation outside of protected areas is caused by many linked variables, and is a difficult problem to solve.

Table 2: Comparison of Costa Rica, Central America, and the United States Characteristics of Wealth.

Characteristic	**Costa Rica**	**Central America (1)**	**United States**
GNP per capita	$1,841	$1,201	$22,356
Agricultural Labor Force	24%	36% (2)	2%
Birth Rate (per thousand)	26.3	34.9 (2)	15.9
Total Fertility Rate	3.1	4.4 (2)	2.1
Life Expectancy	76.3	67.28 (2)	75.9

Death Rate (per thousand)	4	6.8	9
Infant Mortality	14	45.4	8
Assess to Clean Water			
Rural (%)	84	41	not available
Urban (%)	100	89	not available
Assess to Sanitation Service			
Rural(%)	93	44.4 (3)	not available
Urban (%)	100	75.6	not available
Government Expenditure for Health (%)	26.3	11.8 (4)	13.5
Adult Female Literacy	93	69 (5)	99
Adult Male Literacy	93	75 (5)	99
Couples using Contraceptives	70	40 (1)	74
Per Capita Energy Consump (gigajoules)	16	12.1	320
Percent change(since 1971)	30	7	-4
Per capita carbon dioxide emissions (%)	1.06	0.53	19.53

(1) Central America calculations exclude Costa Rica

(2) Excluding Belize

(3) Excluding Nicaragua

(4) Excluding Honduras, Nicaragua, and Belize

(5) Excluding Belize and Nicaragua

Source: World Resources Institute, 1994.

Policy Recommendations - For the Donor International Community

Costa Rica is experimenting with a form of economic development that does not sacrifice environmental quality. The international community should pay close attention to this experiment because all nations in the future may have to link economic growth and environmental protection. Therefore, the donor international community should support Costa Rica's efforts with financial, technical and scientific support. Financial institutions should forgive the massive external debt that has accumulated in Costa Rica (Figure 6). This external debt may pose the greatest obstacle to the Costa Rican efforts of sustainable development. The country is so pressed for revenue that polluting industries are actually welcomed in this conservation-conscious nation. The country is forced to cannibalize its own economy and natural resources to service the debt. Debt-for-nature swaps may not adequately address the current $4 billion external debt. International financial support is also important for the institutional management of the protected areas. This aid can help ensure stability for the protected zone.

Figure 6: External Debt of Costa Rica.

This concept of additionality has been incorporated in several international agreements, such as the United Nations Framework Convention on Climate Change, the Convention on Biodiversity, and Agenda (Jordan, 1994). Additionality refers to financial aid on top of or in addition to the aid that is currently received by the developing world to finance sustainable projects.

Policy Recommendations - for Costa Rica

The International Monetary Funds structural adjustment program requires Costa Rican government departments to reduce their staffs and budgets (Baker, 1995). This reduction of government is designed to improve both the macro- and micro- economic performance of the country. However, this reduction of government may adversely affect both conservation projects and social programs. The Costa Rican government should strive to maintain these programs, and not cut funding for the conservation areas, health care, and family planning during this period of structural adjustment. The social improvements of the last forty years should not be reversed. The government should look to other programs to eliminate.

Costa Rica, like the rest of the Latin American countries, cannot sustain economic growth, improve the standard of living for the population and protect the environmental with the heavy weight of the countrys external debt. Therefore, the Costa Rican government should default on the external debt.

Deforestation experienced today in Costa Rica results from a variety of local decisions. A strong regional planning system should be implemented to address local needs, economic growth, and environmental protection. This type of institution is absent in the sustainable development model. One type of planning agency that may work to reduce deforestation and improve the local economic situation is a watershed management planning unit. Watershed management uses the boundaries of hydrologic units to create the political boundaries of a planning institution. The watershed is managed as a holistic entity; land use decisions are made in the best interest of the entire drainage area. The drainage map of the country will serve as the basis for the construction of watershed management units. Each planning unit should have adequate funding, political authority, and local participation to ensure that development choices will not adversely affect the watershed. The ultimate success of any development scheme will depend upon the choices made at the local level. Finally, the creation of a Ministry of Forests or a Ministry of Natural Resources may help avoid potential conflict of interests within the Ministry of Natural Resources, Mines, and Energy.

Conclusion

The problem of tropical deforestation is a complicated one, so it must be anticipated that the solution will be equally complicated. One important key to reduction of deforestation is understanding all of the variables that contribute to the deforestation rate, and attempting to integrate these variables into the solution. Costa Rica is a poor country with a rich environment. The national government is pursuing economic growth that does not adversely affect the environment by creating a model for sustainable development, and should be applauded for these efforts. The model has many positive attributes, but, at this time, does not appear to adequately address the reasons for deforestation outside of the protected areas. Perhaps support from the donor international community and institutional reform will ultimately halt

this deforestation.

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CHAPTER TWELVE

ERIN N. PERRY

URBAN GROWTH AND THE ENVIRONMENT IN KENYA

Introduction

Humans are a plague upon the planet. This is the philosophy that many environmentalists and zero-growth advocates live by. Regardless of whether or not one agrees with this statement, it is clear that exponential growth of the human population will affect the natural environment. As our human numbers increase, the finite supply of natural resources needs to support more and more people. Further, as Third World countries develop and levels of affluence increase, the citizens there will demand more goods per person. Pollution is bound to increase, as it has been for decades, and resources are bound to become more scarce, but for how long? How much can the Earth supply before our rates of growth level off?

These are questions that the establishment of a population-environment dynamic hopes to answer. Specifically, this paper will examine the urbanization transition (along with the demographic transition) and the corresponding effects on the environment. Kenya will serve as the study area, as a country in the midst of both of the above transitions. Continued high rates of population growth strain many sectors of Kenyan society, including agriculture, education, urban infrastructure, sanitation, water supply, energy, and employment.

Growth of the urban environment appears to coincide with overall population growth. Urban growth has intense and often specific effects on the environment because of its high population densities. For example, the need for employment brings industry to cities, and along with it air and water pollution and increased need for energy. Citizens of large Third World Cities such as Nairobi demand improved roads and sewers; this requires more energy, construction materials, and a steady water supply (often entailing more hydroelectric projects in the country). Demand for food in the cities must also be supplied by rural areas, and with fewer people per hectare of arable land because of rural-urban migration. This necessitates more capital-intensive agricultural practices, such as herbicide and pesticide use (with obvious negative effects on soil and water supply). As more and more rural people migrate to cities in search of better employment and educational opportunities, poverty-stricken shantytowns flourish around the outskirts of major cities. The basic needs of residents of these areas, including health services, often remain unmet. In the wake of urbanization and the resulting inequities (or perceived inequities) between urban and rural residents the potential for social unrest increases.

Despite all the problems that proliferate in cities such as

Nairobi, I will assert that cities can exert positive forces on the population environment dynamic as well. In areas such as education and sanitation, urban areas can exert the power of economies of scale that rural areas cannot. Better education and better access to health services, as more often found in urban areas, can lead to reductions in fertility, which relieves pressure on the environment. This reduction in fertility is crucial to the survival of the Kenyan people, in that agricultural limits are approaching, environmental stresses are increasing, and food shortages may be in Kenyas future.

Africa in general

According to the United Nations Environment Programme, most of Africa is actually under-populated (UNEP 1). The problem, however, is whether or not the increasing numbers of people will "be gainfully employed or whether, on the contrary, they will swell the ranks of the under-employed and the jobless" (UNEP 1). Their fear is based on the prediction that the growth of urban areas will continue at a rapid rate without a complementary increase in activities or the creation of an adequate number of jobs (UNEP 4).

Background

Kenya is largely an agricultural nation, despite recent trends in rural-urban migration. In fact, the Kenya Highlands is one of the most productive agricultural regions in Africa (CIA 160). The labor force consists of 15% agriculture, 50% public sector, 20% services, and 14% industry and commerce. Climate in Kenya is quite variable, from tropical at the coast to arid in the interior. As of July 1989, the population of Kenya was 24,346,250 with an annual growth rate of 4.2% (CIA 160). As shown in Figure 1, Kenya has one of the highest growth rates in Africa. The United States Central Intelligence Agency estimated literacy at 47% of the total population in 1989 (CIA 160).

The population of Kenya in the 1979 census was 15,327,061, and had risen to over 24 million by 1989 (CIA 160). Of the total figure, 827,775 live in the capital of Nairobi and 341, 148 in the coast city of Mombassa (Central Bureau of Statistics 13). From Figure 2 below, we can see the trends in birth and death rates in Kenya. In 1989, according to CIA figures, total fertility in Kenya was at 7.8 children born per woman (160). The 1989 birth rate was 51 births per 1000 population while the death rate was only 9 per 1000 population. The birth rate has been slow to "catch up" with the steady decline in the death rate, although it is declining and projections by the World Resources Institute indicate that it will continue to do so. This pattern is typical of countries such as Kenya in the early stages of economic development (Ominde 1984, 41). Despite movement towards the urban areas, Kenya remains a largely agricultural nation, with some 80 percent of the population working on 17 percent of the land. The vast majority of Kenyans are small scale farmers; however, large scale farms dominate coffee, tea, cereals, and livestock products-the export oriented sector of agriculture (Brass & Jolly 11). The potential impacts of urban-rural migration on agriculture and land-pressures will be discussed later.

Figure 1. Thematic Map of Africa by Population Growth Rate.

What stage of the demographic transition is Kenya in?

The demographic transition involves moving from a state of high birth and death rates to one of low birth and death rates. According to William Drake, at the beginning of the transition when birth and death rates are high they are "in relative equilibrium with each other" (304). By some event the death rate then dramatically drops, starting the transition. The widespread availability of western style health care such as immunizations in the Third World has recently caused this drop in death rates. By definition of the transition, after a time lag, the birth rates slowly drop to catch up to the death rates until another equilibrium is reached (Drake 304). Because of this time lag, some growth in population is inherent in the transition. How drastic/sudden is the drop in the death rate determines largely the manageability of the population growth. If a very sudden drop in the death rate occurs, such as in many Third World countries including Kenya, a population explosion occurs "and society experiences all the stress and human misery created by this condition" (Drake 304). This combination of high fertility and low mortality is characteristic of the contemporary demographic situation in northern Africa. However, countries in eastern and western Africa have generally experienced both high mortality and high fertility (typical of a country that hasn't gone through the demographic transition). Kenya was one of these countries, until it experienced substantial mortality declines in the 1970's. This resulted in considerably increased growth rates for Kenya (Ominde 1984, 27). In the mid-'70s, Kenya's growth rate was estimated at 3.7 percent, the highest in Africa (Ominde 1984, 28). In 1989, the growth rate had risen to 4.2% (CIA 160). Kenya has long been considered one of Africa's success stories because of its relative political stability and social tranquillity. However, this success has been tempered in per capita terms by its rapid population growth (Brass & Jolly 8).

Figure 2. Birth rates and death rates superimposed on total population.

Date source: World Resources Data Base 1994-95.

As seen in Figure 3 below, population growth appears to have been the highest in semi-arid parts of Kenya, due in large part to reductions in infant mortality among pastoralists (Livingstone 6). In contrast, low rates of growth in areas such as the Victoria basin reflect reductions in the natural rate of growth by migration to other areas because this area has run out of capacity to absorb population (Livingstone 9).

According to Brass and Jolly, "Kenya has undergone the first stage of a classic demographic transition, declining mortality coupled with relatively constant fertility. This phase would now appear to be complete, because future mortality declines will be more modest and therefore not affect the overall growth rate as much. Fertility is now the crucial process governing growth (21). According to Ominde, the demographic trend parallels that of many of the countries in similar stages of development. The difference, he asserts, is that in Kenya the combination of high fertility and rapidly declining mortality is "virtually unprecedented in demographic history" (Ominde 1984, 53).

Fertility

As shown in Figure 4 below, the risk of dying at a young age has dropped dramatically since 1940, life expectancy has risen, but total fertility has continued to rise.

Figure 4. Fertility Rate, Probability of Dying and Life Expectancy.

From: Brass and Jolly.

Fertility is highly related to mortality, as Ominde discusses. "Expectations of life have a direct bearing on the extent to which population is just replacing itself or exceeding the replacement level" (Ominde 1984, 30). Mortality conditions were such in Africa that a woman needed 3.5 births to replace the parent generation, whereas in the United States only 2.1 births were needed (Ominde 1984, 30). Where female death rates are high, a higher level of fertility is required to maintain the population at the same level. By 1972 the total fertility rate was estimated at an astonishing 8.1 births per woman (Ominde 1984, 43). Some reasons for this rise in fertility include better health conditions in Kenya, which created a tendency for miscarriage rates to decline. As an indicator, the percentage of childless women declined noticeably between 1969 and 1977, from 7.9 percent of women 45-49 to only 4.5 percent in the same age group in 1977 (Ominde 1984, 43). Researchers have also found that fertility declines drastically with secondary-school education for women. This may be because increasing education is generally associated with a tendency for women to delay marriage and childbearing. As Micah Cheatham points out in the chapter on fertility reduction in India, education is negatively correlated with fertility when looking at data on primary school education and fertility rates of females aged twenty-five and over from countries in all stages of the demographic transition. Also, increased education for women leads to increased chance of modern sector employment, which can entail changing values about family size (Ominde 1984, 44). Urban women are much more likely to be of the group of women with higher levels of education, which tends to reduce fertility. However, they also have better access to health care and nutrition, which are factors which tend to reflect a more fertile (physically healthy) population.

As can be seen in Figure 3, urban fertility is systematically lower than rural fertility in every province in Kenya, the highest fertility rates being found in the Western Province and the lowest in the East.

In urban environments, patterns of fertility differ from those in rural areas. In a rural setting, children are viewed as a form of consumer durable yielding a flow of services over time. The labor of children adds to family income and it provides economic and social security for the parents in the future. Of course, there are costs to having children as well, such as the opportunity cost of parents not working while raising children. Families tend to balance the utility of children against the costs of bearing them and raising them. In rural areas, the utility of the childrens labor and income generating potential clearly outweighs the costs, since few women have significant employment opportunities. However, as wage/income earning opportunities increase, alternative uses of time increase the price of children relative to other goods, mostly through increasing the opportunity cost of the mothers time. Also, increased income leads parents to spend more on better clothing, housing, nutritious food, and high quality education. Thus the cost of raising each child increases. These characteristics of increased income generating opportunities, better wages, and better opportunities for purchasing the above amenities are prevalent in urban areas. Thus, the logical conclusion is that family size and fertility will decrease in urban areas (Oberai 155).

This set of circumstances may indicate that increased urbanization is a good way to reduce fertility and therefore reduce population pressures. However, many migrants to urban areas are not affluent enough to afford the amenities which increase the costs of having children. More common is that in-migrants live in slums on the outskirts of the city. Surveys indicate that in poor urban areas such as the slums outside of Nairobi, only 20.5% of households have flush toilets, 46.7% have regular garbage disposal services, and 55.45 have access to public water standpipes (Oberai 157). This lack of facilities in slum areas reflects the lower probability that these residents will spend more on relative luxury goods such as education and better clothing for their children. Women will also have fewer opportunities to earn higher wages while living in these shantytowns. Thus, slum dwellers have higher fertility levels than the general population in many Third World cities like Bombay (Oberai 159). According to Oberai, The results of studies reviewed...suggest that in general urban poor have larger families than the urban non-poor, both because of their desire to have more children for reasons of economic security and because of their limited access to education, health facilities, family planning and other social services (Oberai 160).

Population momentum and the future

The concept of momentum is an important one in analyzing population dynamics. The effects of reductions in fertility, say, as the result of family planning programs, will not be felt for many years due to the youthful character of the population. As shown in Figure 5 below, the age structure of Kenya is heavily weighted toward the bottom, younger, segment of the pyramid. Because the young people still have to grow up and reproduce, the "population momentum" will carry population levels up until the next generation is born and the effects of the family planning programs can be felt. So even if this generation of young people entering child bearing age has only 2 children per couple (replacement level fertility), the

Figure 5. Age Structure.

population will still increase greatly before reaching a stable level. As Ominde explains this concept of population momentum: "The imbalances in the birth-rates and death-rates and the fact that more than half the people in these regions are under the age of 15 mean that the demographic upsurge will not relent until well into the twenty-first century" (1984, 32). Where this population pyramid is broad based, with high proportions of younger ages, dependency ratios are high; many young people are dependent on relatively few adults. This results in resources being diverted to more consumption and thus less savings and investment (Ominde 1984, 40). Urban poverty often exacerbates this dependency problem. A poor urban household is characterized by low, irregular earnings by one principal worker and a large number of people: hence the high ratio between household size and the number of earners (Oberai 145).

History of Urbanization in Kenya

The population in Kenya has been largely distributed around environmental factors and productive agricultural areas. Sparse populations in vast parts of the country is due to rainfall patterns; the Kenyans have tended to settle more densely around areas which receive high rainfall and therefore have a high potential for development (Alikhan 65).

Figure 6. Monthly rainfall data by district. From Odingo.

Another major factor contributing to the uneven distribution of population was the alienation of large amounts of productive areas for the occupation of white settlers during the period of colonial rule. Prior to colonial administration, land was largely owned on a tribal basis (Ominde 1984, 6). During colonial rule, the African population was confined to Native Reserves; the areas that once were these reserves continue to be the areas with the highest densities (Kisii, Kakamaga, and Kiambu for example). Lands occupied by pastoral tribes such as the Masaii tend to have the lowest densities, districts such as the Tana River, Lamu, Narok, and Samburu (see Figure 7 for locations). While urbanization has increased in most all of Kenya from 1969-1979, the Coast province has remained relatively unaltered; curiously, this is the only province with an indigenous urban tradition (Alikhan 66-67).

Figure 7. Map of Kenya

Areas with the highest levels of urbanization are located in the former White Highlands, where towns grew in response to economic development during colonial times, and in the Coast Province where the urban tradition dates back to a period of Arab influence (Alikhan 67). Urban agglomerations in the Arab Coast province arose in the form of trading centers from the ninth century onward (Ominde 1984, 59). The arid and semi-arid regions of Kenya are more urbanized than their more environmentally favorable counterparts in the southwestern part of the country (see Figure 8).

Urban-Rural Migration.

Environmental problems associated with population growth often manifest themselves in the urban areas. Thus, it is important to examine the phenomenon of urban-rural migration along with population growth to establish a population-environment dynamic. First, we must determine whether or not there is a link between population growth and urbanization. If we examine Figure 9 below, it appears that there is a positive correlation between population growth and growth in the urban population. Both are growing at an exponential rate, a characteristic that becomes unmanageable very quickly.

According to Livingstone, rural-urban migration tends to have a bias toward young people with some education (10). Those with more education seem to be less content in rural areas and seek out the cities in search of employment. Whether or not cities can actually provide this employment and whether or not existing services can absorb these new immigrants is debatable. Overall, 37.8 percent of all male migrants in

Kenya move from rural to urban areas, and 31.1 percent of all female migrants do the same (Ominde 1984, 76). This gap between male and female percentages can possible be explained by the above assertion that migration to urban areas has a bias toward those with some education, a group that is predominantly male. The next largest category of migration within Kenya is rural to rural, which accounts for 35 to 36 percent of all migration (Ominde 1984, 76).

Some general characteristics of migrants to Nairobi will help in analyzing the reasons for this movement and may lead us to policies to make the flow more manageable. Over forty percent of migrants to Nairobi are Kikuyu, the major ethnic group in Kenya (composing 20.8 percent of the total population) and 35.9 percent come from the central district (Alikhan 168-169). A large majority of migrants come directly from their place of usual residence (76 percent). The vast majority of migrants to Nairobi are between 20 and 34 years of age and are Christian. Sixty-seven percent of migrants to the city have more than a primary education. Respondents of Alikhan's field study indicated that the major reasons for migrating to Nairobi were for job availability, better paid jobs, and better educational facilities (Alikhan 181). These statements are a testament to the inequalities between urban and rural areas in terms of services, and suggest that if job opportunities were increased, wage differentials between cities and rural areas were diminished, and educational facilities were improved in rural areas, the pulls of the city would be lessened, along with the pace of migration. Indeed, we must not forget the role of women in major cities of the Third World, as they often carry an exceptional burden, providing economic support and performing housekeeping and child-rearing as well.

Migration occurs because of certain "pushes" urging people out of their area of residence and "pulls" toward the cities. Some of these pushes include relief of population pressure in the rural areas (especially when the move to the city is permanent), the need for a supplementary source of income (which can be accomplished through remittances to the family at home from the migrant), and the need for capital for the development of farms or other activities in the rural home areas (Livingstone 12). In rural areas, certain "pushes" operate to encourage people to move to the cities. Often, education is seen as giving access to employment outside the farming sector, which has great value to families during years of crop failure (offering a measure of security). "Households used income diversification both to secure themselves against risk and to build up savings for investment in the farm" (Mortimore, Tiffen and Gichuki 142). It is important to note that persistent rural-urban migration has increased the incidence of female-headed households in rural areas, especially in areas where male out-migration has been substantial. This has implications for income, welfare, and agricultural extension and production (Livingstone 15).

Figure 9. Growth in Urban Population versus Total Population Growth.

Data source: World Resources Data base 1994-95.

Why is urbanization such a concern in the Third World while First World countries went through the transition without much discussion? Granted, there have been great problems with urbanization in industrialized countries, including pollution, traffic congestion, shortage of housing, insufficient sanitation, social friction, delinquency, and aesthetic environmental deterioration. However, in less developed countries, such as Kenya in the wake of the end of the colonial system, "cities now grow with even greater speed, despite the meager resources available for coping with the adverse consequences" (Ominde 1984, 30). This rapid growth magnifies the problems experienced by developed countries in lesser developed nations. In these developing countries, "the rate of increase in absolute numbers of urban population and the associated growth in rural population has no parallel" (Ominde 1984, 30). Natural rates of population growth in developing countries like Kenya are much higher than any ever experienced in currently industrialized nations. In unplanned slums of major cities like Nairobi, population growth rates approach 7-8 percent while the general urban population is growing at approximately 5 percent per year (Ominde 1984, 30).

In now-developed countries, urbanization occurred because of increases in agricultural productivity which provided capital accumulation and less need for labor; thus creating a rural labor surplus. Capital inputs were available as a result, and so industry could expand and offer more opportunities for labor. Thus, "Urbanization in the experience of now-developed countries was thus both a cause and a consequence of higher standards of living" (Oberai 24). In countries such as Kenya, the rapid increase of rural populations led to an increase in the rural labor force which could not be absorbed by the agricultural sector. Therefore, in Kenya and other Third World nations, urban growth has resulted from pressures of rural poverty, and so its consequences have been negative (unemployment, slums, and poverty-Oberai 25).

Figure 10. Demographic trends worldwide. From Ominde 1984 (Population and Development in Kenya)

From Figure 10 above, urban population growth in Africa occurred at a rate of 4.8 percent per year, while rural areas grew less than half as fast (1.8 percent). This is partially due to the phenomenon of rural-urban migration, which now constitutes the largest volume of migration in the world (Ominde 1984, 31). Many problems are associated with this rapid urban growth. A few major concerns in Kenya include: the squalor of rapidly growing slums, deterioration in public services, shortage of housing, congestion in the streets, growth in unemployment, and worsening imbalance in income distribution (Ominde 1984, 32). In 1985, industrial workers earned three times as much as agricultural workers in developing countries (Oberai 31). All of these problems lead to less direct effects on the environment, which will be discussed in the next section.

Urban Growth and the Environment

Growth in urban areas has ramifications on the environment that stretch well beyond the boundaries of the city. Increased numbers of people must be supported by the same amount of land in rural areas and relatively fewer people to manage it (as greater proportions of people migrate to the cities). In 1969 approximately two-thirds of the total area of Kenya supported only 8 percent of the population: the urban population (Ominde 1984, 54). This spatial inequality in the distribution of population leads to many problems in resource development. Agriculture must be intensified or expanded to feed the urban dwellers. Hydroelectric projects must be used more frequently to supply water and energy to the cities. Industry blossoms in the city, increasing pollution and taking resources from rural areas.

Industrial growth seems an inevitable consequence of urbanization, for industry exploits the economies of scale found in large cities such as Nairobi. Whether or not growth in industry can occur rapidly enough to accommodate immigrants from rural areas who seek formal sector employment is questionable, however some burgeoning of industry is almost certain. As we can see from the graphs below (Figures 12-15), increases in urban population in Kenya have produced corresponding increases in fuel and charcoal production and carbon dioxide emissions (although CO2 emissions are more erratic). Using best fit curves to project this data set into the future, we can see that if current trends continue pollution will increase and pressures for coal and fuel resources from rural areas will increase.

From Figure 11 below, it appears that agricultural intensification is the wave of the future, because agricultural land has not expanded much in recent decades. All the land area suitable for rainfed agriculture is already being cultivated and there has been a shift in the agricultural boundary into some semi-arid areas in the east and north (Darkoh 1991, 61). This expansion of agriculture could mean increased desertification if current farming techniques are used (which tend to promote erosion). Erosion ravages prime agricultural areas and leaves little potential for production.

Some 483,830 square kilometers of Kenyas total area of 569,137 square kilometers is already experiencing some form of desertification, or 85% of the total land area (Darkoh 1991, 61). This desertification, caused in large part by agricultural expansion, has repercussions on agriculture, creating a sort of negative feedback loop. About 30% of land in Kenya has been moderately to seriously affected by desertification with about 55% in imminent danger of declining in productivity, leaving only 15% of the land in good condition for farming (Darkoh 1991, 61). Estimates suggest that by the year 2000 Kenya will only be able to feed 17% of its population from its own land, using low inputs such as fertilizer and pesticides, and will not be able to produce adequate food for its entire population even at intermediate levels of inputs (Darkoh 1991, 66).

Intensification of agriculture to produce needed food for urban areas could also have effects on the income distribution of Kenya. The demand for inputs, many of which are urban-based, will likely increase with agricultural intensification. Therefore rising rural incomes will also increase the demand for goods and services produced in the city, thus stimulating urban incomes and expenditures disproportionately (Anker and Knowles 45). Despite this inequality, the experience of the Machakos area in Kenya supports the hypothesis that increasing population density leads to intensification through changing labor-to-land ratios (Mortimore, Tiffen and Gichuki 141).

Figure 11. Land use changes in the Kenya Highlands between 1920 and 1960. From Odingo.

Figure 12. Curve fit and actual data for Charcoal and Fuel Production in Kenya. Data source: World Resources Data Base 1994-95.

Figure 13. Commercial Fuel Production and Urban Population in Kenya. Data Source: World Resources Data Base. [A logistic curve might also be fit.]

Figure 14. Traditional Fuel Consumption in Kenya. Data Source: World Resources Data Base 1994-95. [A logistic curve might also be fit.]

Figure 15. Industrial CO_2 Emissions and Urban Population in Kenya. Data source: World Resources Data Base 1994-95. [Compare this curve to the graphs of the rainfall data, Figure 6.]

Water supply for the growing urban populations is also a major concern. In Nairobi, the mean annual water use per capita was 154 liters in 1968, compared with 556 liters in U.S. cities (White, Bradley and White 115). Water deficiencies are common from January to March and July through September in Nairobi. Per capita water use is dependent on many factors, including size of family, income level, education, cultural heritage, and the cost of obtaining water (White, Bradley and White 117). Low-density urban areas tend to use the most water per capita (252 liters) compared to medium high density areas using 167 liters per person (White, Bradley and White 118). Therefore, it seems that as urban densities increase, per capita water use decreases. This may be interpreted as a positive consequence of urbanization in Kenya. However, the increasing numbers of urban dwellers may dampen the positive effects of lower per capita use, resulting in still higher demands on water supplies that are currently in shortage many times during the year.

In most of the highland area of Kenya, where Nairobi is located, rainfall is variable and uncertain (Odingo 150). Farmers in the area are facing increased pressures for livestock development because of the demands of a more modern urban population. This in turn requires more water, and so more boreholes and dams. Large scale dams and other water projects have been shown to have large negative effects on surrounding land and populations. Large areas of land are submerged by dam retention areas, including areas along the Tana River where past water projects were located. Disease also increases around water retention areas as water-borne viruses flourish. Therefore the demand for water and agricultural products in urban areas often degrades the environment in rural areas.

Increased energy demand from urban areas is having a large negative effect on the environment of Kenya. Urban demand for charcoal, largely in Mombassa and Malindi, leads to the wholesale cutting of forests in the Kilifi district (Darkoh 1991, 69). Forests have been cut to the point of encroachment onto traditionally reserved areas such as the Kaya forests (Darkoh 1991, 69).

Urbanization, the Environment, and the Future.

Some have attributed environmental degradation in Africa to the absence of environmental awareness among the poor. It is, of course, unreasonable to expect people living on the edge of existence, worrying about their next meal, to be concerned with the larger environment. Darkoh contends that environmental degradation is largely caused by "human population pressure and outside influences (e.g..-modernization) leading to over-exploitation and poor management of resources (forests, soil, water, atmosphere, etc.) through over-cultivation, overgrazing, deforestation, poor irrigation practices, pollution, etc." (Darkoh 1993 60). Disproportionate growth of urban areas plays a large role in this phenomenon as pressures for goods and services increase. As Darkoh points out, "demand for household fuel poses a clear threat to economic development in several countries. It has led to denuded forests near rural villages and round towns and cities. With the loss of tree cover comes increased erosion and lower crop yields. The resulting loss of soil fertility reduces harvests which in turn means poverty for the dependent population" (2, 60).

This environmental degradation in rural areas, caused in large part by the demands of cities, can in fact cause even more people to go to cities in search of better conditions. The case of the Ethiopian Highlands illustrates this experience: starvation and death forced the exodus of millions of environmental refugees to urban areas or less degraded lands elsewhere (Darkoh 1993 61). Could this happen to the currently productive Kenyan Highlands? Those who are poor and hungry will often cut forests, overgraze grasslands, overuse marginal land, and crowd into already congested cities. This cycle must be interrupted for any policy to be effective.

Predictions for the future are varied. Some, including Peter Kimm, assert that within 10 years most of the poor will live in urban areas (3). The predicament of cities such as Nairobi cannot be overlooked. An easy solution to the problem of population growth and environmental problems would be to heavily regulate industry in cities, and generally make living in cities more difficult so that people will remain in rural areas. However, cities currently contribute over half of the gross domestic product of developing countries and by the year 2000 it is predicted that they will contribute over two-thirds (Kimm 4). Without the economic development provided by cities, countries such as Kenya have little hope of developing, which is usually the precursor to lower population growth rates.

Growth of economically productive employment must be stimulated so that cities may absorb an expanding labor force. The agricultural sector does not provide a solution to the employment problem, as the agricultural land in Kenya is already being subdivided into plots too small to support a family adequately (Lewis 142). Employment must be increased, however, such that industry does not over-exploit natural resources and create intolerable amounts of pollution. A process called "technological leap-frogging" may be a means to accomplish this. Leap-frogging involves transfers of cleaner, more efficient technology from developed nations to countries like Kenya trying to grow economically.

Some suggest, however, that it is prohibitively expensive to create a significant number of new jobs in the capital intensive industrial sector (Lewis 142). They assert that the basic need is to encourage growth of smaller secondary urban areas. Smaller urban areas may address the need to foster backwards and forwards linkages with agriculture, and would provide readily accessible marketplaces for farmers (Lewis 143). If this strategy is pursued, the need for sanitary water supplies, sanitation systems, control of rain-water run-off, streets, and other infrastructure issues become critical (Lewis 146). However, the major difficulty with this strategy is that to decentralize, the central government must be willing to decentralize, and hence give up some of their power, which may be unlikely.

Kenya's government is moving in the right direction in terms of its philosophy for development. Its policies with respect to the preservation of the environment are based on the premise that prevention of harmful effects is less costly than their subsequent correction. The policies emphasize that environmental considerations must be incorporated at the planning stage of development projects. However, either through lack of political clout or necessary machinery for monitoring and surveillance, there is often no follow-up observation of the impact of rural development schemes (Darkoh 1993, 71). Improving monitoring and enforcement of existing policies can not only improve environmental conditions, but also provide formal sector employment for so many urban dwellers that are in need of income.

It seems that, from examining all the evidence presented here, that there are two ways of looking at urban growth and the environment in Kenya. One school of thought asserts that increased urbanization is a good thing for environmental quality in Kenya. In this scenario, urban-rural migration has a dampening effect on total population growth, therefore reducing pressures on the environment. As population grows, rural poverty pushes people to urban areas. During this migration, people tend to acquire more education (either before migrating or after they reach the city). This higher education level leads to a desire for smaller families, thus reducing the rate of population growth.

The other theory is that urban migration is a positive feedback to population growth, and therefore increases pressure on the environment. Once again, as population increases people migrate to urban areas, Because of the increased proportion of people in urban areas, greater pressure is placed on the rural environment to provide goods and services for these new urban dwellers. The new demand for production in rural areas will thus reinforce the need for large families there. The cycle of unmanageable population growth is thus perpetuated.

This author tends to agree with the former theory of urban growth, in that the rate of growth of cities is occurring too quickly, without the jobs for migrants and the agricultural surplus to support it. Of course, some policies are in order to improve conditions in urban areas, but not to the point of increasing the pushes to these areas from the rural lands. For example, efforts to reduce urban poverty, including increasing formal sector and industrial employment, will increase incomes for urban families and encourage the view of children as an economic liability. Technological leap-frogging is a viable option for Kenya, soliciting help from nations such as the U.S. in adopting more advanced technologies for production that are less polluting than those that would normally be adopted in the course of development.

These policies will not reduce environmental degradation alone. Rural areas must also be targeted for increased income generating opportunities and improved services so that people won't have such a strong incentive to flee to the cities. Better education and access to health care are essential in rural areas. Opportunities for women to earn income are also crucial to not only improving conditions in rural areas but to reducing the desire for large families (i.e.-increasing the opportunity cost of women's time). These activities could include working in health care, teaching, and selling hand-made goods. The establishment of smaller urban centers will help in this endeavor, allowing more agricultural distribution areas (also a place where women could work) and places to sell wares. By keeping activities decentralized, pushes from rural areas can be decreased, influx to large urban centers like Nairobi can be slowed, and population pressures can be reduced.

As we can see, population growth, urban growth and the condition of the natural environment are intricately entwined. As countries such as Kenya develop, urban populations are bound to increase. Our job as policy makers is to see that the pace of this urban growth is manageable, that migrants can earn a living and that both urban and rural environments can be sustained.

References

CHAPTER THIRTEEN

LYNELLE PRESTON

DEMOGRAPHIC INDICATORS OF DEFORESTATION:
A MISSING LINK IN DEVELOPING FOREST POLICY IN SIKKIM

Introduction

Deforestation is increasingly becoming recognized as the number one threat to mountain ecosystems and mountain cultures. The Himalayas are no exception. During the last 20 years studies have focused on the relationship between deforestation and the corresponding increase in population. Although extensive numerical statistics are lacking, the trends and indicators blatantly illustrate this causal relationship. This study examines Sikkim as a specific example of the larger trends that are occurring in the greater Himalayan region. Although Sikkim has not yet suffered as extreme deforestation as its neighbors, its rate of deforestation is much more dramatic. Because Sikkim is only in the early stages of deforestation, there is a greater chance that this destruction is reversible. This study examines different demographic factors which contribute to the amount and rate of deforestation and then outlines policy recommendations which could be used to slow or reverse these trends.

Sikkim, the newest state of India, is located in the northeast corner of the country bordering Tibet on the north, Nepal on the west and Bhutan on the east. (Appendix 1, Map 1) Compared to the rest of the Himalayas, the state has been visited by few outsiders and therefore has been less disturbed by western influences and consumptive tendencies. As in other areas, resources are becoming more scarce as population increases and consumption patterns continue at present levels.

According to Dr. William Drakes theory of transitions, Sikkim appears to be in the midst of a forestry transition -- a period of rapid change, relative instability and volatile conditions. Sikkim is at this vulnerable state because it is in the beginning stages of dramatic change rather than being near the end of the transition, a period returning to relative equilibrium and stability. While this transitional stage makes Sikkim especially vulnerable, the transition period also provides policy makers in Sikkim with unique opportunities to direct change in positive rather than negative directions. Typically, when such periods of transition and crisis are recognized, people tend to act aggressively and develop creative solutions. Since deforestation is a relatively recent phenomenon in Sikkim and it is in its early stages, there are great opportunities now to implement changes which will direct and shape future forestry trends.

A Model Simulation to Assess Deforestation

While the majority of research on deforestation explores the causal relationships between the many different factors, it rarely gives an indication of the magnitude or time frame involved. In a paper entitled Man versus Mountain: The Destruction of the Himalayan Ecosystem (Rieger in Lai, 1981), Hans Christopher Rieger has devised a model simulation which graphically illustrates the magnitude and severity of current population and deforestation transitions in the Himalayan region as a whole, rather than simply stating that these problems exist. Rieger uses an ecological model of the deforestation processes based on a set of assumptions describing the Himalayan region to illustrate current forestry trends and to predict future ones. The assumptions include a population growth rate of 2 per cent per annum, an extraction rate of 1400 kg per capita per year, a natural forest density of 360 tons per hectare of timber, and a natural forest growth of 5 per cent per decade. Using these initial conditions, the model was first set in motion for a period of 100 years. The results are depicted in Figure 1.

Figure 1:

Source: Reiger, 1988.

As is expected the extraction curve has a close similarity to the population curve. Since the natural growth of forests curve lies well above the extraction curve, the ecological system appears to be in balance. A policy-maker in year 100 looking back on past developments would have no cause for alarm if he assumes -- as most politicians do -- that the future is most likely to be like the past. However, an examination of Figure 2, in which the same curves have been projected for a further century, shows that this complacency is ill-founded (Rieger, 1981)

Figure 2:

Because of the exponential growth of population, the extraction rate increases so rapidly that before the year 120 is reached, extraction exceeds the natural regeneration of the forests. Within a few decades, the remaining forests are depleted to the point of complete destruction. The result is not only the complete destruction of the forests, but also the destruction of all the people who depend on forests for their survival. This model does not, however, necessarily predict what will happen in the future because other variables are not considered in the equation. But it does illustrate the current trends and projects one possible future scenario (Lal, 1981).

Sikkim is no exception to this model. In fact, the available data indicates that the rate of deforestation in Sikkim may be occurring at an even greater speed than that described in Riegers model. When running the model using initial conditions which are more representative of Sikkim, the simulation yields much more dramatic results. The rate of destruction appears to be occurring at a much faster rate. The population growth rate is faster and thus the population and extraction curves are steeper; the population density, exacerbated by urbanization trends, is higher in Sikkim than that depicted in Riegers model; the changing ethnic composition and the booming tourism industry is affecting the total population growth as well as increasing the resource extraction rates.

Demographic Indicators

Population Growth

One of the most apparent indicators that Sikkims extraction rates will exceed natural forest growth and total forest stock is the extreme population growth rate. While Rieger used a population growth rate of 2 percent per year, the population of Sikkim has grown at a much faster rate. (Figure 3) During the last 30 years, the growth rate has accelerated from 1.77% per year to 5.07% per year in 1981 (Karan, 1989).

Figure 3:

Source: Karan, 1989.

The dotted line on the graph shows the actual population during the last 100 years while the solid line shows the exponential projection of population growth over the next fifty years. This projection indicates that the population will continue to grow at an increasingly rapid rate. This projection assumes stable conditions and does not consider other factors. A closer examination of different demographic characteristics of Sikkim, however, allows one to assess whether in fact the population will continue to grow at the exponential rate depicted in the graph.

The demographic information provides conflicting indicators of the future population growth. During the past 100 years, on of the main factors which has caused the growth rate to approach a 5.07 per cent per annum growth rate in 1981 has been the migration of Nepalese settling in Sikkim. The population growth rate of Nepalese living in Sikkim has averaged around 7 per cent between 1931 and 1981 and between 1978 and 1981, the population growth rate was 8.81 per cent per year. Figure 4 illustrates this:

Figure 4:

Source: Desai, 1988.

Figure 5:

Source: Desai, 1988.

Thus, much of Sikkims population explosion is due to migration rather than to high fertility and other demographic characteristics. Migration however is not necessarily a positive feedback loop, where an increase in immigrants triggers a greater increase. In fact the opposite occurs; when a significant amount has migrated, there is less room and therefore less desire for others to migrate. A high migration rate in one decade does not guarantee a high migration rate the next decade. In fact, at some point the migration rate will start to level off and eventually decline as an area becomes exceedingly crowded and less appealing. The data indicates that Sikkim appears to be nearing the end of its migration transition. (Figure 5) Assuming the ratio of Nepalese to Sikkimese has remained constant between 1981 and 1991, the decline in total population growth of Sikkim indicates a corresponding decline in the population of Nepalese immigrants.

However, other demographic indicators show that while migration trends may be slowing, the total population growth rate of Sikkim will continue to increase dramatically, although perhaps not to the same degree as in the past due to high migration rates. One such indicator that the population growth rate will continue to increase is the age structure of the current population in Sikkim. Figure 6 indicates that almost 70% of the population is under the age of 29 (Desai, 1988). Thus, a majority of the population is either at child-bearing age or will be there soon. According to present patterns, the fertility rate will either continue at the same rate or increase. The fact that only 10% of the population is over 50 years old indicates that the death rate will remain low since most of the population is young and therefore at a low probability of dying.

Figure 6:

Source: Desai , 1988.

Literacy levels can also be used as an indicator of population growth rate since a low literacy rate often corresponds to a high population growth rate. In Sikkim, only 34.05% of the population were literate in 1981. In general, the urban population is more literate than the rural population; the literacy rate in urban areas is 54.86% and in rural areas is 30.05%. Similarly, the literacy rate for males is almost twice as high that of females, 44% and 22% respectively (Balaraman, 1987). Although this study does not directly examine the relationship between literacy and population growth, this causal relationship is generally accepted among demographers. While there are exceptions, a low literacy rate often suggests a high population growth rate.

Sikkims population is currently growing at a rapid rate, a majority of the people are in the young age groups, and literacy rates are low. Thus, it is reasonable to expect that the population will grow exponentially even if migration is slowed. Thus, assuming that the consumption rates in Sikkim are similar to those in the simulation and that there is a similar causal relationship between population and consumption as there is in other parts of thee Himalayas, these demographic indicators suggest that both the population and the corresponding extraction rates are more severe than what is shown in the simulation.

Population Density

Another assumption Rieger makes in the simulation is population density. Rieger assumes a population of 1,000 people living in a 100 sq.km. area, yeilding a density of 10 people per sq.km. After 100 years the density in the simulation was 72.5. In contrast, the East district of Sikkim had a much higher population density with 187 people per sq.km.

in 1991 (Lama, 1994). As a whole, Sikkim currently has an area of 7,096 sq.km., a population of 406,452, and a corresponding density of 57 people per sq. km. Thus, Sikkim does not have a significantly higher population density than that depicted in the simulation. However, since the 4,226 sq.km. in the North district are largely uninhabitable due to rock and snow cover, extreme altitudes and harsh weather, the majority of the population lives in the other three districts. Consequently, 92% of the population lives in 40% of the geographic area (Map 1, Appendix 1; Figure 7, 8). Thus, while the density of the country as a whole is only 57, the density of certain districts is significantly greater than the density assumed in the model both under the initial conditions and after the first 100 years. Figure 7 and 8 illustrate this phenomenon.

Figure 7:

Source: Desai, 1988.

Figure 8:

Source: Desai, 1988.

Urbanization

Current urbanization trends in Sikkim further indicate how much more densely populated these southern three districts will become. For example, not only is the East district already more densely populated than the North, but the population growth rate is also much higher than the growth rate of the North district. This difference in rates is at least partially a consequence of the fact that population growth, as mentioned earlier, is a positive feedback loop: a chain of cause-and-effect relationships that closes in on itself so that a change in any one element in the loop will change the original element even more in that same direction. Hence, an increase will cause a further increase (Meadows, 1992). Therefore, since the East district has more people than the North now, the positive feedback loop suggests that the East district naturally will increase at a faster rate, even though the resources are more scarce.

Another reason that the East district is becoming more densely populated is because of the recent urbanization trends. Figure 9 illustrates the urbanization transition which has been occurring over the past fifty years. In 1941, the census revealed no urban population at all. By 1981, however, almost 20% of the population was considered urban. This indicates that much of the population is concentrated in pockets, thus placing even more constraints on the resources in these urban centers. While in some countries, urbanization trends have had beneficial impacts on deforestation because large amounts of people with not enough forests are forced to find alternative sources of energy, in Sikkim it is the urban centers which have suffered from the most deforestation as evidenced by land slides (Desai, 1988). Nevertheless, the unevenly distributed population and the increasing urbanization trends mean that certain areas of Sikkim are becoming much more densely populated than that depicted in Riegers simulation.

Figure 9:

Source: Desai, 1988.

Just as the number of people per geographic area is significantly higher in parts of Sikkim than in the simulation, so too is the corresponding number of people per forest area. The simulation begins with an assumption of 1,000 people and 9,800 hectares of forest; this yields 9.8 hectares of forest per person. After 100 years, the simulation indicates 1.18 hectares of forest per person. According to many estimates of deforestation in Sikkim, the remaining forest area in the 1980s was 265,210 hectares while the population was 316,385. This indicates a ratio of .84 hectares of forest per person. Since .84 is already well below the simulations 1.18, this may indicate that the lines on the graph are actually closer together than those in Riegers simulation.

By using a different population growth rate and a higher density, and assuming that extraction rates per person is similar to that used in the simulation, it is clear that the population and extraction curves will both be steeper than those in the simulation. No data could be found on the natural forest growth rate or the rate at which forest stock is declining. Therefore, by using the forestry rates depicted in the simulation, combined with higher population and extraction rates, it becomes clear that the point where these lines cross may occur sooner in Sikkim than in other Himalayan regions. Consequently, Sikkim is currently at a point along the transition more similar to that projected for the second hundred years where the lines are closer together. Perhaps today is most accurately represented by the 100th year of the simulation rather than the 10th year. Such information is critical for policy-makers and forest managers. The immediacy of the situation needs to be considered in adopting and implementing new forest policies.

Changing Ethnic Compositions

There are other demographic characteristics, not accounted for in Riegers simulation, which significantly affect resource use and consequently affect the forestry transition. Numbers and statistics are often the most commonly used indicator of change in a society although other factors may have a more significant impact on resource use in a particular region. For example, the different ethnic groups in Sikkim utilize forest resources very differently and consequently have very different impacts on the environment. An increase in the population of

Nepalese people in Sikkim has caused corresponding changes in forest use. Historically, Sikkim was inhabited by two major ethnic groups -- Lepchas and Bhotias. The Lepchas are believed to be the original inhabitants of this area while the Bhotias are the Tibetan immigrants who took refuge in Sikkim in the fifteenth and sixteenth centuries. These two groups intermarried and became assimilated.

Before the 1900s, the Nepalese began to migrate to Sikkim because their lands were deforested, over-cultivated, and over-populated (Kazi, 1993). In 1904, however, when Sikkim became a British protectorate, The Nepalese began to migrate in large numbers. The Indian government encouraged Nepalese people to settle in Sikkim, help bring the land under cultivation, and build roads. The Indian government also brought Nepalese people to Sikkim in an effort to outnumber the Tibetan-minded Sikkimese peoples so that the state as a whole would be more closely aligned with India than with Tibet. As a government official said, an influx of hereditary enemies of Tibet (Nepalese) is the surest guarantee against revival of Tibetan influence. (Desai, 1988) As a result, Nepalese people have moved in and now comprise approximately 80% of the population as shown in figure 10. Not only has it changed the culture of Sikkim, but it has also impacted the forest base.

Figure 10:

Source: Desai, 1988.

In addition to the actual speed of immigration, the cultural differences between the Nepalese and the other ethnic groups has had a significant impact on forest destruction. The traditional Bhotias and Lepchas practiced a shifting cultivation called jhuming in which they moved to a new location every time the soil began to erode and became less productive. New land was cleared while old land was given time to rejuvenate. Given the low population of Bhotias and Lepchas before the Nepalese arrived, there was always plenty of land to practice this type of agriculture sustainably. However, when the Nepalese came, they brought with them knowledge of terrace farming in which they settled in one location and farmed the land. Terrace farming has definite advantages over jhuming in terms of soil erosion; however, since the Nepalese came in such large numbers, most of the available land was cleared for these permanent settlements. Additionally, with all the land in agriculture and a decreasing amount of forests, the amount of rainfall is reduced.

The Nepalese were also brought to Sikkim to help build roads. This meant that not only were forests cleared for roads, but they were also cleared for new agricultural lands which became accessible by the new roads.

The influx of Nepalese people also has an impact on the total population growth rate because as a group the Nepalese have a much higher fertility rate than the Bhotias and Lepchas. While the Lepchas and Bhotias are poorer and therefore marry later because of the high bride price , the Nepalese have typically married at an early age and have traditionally practiced polygamy. Since the Nepalese have a higher fertility rate, an increase in Nepalese residents means an increase in the overall fertility rate and consequently a higher growth rate for Sikkim. While the arrival of Nepalese has caused Bhotias and Lepchas to assimilate, the Nepalese have maintained their traditional culture and fertility patterns rather than adapting to those of the host cultures.

While on some levels the Nepalese seem to contribute more to deforestation, there are other situations in which the Bhotias and Lepchas use more resources than the Nepalese. While the Nepalese typically build concrete or mud thatched houses, the Lepcha and Bhotias have traditionally built their houses out of valuable timber even when other materials are available. A house for 5 people requires one tree trunk annually for construction purposes. Consequently, about seventy cubic meters of valuable wood is logged per house although less than twenty cubic meters would suffice if properly and efficiently utilized (Karan, 1984).

The Lepchas and Bhotias also have more livestock than the Nepalese. These animals utilize the forests for grazing and deplete the forest density. While tracts of forests are not necessarily cut down for the livestock, the animals feed on the undergrowth and on young plants which affects the forest health and productivity.

Understanding these cultural differences in resource use enables policy-makers to design programs which target some of the fundamental causes of high extraction rates. For example, by limiting the flow of immigration, less forests will need to be cleared for agriculture. Similarly, by providing education and incentives for Lepchas and Bhotias to utilize less valuable timber or other building materials for their houses, timber resources would be utilized more wisely.

Tourism

Another significant change which has affected resource use in Sikkim is the increasing number of tourists. As other popular Himalayan tourist destinations become over crowded and deforested, tourists are flocking to Sikkim in search of unexplored and undisturbed environments. Relative to its neighbors, tourism is a recent phenomenon in Sikkim. While tourism in Nepal and Darjeeling began in the 60s and 70s, tourism in Sikkim only recently began to accelerate in the 80s. Although numbers and hard data describing the tourist trend in Sikkim are not available, a look at the trends in Nepal and Darjeeling, two places with similar natural resources and similar pressures, provides an indication of what may be currently occurring in Sikkim and also what is likely to occur. Tourism in Nepal increased from 12,000 tourists in 1966 to

110,321 in 1975, an increase of 8.2%. The number of foreign tourists in Darjeeling increased from 3,299 in 1974 to 10,977 in 1983 (Lama, 1994). Based on a survey done in 1976, over 90% of the tourists visiting Darjeeling are Indian nationals. Therefore, it is estimated that between 1974 and 1983 the number of tourists rose from 32,990 to 109,770. While this is only a 3-fold increase in Darjeeling, tourists comprised one-tenth of the total population of Darjeeling at that time. In both Darjeeling and Nepal tourists represent a significant percentage of the population although they are not typically accounted for in census data. Thus the actual population in these areas and their corresponding use of resources is significantly greater than what is depicted in the figures.

Not only are the number of tourists significant, but also the type of tourists are important in that different types utilize resources differently. The tourists in Nepal and Darjeeling can be divided into two major types, domestic and foreign. In Darjeeling 90% of the tourists are Indian nationals who are coming to the hills for a long weekend or short stay. These people are among the wealthier and are looking for somewhat luxurious tourist facilities. Consequently, Darjeeling has 67 hotels in the 4.4 square miles of the state.

Nepal, on the other hand, caters to a different kind of tourist--trekkers who have come from places outside of India to hike in the Himalayas. The resource needs of these tourists are very different from those of Darjeeling visitors. Relatively speaking there are not many hotels in Nepal because the majority of tourists are hiking, staying in modest accommodations, and theoretically eating more locally grown foods. Thus, these tourists consume less of the forests. However, the situation is not that simple since many of the trekkers in Nepal hike and stay at higher elevations near tree line, where the forests regenerate at a much slower rate than in the moist hill regions. Thus, the location of these tourists has more destructive impacts on the environment.

Sikkim has a mixture of these two types of tourists with an estimate of 80% domestic tourists and 20% foreign tourists (Lama, 1994). Using the information from Nepal and Darjeeling, Sikkim has the opportunity to develop a tourism industry which caters specifically to the types of tourists who will have the least impact on the environment.

Environmental Impacts of Population Pressures

The actual relationship of human activity and forest destruction has recently become more heavily studied and understood. Although the exact rate of deforestation is unknown, the fact that it is occurring at fast speeds is suggested by the increasing number of landslides, one of the most common visible effects of deforestation in mountain environments. While exact statistics on landslides are not available, experts agree that landslides are occurring more frequently than in the past (Blaraman, 1987). The fact that they are reported to be most common around places with the highest density of people is an indication of the interrelationship between people and landslides even though no specific data is available.

However, landslides have historically been a part of life in this area. The physical geography, steep slopes, high amount of rainfall, drastic altitudinal changes and variety in soil types, as well as the geologically unstable, young nature of the Himalayan region, located on a fault line between two tectonic plates make Sikkim extremely susceptible to landslides. Although there are many natural causes of landslides in Sikkim, there are also human factors which contribute to landslides.

The most obvious connection between human activity and landslides is deforestation. As land is deforested, there are no longer root systems to keep the soil in place on the steeper slopes. Thus, in a heavy rain, the soil is washed downhill resulting in huge landslides. Deforestation is probably the leading cause of soil erosion and hence land slides. Figure 11 illustrates the impact of humans on the environment.

Figure 11:

Source: Desai, 1988

The chart illustrates that deforestation is caused by a combination of the number of people and the behavior of people. Some of the boxes on the top level of the flow chart are areas that have been emphasized in this study -- differing demands for shelter among ethnic groups and tourist types, food demand, construction techniques, agricultural techniques, and grazing. Each of these uses trigger other processes leading directly to deforestation and landslides. For Example, Cardamom is one of the largest commercial crops and is grown along steep river banks. When the crops are harvested the soil is loosened and washed down stream after a heavy rain fall. A use that is not depicted on the chart is the unscientific construction of roads and buildings on these steep slopes. This is one of the biggest factors that can destroy natural ecosystems and trigger landslides (Desai, 1988). Such construction prevents the free lateral movement of moisture. Once this equilibrium is broken, progressive erosion occurs (Desai, 1988).

The steep slopes and heavy rainfall mean a high velocity of water flow and therefore the transport of large quantities of silt, sand, boulders and timber. This erodes the river valleys and decreases the lateral support to hill sides, causing cracks in the upper level due to mass stress. As the cracks fill up with water, the resistance of the hillside decreases and major landslides occur. Such landslides can extend uphill and lead to the collapse of steep faces causing dangerous damming of big rivers (Desai, 1988).

Policy Implications and Recommendations

The consensus among experts that there is an increasing number of land slides and that these landslides are at least partially caused by deforestation has been enough to trigger forestry policies and programs in Sikkim. While the existence of government programs suggest progress and action, the approach used to arrive at such programs is often flawed; the policies are not based on scientific data or carefully designed and therefore fall short of achieving their objectives. It has been a trend throughout history that policy makers prefer to make new policies rather than to successfully implement or monitor polices which have already been adopted. Consequently, many policies are adopted haphazardly, do not address all the aspects of the problem they intend to solve, and are not monitored to see whether they are in fact effective.

In Sikkim, as in other areas and countries, the solutions to a problem as large as deforestation have been piece meal; each government department, development worker, or scientist has a different perception of the problem and a different solution. The typical response to a problem such as deforestation is to sound the alarm and then take the driver seat, without analyzing the full scope of the problem and all its components. In Sikkim for example, there are more than ten different government-sponsored developmental programs working on fixing deforestation -- the department of education, forest, land use, soil conservation, agriculture, horticulture, animal husbandry, rural development, public works, power, health, and the Sikkim Trading Corporation and Spices Board. While each department is working on an important component, there is no unified comprehensive overall natural resource management strategy. There has been little collaboration among the different departments to collectively try to understand the complexity of the problem. The issue of deforestation spans many disciplines. Consequently, solutions lie in an integrated cross-disciplinary approach where physical scientists, social scientists and demographers, local residents, and policy makers work together as a team.

The first and most obvious gap in Sikkims forestry policies is the dearth of numerical data and the uncertainty of the data which does exist. Measuring forest cover has always been more of a challenge in mountainous regions, however the need for data here is as important if not more important than obtaining forestry data in other parts of the world. The data that is available is largely qualitative. For example, one scientist writing about deforestation (Moddie, 1981) describes the road heading north from Gangtok. In 1947, 15 km up the track from Gangtok was one of the worlds finest rhododendron forests, dripping with 500 cm of rainfall a year. It was a shock to discover ten years later, that not one tree stood there. Such data is typical of what is available on the deforestation situation in Sikkim. Many of the reports discuss the fact that there are only 265,210 hectares of forest area left. This figure is from the early 1980s and is the only figure found in all the different sources of information. Thus, it is probable that one scientist came up with the figure and all the others have relied on that information as the commonly accepted amount of forest cover left.

Figure 12:

Among the various reports I found only one map illustrating the land use patterns (Figure 12). While this map is better than nothing, it does not have enough detail upon which forestry policies and reforestation schemes can be based. There is a real need in Sikkim for GIS and remote sensing technologies in order to understand the situation accurately enough to design strategies that will be effective. Obtaining accurate and sufficient data should be the first step in developing policy recommendations. Such information will serve as base line data against which success can be measured. Having base line data is an essential tool needed to monitor the success of policies, and to know when certain policies need to be altered to better achieve their goal. Depending on the level of local expertise in this area, training programs may be needed in order to develop a skilled people who are able to gather such data.

Another set of information which will be critical to designing effective policy is socio-cultural data. It is becoming increasingly recognized that policies which do not examine and understand the social components and the needs of the local residents are often short-sighted and unsuccessful. Consequently, a comprehensive study of the socio-cultural aspects is desperately needed before any regional forestry policy can be designed. There are many different approaches to use, including participatory rural appraisal or a social impact analysis, however the most essential element is to go to the villages, speak with the resource users themselves and become familiar with their specific needs. This study has outlined some of the social aspects of the deforestation dilemma, yet the source of information has been largely outside experts or government leaders living in the capitol of Gangtok. It is typical for development work to rely on such information without actually going to the communities, having community meetings, and hearing from those groups of people whos voices are rarely heard.

The most important group to target in obtaining socio-cultural information is the village women. These are the people who make the household resource decisions. They gather the fuel for cooking and the fodder for livestock. They are the ones playing the most vital role in the village economies. They are also the ones most underrepresented in government departments or government decisions. Culturally, they do not interact much with men and therefore they do not participate in decisions, nor do they have access to information about natural resource issues. Consequently, it will be essential to spend time with these groups of women to understand their resource needs. Given the cultural norms, the most valuable data would probably be obtained from a female researcher rather than a male one. Such details are often overlooked yet are critical to obtaining accurate data which will lead to effective policy strategies.

The final set of information needed is data regarding deforestation patterns and forestry polices in other parts of the Himalayas. Such information can be used to assess which strategies have previously been used and which ones have been effective. This will assist the government in implementing policies and programs which have a greater likelihood of effectively reversing the current deforestation trends rather than implementing programs which have already failed in other areas.

The most obvious intervention strategy is to improve the regeneration rate of forests using afforestation schemes and erosion/landslide control. However, these two solutions deal with the immediacy of a particular situation yet do not address or alter the fundamental causes of the problem. Looking back to figure 11, soil erosion and deforestation are in the lower half of the flow chart. While schemes to reverse these trends are important and do address the most visible aspect of the problem, the underlying causes of the problem remain unchanged. Consequently, while more trees may be planted, the consumption rate and overall deforestation rate, affected by population numbers and behaviors, will continue to increase. Thus afforestation programs and erosion control measures will not be effective when implemented in isolation.

Solutions need to focus on the causes of deforestation, those boxes that are at the top of the flow chart -- the number of people and the behavior of people. This first part of this study has illustrated how these two factors, number and behavior, affect resource use differently. Utilizing the information outlined previously, policy makers can begin to design solutions which deal directly with the causes of the problem. Consequently, rather than investing money in reforestation and scientific remedies, it is important to address the human components which are at the heart of deforestation.

The foremost social intervention involves reducing the population growth rate. Based on the first part of the paper, it is apparent that handing out birth control may not be the most direct approach to limiting population numbers. In fact, the most important strategy does not involve fertility rates at all, but rather, involves the migration rates of Nepalese residents since this has been the driving force behind rising population growth rates. The second area to target is fertility rates. However, these programs need to specifically target the Nepalese residents rather than the Bhotias and Lepchas; the Nepalese are the ones with high fertility rates. Such details, based on a sound analysis of the situation, are absolutely critical to the success of the various policies. A typical policy maker, government bureaucrat, or development worker may not realize these subtleties and may invest significant amounts of money on birth control in an area dominated by Bhotias and Lepchas who have an extremely low fertility rate anyway. Reducing migration and curbing the fertility rate of Nepalese are two initial strategies to reduce the number of people. After a comprehensive analysis of socio-cultural factors has been conducted and more base line data has been gathered about the specific regions of Sikkim and the different ethnic groups, other strategies can be devised which specifically address the needs of these people.

The second social intervention that can be used to reverse deforestation is to change population behaviors and therefore consumption rates. This study has outlined the various ways in which differing behaviors affect resource use differently in Sikkim. Based on this study, specific behavior patterns can be targeted in an effort to decrease the rate of deforestation.

The first and perhaps most effective strategy in changing anyones behavior is through education. In addition to targeting those people who currently go to school, education programs need to address those populations who do not attend school and instead are at home managing the natural resource needs and decisions. These are primarily the women. Women are the ones who make the majority of natural resource decisions yet they have the least access to information on conservation and resource management techniques. Targeting this female population through village workshops, adult education programs, and dissemination of educational materials would be an important first step. There needs to be a mixture of formal technical programs and informal non-technical ones which cater to the different learning styles. Once a group of women are educated, these women can then work as a team to educate other women in rural communities about natural resource management techniques. More broad educational programs should follow after these initial female education programs have been implemented.

Some of the most obvious behaviors to change are those at the top of the flow chart in Figure 11. For example, housing construction and agricultural techniques are two aspects discussed earlier which contribute to high consumption levels. By providing education to the Bhotias and Lepchas about the wood they are using to construct their houses, these people may be willing to change their practices if they understand the environmental impacts and consequences of their current construction methods. Showing them alternative housing styles which use different types of wood or different building materials altogether could be enough to encourage them to change their current practices. The initial socio-economic studies will be helpful in assessing their current housing needs and in finding suitable solutions.

A second behavior change which could be encouraged is a shift in the agricultural techniques which are currently being used. For example, by having the Bhotias and Lepchas practice less jhuming (shifting cultivation) and switch to terrace farming, the land that was traditionally left fallow can be used for tree nurseries and reforestation programs. In addition, a closer examination of the different agricultural techniques that are being used in the Himalayan region is needed in order to determine the most effective agricultural techniques with the least destructive impacts. Agroforestry programs, which have been started in Sikkim, have been fairly successful although they are not widespread. By planting certain species, farmers can reduce soil erosion while also earning economic profits from exported products such as cardamom and mandarin oranges. By capitalizing on specific agricultural approaches such as these, farmers will be able to maximize production while minimizing environmental degradation.

Another potential behavioral change which would require further study is the impacts of urbanization. In some parts of the world, urbanization has had a positive effect on rates of deforestation. In such situations urbanization trends have been paralleled with a rise in alternate energy sources. This arose out of necessity because the amount and location of forests were inadequate for the large numbers of urban residents. If Sikkim adopted alternate cooking fuels like kerosene or solar power, the urbanization phenomenon may not have a negative impact on forest resources from an energy perspective.

However, unless there is an increase in construction technology, urbanization will still be destructive from a soil erosion perspective. Currently, the poor technology used to build roads and buildings has led to an increasing number of landslides. A study of similar urban areas located in mountainous terrain would help determine how, if at all, to develop urban areas in Sikkim. A study could show that given the extreme vertical topography, it is not feasible to have large urban centers. In this case, there needs to be policies which provide adequate services to the villages so that there are few incentives to migrate to urban areas. The issue of urbanization is a good example of an aspect of deforestation which may be overlooked by those developing forestry policies, yet is clearly interrelated.

A final aspect of deforestation which addresses both numbers of people and behaviors of people is the growing tourism industry. As mentioned previously, the tourism industry is just recently beginning to grow and expand. The government needs to understand the dynamics of tourism and the potential environmental and social impacts before it can develop an effective strategic plan for the area. In recent years, Sikkim has responded to tourism by developing facilities as needed. For example, they have upgraded the accommodations with modern amenities, improved the transportation system with a fleet of comfortable vehicles; increased the opportunities for adventure tourists by providing trekking equipment, new trekking routes, and even hang gliding and river rafting; and finally, they have improved the publicity and availability of tourist information through private and governmental media. While all these approaches are appropriate, the country lacks an overall tourism management plan. The country needs to be proactive in determining what kinds of tourism are best for Sikkim and then devising strategies that are in their best interest rather being reactive to the tourist demands.

The government again, needs to examine successes and failures of other Himalayan tourist destinations, especially those areas that have failed. This will help Sikkim to create a tourist destination that not only provides the best services for tourists, but also has the least environmental and social impacts on the area as a whole. As mentioned in the analysis above, Sikkim now caters largely to domestic tourists rather than foreign ones. There needs to be a formal study on the difference between these two types of tourists to determine which type of tourist will be more beneficial for Sikkim. Through a careful analysis of all the components of tourism, one can arrive at specific innovations which will determine the success and sustainability of Sikkims tourism industry in the future.

For example, if a study indicates that trekker tourists in general uses fewer resources than wealthy weekend tourists, yet has a significant negative impact on the fragile alpine environment, strategies can be devised which reduce such impact. For example, trekking routes can be designed through the lowland areas where the vegetation is more sturdy. In addition to having less impact, these new routes could make trekking more appealing to those populations who traditionally prefer to avoid extreme altitudes or cold temperatures.

Another solution would be to devise a way for trekking at high altitudes to have less negative environmental impacts. Since almost a third of Sikkim is uninhabitable because it is under rock and snow, perhaps trekker tourism would be a good way to put this land to use. This would require designing specific trails and encouraging tourists to stay on them, providing for increased litter and trash, having kerosene imported for cooking, and possibly even having solar outhouses to take care of human waste. Opening up such a high altitude trekking industry would provide many jobs, especially for those people who live in these extreme conditions of the North District and are well-suited to fill these roles. There would be a need for some outside technological help, yet this could be the perfect avenue for development agencies eager to fund useful projects.

If the results of a tourism study show that trekkers overall have less impact than domestic weekend visitors, then publicity strategies are needed which attract foreign trekker tourists and discourage domestic ones. The simplest approach to limiting domestic tourists is to limit the number of luxury accommodations.

In sum, Sikkim needs to take an active role in shaping the future of their tourism industry rather than simply responding to the tourism demands as they arise. This will enable Sikkim to plan for the future and to develop an industry that will be effective and sustainable when other Himalayan destinations are deforested and overpopulated.

This policy section has outlined a number of possible steps which could be taken to reverse the deforestation trends. Underlying all of them is the need for a rigorous monitoring and evaluation system. As mentioned previously, in many parts of the world, policies are implemented but there effects are rarely monitored and therefore it is difficult to determine if the policies have been effective. Given that there will be baseline data from the initial studies, the Sikkimese government will be able to monitor the different components of the overall strategy in order to terminate programs that are not working, alter ones that could be working better, and to also determine which programs are effective and should be replicated in other areas. By monitoring programs and sharing the information about successful and unsuccessful programs, effective deforestation programs will emerge.

Conclusion

This study has used other Himalayan regions in an effort to first predict deforestation trends in Sikkim and then examine the population and environmental factors specific to Sikkim which have influenced the rate of deforestation. This has provided a more accurate picture of the deforestation transition in Sikkim despite the absence of numerical forestry data. Hopefully the study has illustrated for policy makers and others, the complexity of issues surrounding the deforestation phenomenon. The final policy section has provided a map of issues for policy makers to consider before adopting any one specific policy or strategy. Deforestation needs to be addressed in its entirety, incorporating all the interrelated aspects of the problem. Strategic planning must be a joint effort of multi-disciplinary experts combined with the local people who utilize the resources. Plans must be focused on long-term visions and goals and not just on solving immediate problems and disasters. By addressing these needs, Sikkim has the potential to be a model Himalayan ecosystem which has maintained its biodiversity of species, unique and pristine mountain environment, enclaves of traditional cultures, and a sustainable economy.

APPENDIX 1

Map 1: Sikkim

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CHAPTER FOURTEEN
KAREN ROWE
HYDROPOWER IN NEPAL

Introduction

Nepal is a mountainous region with a number of Himalayan rivers flowing throughout the country, and there is no doubt that harnessing some of these waters will assist in improving the socio-economic well-being of Nepals people (see map). By investing in hydropower projects Nepal will be exploiting a clean, renewable energy source. However, it becomes Nepals task to recognize the trade-offs that exist in implementing different types of dams, to truly ensure that the country is working towards improving the socio-economic well-being of its people.

There is an ongoing debate over small and large dam projects. In this paper evidence of the merits and drawbacks of each of will be considered and this evidence will lead to a rationale which supports the notion that Nepal is not ready for large scale dam projects. Therefore, Nepal should focus its efforts on creating policies directed to smaller projects. A general overview of both the positive and negative effects of dams is discussed, followed by a more specific look at the benefits and threats to implementing dam projects in Nepal.

This position will be supported by using the Transition Theory. Investigation of population-environment dynamics is complicated and can involve a number of intricate analyses. Transition theory is an effort to break down this complex dynamic. It views the population-environment relationship as a family of transitions. Drake (1992) has defined transition to describe a specific period of time which spans the shift from slow to rapid change in the sector and then usually a return to relative stability (p. 302). Transitions have similarities and differences and the timing of them is very important because the timing affects societal vulnerability and is frequently influenced by public policy (p.303). It is also important to recognize that various sectors can experience transitions simultaneously and this reference serves to maximize or minimize the effects on the societys ability to cope with the transition. Which stages of transition a country may be in should be examined to determine whether it is in its critical period when society is vulnerable to damage. Also, transition theory explains that the completion of a transition, meaning returning to a steady state, does not necessarily lead to improved conditions, but may be more detrimental to a society. Intervention and action is therefore needed to assure the smooth progression of sectors through their various transitions (Drake, 1992).

The case of Nepal illustrates that the timing of transition is crucial, and that lack of positive interventions may result in deleterious consequences. An examination of the agriculture, forestry, energy and demographic transitions will be presented in order to understand how these transitions interact and serve to impede or enhance Nepals overall development and growth, with particular attention to the energy sector and its role in Nepals future.

General Dam Information

Modern dam construction was initiated in the 1920s, advanced after 1950 up until today, and today globally there are more than 38,000 dams (Gardner and Perry, 1995). Although there was a decline in dam construction in the 1980s, both the number of dams being built and the average dam size have been increasing in the 1990s.

Industrialized nations were the first to construct dams, yet more recently three quarters of dam projects undertaken are in developing countries. It has been recognized that dams have generally been regarded as a symbol of modernity and a source of national prestige, partly because they are seen as a multipurpose tool of development (Gardner and Perry, 1995, p.201). The potential uses and benefits from dams are well known. Dams are a source of electric power, a means of flood control, a source of supply for water irrigation projects and a possible recreation outlet. In 1992 more than 18% of the worlds electricity came from hydroelectric power created by dams. Dams have also provided assurance in areas where drought occurs by holding water in reservoirs that can be used when there is no rainfall. Dams can also control the flow of rivers and thus alleviate flooding problems. More recently the impetus for building dams has come from the apparent need for more sophisticated irrigation projects due to countries growing need for food and water.

Within a broadly focused dam project there are a number of possible negative side effects. Reservoirs can produce decomposing plant life at the bottom which may release greenhouse gases (CO2 and Methane) into the air, at rates comparable to coal production plants (Gardner and Perry, 1995). In addition, the nutrient rich sediment used for soil may get caught in a dams reservoir and this sediment may shorten the expected life of the reservoir. Finally there is a degree of uncertainty as to the long-term usefulness of a reservoir which is determined by its level of siltation and sedimentation.

Dams have potential negative effects on the human population as well. Large scale water projects were a major contributor to the 75% global increase in cases of schistosomaisis. In addition, to create reservoirs or even build roads to facilitate the construction of dams, it becomes necessary to displace certain individuals and communities. In the past, most resettlement or relocation of individuals has not been well thought out and has left these people in worse conditions than before. Often these individuals attempt to move back near their original homes and people who live near dams face increased health risks. Another negative effect on people is the loss of arable land. Dams are intended to increase irrigation, and improve the productivity of the land, yet reservoirs eat up the arable land. The larger the project, the bigger the land loss, and consequently the more people ousted from their farm land. Finally, dams in seismic regions can cause severe suffering to a country.

With dam projects, the positive and negative effects are influenced by and vary greatly depending on the environmental, social and political context within the country or region. A look at Nepals geography, environmental condition, and social and political status illustrates the importance of examining these relevant aspects within the context of the country. Potential dam construction will have a strong impact in many of the sectors in Nepal, most directly affecting the agriculture, forestry and energy sectors.

Nepal: General Review

Nepal is a small landlocked country about 500 miles long and 100 miles wide. It is located in the Himalaya mountains and bordered by China to the north and India to the south, east and west. It is a mountainous country with approximately 77% of its total area occupied by hills and mountains (Poudel, 1991). It is a country of physical extremes from the arctic high Himalaya in the north to the subtropical hot flatlands in the south. It has a population of approximately 20 million, made up of many different ethnic, cultural and linguistic backgrounds. In Nepal there is a hierarchical society with a strong caste system still dictating ones place in society.

Nepal is one of the least developed nations in the world, and has one of the lowest per capita incomes. In addition, there continues to be an increase in the population and an increase in misuse of the land. Infant mortality rates are among the highest in the world and life expectancy at birth among the lowest. Half the population lives at or just above the starvation level; this fact has a significant impact on the environmental degradation. The extreme poverty is both a cause and effect of environmental degradation. The impoverished farmers lack access to economic assets and are forced to exploit whatever resources are available, without consideration of the environmental consequences. Dahal and Guru-Gharana (1993) in their paper Environment and Sustainable Development in Nepal assert that:

> *Poverty, population growth and lack of education and awareness (including personal and environmental hygiene), coupled with institutional problems including inefficiency and poor technology of public utilities are causing this process of environmental degradation* (p. 171).

Additionally, the countrys lack of infrastructure, such as transport and communication, has severely limited its economic opportunities. Such conditions lead to heavy reliance on its natural resources. There is an over exploitation of some its natural resources such as forests, yet there is an under exploitation of other resources such as water (i.e. hydroelectric energy source) (Dahal and Guru-Gharana, 1993). Historically Nepal has relied heavily on foreign aid for development and the majority of the development projects are conceptually born in the aid negotiation arena rather than on the planning desk (Bhadra, 1982, p.6).

Finally, as Nepal is a landlocked nation with a small domestic market, and limited natural resources, it must rely on its neighbor, India, for any international market opportunities. Since Indo-Nepal relations have been rather tenuous, Nepals manufacturing sector has remained small, representing a mere 1% of the Nepalese workforce.

Hydropower Development in Nepal

Water Resources in Nepal

Nepal has over 6,000 rivers and streams. Its water resources constitute about 2.27% of the world stock for about .35% of the world population (Dahal and Guru-Gharana, 1993). It is drained by 3 major river systems: the Kosi in the east, the Gandaki in the central region, and the Karnaki in the west. Most major river basins originate in the Himalaya and are snow or ice glacier fed and maintain relatively high flow. Thus with such steep topography and such immense river resources (see Map 1) the potential for hydroelectric power is great. Based on annual run-off of rivers the theoretical potential hydropower of Nepal is estimated to be about 83,000MW. Of that 83,000MW the amount that can be economically exploited ranges from conservative estimates of 30% to just over 50% (UNCED, 1990, Shresta, 1991). Yet the actual installed hydropower capacity by the end of 1990 was only 238MW, about .29% of the theoretical power potential.

Hydro facts
1000 watts = 1 kilowatt (kW)
1000 kW = 1 megawatt (MW)
When 1kW of electricity is used for 1 hour, 1 electrical unit is consumed (1kWh) Hydro-electric power plants are generally classified into two types as storage and run of river systems. A storage system involves a dam which holds water back to form a reservoir having sufficient capacity. Run of river plant is built on a river which has a sustained dry season flow that can be diverted for electricity generation (Dixit, 1991).

Energy and Hydropower

Figure 1 below reveals that Nepal is not energy independent, rather it relies on energy imports of coal and oil to meet most of its commercial energy needs. Meanwhile, it is evident that the amount of hydropower exploited thus far is too minimal to help the country meet its commercial energy needs.

Figure 1.

Source: World Resources Data Base, 1995.

However, if Nepal were to further exploit its hydro-electric energy source, the country could achieve energy independence, as well as bring in revenue to help economic development. But at what cost to its people and their environment? Is energy independence something Nepal is in a position to be striving for, and more importantly what are the trade-offs of achieving this independence? In order to become an energy independent country Nepal would have to implement large, expensive dam projects. This cannot be done without outside financial assistance and regional cooperation from its neighbor, India. However, smaller dam projects aimed at rural development and rural electrification may prove to be less risky financially, environmentally and socially, and thus more suitable to a country that is already financially strained, environmentally threatened, and politically weak. Table 1 shows the major potential benefits and detriments to both large and small dam projects in Nepal.

Table 1. DAM PROJECTS IN NEPAL.

	Benefits	Detriments
LARGE DAMS PROJECTS	• Export electricity • Generate revenue hydro dollars • Improve irrigation and agricultural output • Improve relations and regional cooperation?	• Huge financial burden • Heavy reliance on foreign aid • Seismic hazards - earthquake, landslides • Flooding of valuable landfrom reservoir • Unknown life of reservoir because high sedimentation
SMALL	• No risk of bursting dams • Run of river type-no large storage requirements to meet national demands • Easier to construct and maintain • Less	• Do not generate enough electricity

DAM PROJECTS	environmental damage • Improve rural development: create small industries, small fertilizer industries, lift irrigation • Create ponds for fish farming • Conservation of wood fuel	• Lack potential for increasing their capacity • Poor load factor

Nepals energy needs are increasing, as seen in Figure 1, and hydropower development seems beneficial. Nepal can exploit this resource not only as a clean energy source for domestic needs but also as a resource to sell electricity to India to benefit economically. Water resource development can provide great opportunities for regional cooperation. Both India and Bangladesh could benefit if dam construction led to flood reduction and improved irrigation; Nepal could benefit economically from the sale of electricity. Yet there are a number of potential negative side effects that need to be considered carefully before a decision to embark on some sort of sharing a river project.

Nepal, historically and currently, overuses its forest for energy, resulting in severe deforestation. Dams in Nepal could provide a renewable, clean source of energy to take the pressure off the much overused forestry sector. Dams would also prove highly beneficial in assisting the agriculture sector by improving irrigation with a consequent increase in production. An increase in food production has a direct effect on the quality of life of the people. Finally, large, regional dam projects would allow for electricity sales and hydro-dollars that could contribute significantly to Nepals economic growth.

The need to exploit water resources seems apparent and appears to be needed to improve the socio-economic well-being of Nepals people. However, careful consideration of the type of dam project most suited for Nepal is also needed to prevent negative consequences which would be harmful to the people. Therefore a closer look at Nepals demographic situation, as well as the environmental conditions in the forestry, agriculture and energy sectors is provided.

Transitions in Nepal

Demographic Transition

In the demographic transition it is important to consider the crude birth and death rates and the overall timing of these two rates. Generally in the demographic transition the death rates start to decline earlier than the birth rates. How this process occurs is influenced by a number of factors, some of which can inhibit a country from lowering its population growth rate in order to complete a successful demographic transition.

Continued high population growth rates is evident in many developing countries. This translates to increased demand for goods and services and puts direct pressure on the environment. Public policy and positive interventions are often implemented to help a country reduce its population growth rate and thus begin to improve its management of impacts caused by severe population pressure. The timing of when a country begins the demographic transition, and of how fast fertility declines once the transition begins are critical factors which have significant impact on many other sectors.

Figures 2 and 3 illustrate that Nepal is in the beginning stage of its demographic transition. The birth rate has begun to decrease, and the population growth rate has also begun to decline.

Figure 2.

Figure 3.

However, it is important to remember that while the population growth rate has peaked at 2.8%, it is still quite high and therefore the total population growth will continue to increase at possibly an unmanageable level. Some estimates project that current efforts to slow population growth will not make a significant impact until 2030 (UNCED, 1990). The World Bank reports conclude that Nepals demographic situation is among the worst in the world (Seddon, 1994). Also, one should be aware that different sources indicate rather different projection estimates, and data from many developing countries is at best questionable. Yet for Nepal, all generally conclude that their population will continue to increase and that crude birth rates are still high despite concerted population control efforts.*

The population distribution in Nepal has also been experiencing changes since the late 1960s. Increased migration to the Terai (flatlands) began when forests were cleared through a malaria eradication project in the 1950s. Environmental stress in the hills caused by deforestation, a shortage of wood fuel and soil erosion, and an increasing population pressure on the land was recognized. Thus with the clearance of the forests in the Terai, more agricultural lands opened up and hill farmers suffering from the poor conditions in the hills began to head south to obtain land or to farm others land (Sill and Kirkby, 1991). In addition to males migrating for agricultural opportunities, females too began to migrate for marriage opportunities. As families recognized the severity of the situation in the hills, and the opportunities in the Terai, they began sending their daughters to the Terai to find husbands who had obtained land and presumably, a better life.

Table 2 reveals the change in the make up of the hills and Terai from 1970 to 1980. In the 1970s towns in the Terai started to emerge along with industrial and commercial development. This occurrence caused additional increase in the internal migration pattern. If migration to the Terai continues, Nepal will slowly evolve from being a hill and mountain society to a plains and urban country (Sill and Kirkby, 1991).

Table 2 Internal Migration in Nepal

	1971	1981
Mountain	9.9%	8.7%
Hill	52.5%	47.7%
Terai	37.6%	43.6%

Source: Atlas of Nepal in the Modern World, 1991

However, counter-beliefs as well as empirical evidence indicate that this is unlikely. Rural to urban migration does not yet appear to be very significant in absolute numbers.

Another important factor inhibiting the structural change from the hills to plains society is the impact that tourism is having on the mountain areas. Nepal has become a paradise of sorts to many tourists who visit Nepal for the trekking, mountaineering and sight seeing. Tourism has become a major foreign exchange earner (23% of the total foreign exchange earnings) and plays a role in enhancing the economic development of the country. The number of tourists continues to grow and has increased exponentially since the 1950s when Nepal first opened its doors to foreigners. In 1966 the number of tourists was 12,000 while in 1988 more than 300,000 tourists visited Nepal (Bista, 1991). The impact of mountain tourism on the economy seems to have slowed the trend of migration to the Terai.

> *Mountain people like the Sherpa have shown great tenacity in holding on to their subsistence lifestyle and the development of mountain tourism has enhanced the resource value of otherwise negative environments* (Sill and Kirkby, 1991, p.25)

Mountain tourism can also have profound negative environmental effects and policies should be made to minimize the negative environmental, social and cultural costs associated with tourism, and to maximize the positive effects of providing foreign exchange and becoming a positive means of economic development.

The demographic factors in Nepal reveal high but decreasing infant mortality and crude birth rates, yet the total fertility rates remain quite high, 5.47 in 1995 (WRD, 1995) and have changed minimally in the past decade. The resulting continued increase in the population has led to population pressure on the land that can not be solved by internal migration. Nepals population dynamic has severe implications for the environment. As environmental conditions worsen it becomes more difficult for other sectors to complete a smooth transition to a steady positive state.

Forestry Transition

In Nepal the present rate of deforestation exceeds the rate of plantation and natural regeneration (UNCED, 1990). Forest degradation has been recognized in Nepal for a number of years and direct attempts have been made to address this hazardous environmental problem. Nepal is currently in the midst of the forest transition, experiencing rapid deforestation. It is in the critical period when rates of change are high, limited societal adaptive capacity and an imbalance among key variables exists (Drake,1992). Over 75% of energy needs and over 40% of fodder needs are met by forests (Bajracharya, 1993).

The rate of deforestation is often driven by the general demand for forest products and in Nepal the demand is extremely high. Forests alone are the source of almost 96% of rural household energy needs (Dahal and Guru-Gharana, 1993). Forest use in Nepal is primarily of three kinds: cutting of branches for fuelwood, cutting whole trees for paper, construction and commercial use and the clearing of forest area for agricultural land use.

Nepals local condition impedes a successful movement through the transition. It is believed that if there is a heavy local demand for fuelwood, steep slopes, infertile soils and limited water availability, the forest transition can take a different form (Drake, 1992, p. 316). Nepal certainly is represented by all of these characteristics since more than two thirds of the countrys land is steep slopes, fuelwood remains the countrys main energy source, population pressure on the land is causing the soil to be overused and become increasingly infertile. Finally, limited ability for sophisticated irrigation schemes on such steep slopes has at times resulted in insufficient water.

Additionally, Nepals forests are not evenly distributed in relation to the population, thus intensifying the overuse of forests in many densely populated areas. This uneven distribution pattern of forest and population causes problems for people collecting fire wood and fodder. Estimates show in some hill areas the demand supply ratio of forest produce ranges from 2.3:1 to 4.1:1 (UNCED, 1990). Fuelwood is the major source of energy for cooking and heating in the rural areas, and urban consumption of woodfuel is shown to increase with income despite the availability of alternative sources such as kerosene and electricity. (Sill and Kirkby, 1991) This phenomenon is an important indicator of the Nepalese peoples reliance on the more traditional methods to which they are accustomed. It may indicate a lack of intervention in education and/or policy aimed at helping individuals to make necessary changes. While it seems that discoveries of alternate energy sources would help to alleviate this high pressure on the forest, this example illustrates that the discovery of alternatives alone is not enough.

Deforestation can be directly attributed to human activity. Examples are loss of soil productivity by overuse and increased erosion due to extension of agriculture and roads into the steep fragile slopes throughout the hills. The need for more agricultural land is also drastically affecting the rate of deforestation. It is clear that this continued rate of woodfuel consumption has led to supply problems and environmental damage. Yet if more agricultural land for food is needed, because of an increasing population and thus a higher rate of energy and food consumption, deforestation will undoubtedly continue at high rates.

Agricultural Transition

Agriculture is the defining element in Nepals economy with more than 90% of the population depending on subsistence farming. Agriculture is approximately 57% (data varies depending on the source from 54% - 65%) of the GDP and over 90% of the working population are engaged in agriculture (UNCED, 1990).

Drakes Transition Theory explains that worldwide agricultural production has been rising in relative harmony with population and this is due primarily to two main factors: the extension of land under cultivation and improvements in land productivity. However, in Nepal evidence reveals that while cultivated land has increased in the past in some areas of Nepal due to population growth, this expansion has been to marginal lands and thus minimized the improvements in land productivity. In other areas, the Eastern Hills for example, the amount of cultivated land has remained constant for the past fifty years (Sill and Kirkby, 1991). This expansion of cultivation to marginal lands leads to negative results including a decrease in average crop yields, an increase in soil erosion, and further loss of forest land, which is already being depleted at a high rate to meet the energy needs of the country. From 1965-1985, the amount of cultivated land in Nepal increased by 30% and the cropping intensity increased by 54% (Khatry, 1992). Yet data in tables 1 and 2 indicate that in the future cultivated land will not increase, yet cropping intensity will.

Table 3.

	1985		2005	
	Cropping Intensity %	Yield (mt/ha of cropped area)	Cropping Intensity %	Yield (mt/ha of cropped area)
Mountain	135	1.07	140	1.62
Hills	170	1.30	175	2.33
Terai	163	2.00	190	3.02

Table 4.

	1985		2005	
	Cultivated (ha/capita)	Cropped (ha/ capita)	Cultivated (ha/capita)	Cropped (ha/ capita)
Mountain	0.15	0.25	0.08	0.11
Hills	0.12	0.20	0.06	0.11
Terai	0.17	0.28	0.11	0.22

Source: Khatry, 1992

However, despite such high cropping intensity in the hills, yields are still much lower than in the Terai. This reinforces the observation that much of the land in the hills is not suitable for cultivation, and farmers are forced to continue to farm marginal lands that fail to yield high outputs.

In order, to increase agricultural land productivity both fertilization and irrigation are needed, both of which are severally limited in the hills. Fertilizers need to be imported and transported to the hills, which is costly and unaffordable for the majority of the subsistence farmers. More sophisticated irrigation schemes are too expensive and beyond the technological capability of Nepal. However improvement and enhancement of irrigation schemes is needed to improve agricultural productivity by allowing for more use of fertilizer and the introduction of new kinds of crops.

Figure 4 illustrates that while the amount of arable land seems to have peaked, the irrigated land has been generally increasing, indicating improved techniques. There are a variety of techniques used in Nepal, including some small hydroelectric power projects. However, as indicated by data (see tables 3 and 4) revealing the troubles in both the hills and Terai, it seems more effort is needed to improve irrigation schemes to allow for maximum agricultural productivity on limited land availability.

Figure 4.

Major causes for the downward trend in crop yields is the soil erosion, decline in soil fertility, high soil erosion in the Terai (flatlands) and lack of irrigation facilities. The high soil erosion rate leads to other negative consequences such as landslides. Landslides coupled with high sedimentation levels resulting from sediment loads carried by the major rivers in Nepal increase the dangers of flooding. Even though Nepalese farmers are apparently taking measures to prevent such occurrences, it is certainly not within the capability of subsistence level farmers to tackle such overwhelming problems by themselves. The impoverished farmer is forced to exploit natural resources, because he has no other viable option. Such actions inevitably leads to further destruction of the land and eventually an overall decline in agricultural production. There is a clear need for interventions aimed at improving the land quality to benefit the struggling farmers who make up the bulk of the population.

As is common in other South and Southeast Asian countries, Nepali farmers too, suffer from unequal distribution of land. Two-thirds of all farmers have small plots of land which relegates them to constant poverty. Farms are particularly small in the hills, and the average hill farmer has enough land to feed his family for less than 6 months. Food shortages, loss of land in the hills from landslides and poor soil quality have profound effects on the lives of many hill farmers. This situation has lead to agricultural intensification, the farming of marginal lands and internal migration.

Nepal is aware of its agricultural problems and limitations and they have been a priority in development projects since the 1970s, yet despite such efforts there continues to be a decline in crop yields. That is not to say that Nepali farmers are ignorant and simply continue to promote land degradation. Nepali farmers, are responding to such degradation, with as much innovation as within their power. Many of Nepals hillsides are comprised of terraced land plots in an effort to maximize utilization of the land while preventing the land erosion caused by both landslides and the monsoon rains.

Energy Transition

There are two different energy sources in the developing world: (1) traditional biomass fuels usually found in rural areas including wood, crop waste, and animal dung and (2) modern commercial fuels such as coal, petroleum products, natural gas, and electricity.

Energy Consumption in Nepal

Nepal presently still relies very heavily on traditional biomass fuels for energy consumption. These traditional fuels, especially wood, account for more than 90% of its energy consumption. Such high rates of traditional biomass consumption are evident in both the forestry and agricultural sectors which suffer supply problems and environmental damage. Furthermore, Nepal has the lowest commercial energy consumption per capita of any developing country (World Bank, 1989). There are many possible explanations for this given the present economic and social conditions in Nepal:

* It is still far cheaper for Nepalese to continue to use traditional fuels by stripping the forests
* Since most of the population lives in poverty, they have low purchasing power to buy more modern forms of fuels.
* Traditional attitudes prevail due to a lack of education and policy implementation aimed at change in energy use. (World Bank, 1989))

Finally, their commercial energy consumption levels are far lower than other developing countries because of their slow urbanization and industrialization rates. As a country shifts from an agrarian to an industrial economy, there is a natural increase in commercial energy consumption. However Nepal is still an agricultural society. Map 1 and table 3 reveal Nepals strong reliance on traditional fuels, dependence on agriculture, and very low urbanization rates as compared to other South Asian developing countries.

Table 5.

	Agriculture Labor Force (percentage of total labor force)		Traditional Energy Consumption (percentage of total energy consumption)	
	1970	1990	1971	1991
Nepal	94%	92%	97%	93%
Pakistan	59%	50%	---	22%
India	72%	66%	31%	26%

Energy consumption can be a major contributor to environmental degradation. Even though Nepal is still primarily an agricultural society and industrial growth is presently slow, Nepal needs to make a shift in its energy consumption patterns and move toward more commercial energy practices. If this needed shift is made in a timely and careful manner, a positive change in the energy sector can benefit Nepal by lessening the environmental degradation and improving agricultural capacity.

Figure 5.

Since Nepal is still experiencing relatively little urban and industrial growth, they have the opportunity to explore resource exploitation options and can make the needed shift at a reasonable pace. There is not such a dire need to focus on increasing the energy supply as fast as possible, which is the general paradigm for energy planning adopted by most developing countries (WRD Resource Book, 1995). Unfortunately, when countries push for such quick increase in supplies to meet their rapidly changing energy needs, they are often not effective in managing supplies to maximize the services. Thus, increased energy supply is often not very efficient.

Nepal cannot continue to rely on its biomass fuels because not only will conventional means not be able to meet Nepals growing commercial energy needs, but it is detrimental to the population-environment dynamic in Nepal. The challenge for Nepal to make the shift to commercial energy sources is probably one of the most complex and expensive aspects of the countrys development. The consequences are dramatic to just about all sectors in Nepal.

Energy Production in Nepal

Nepals energy demand is expected to grow at least 8% per year as electricity service is extended. Commercial energy consumption in Nepal includes coal, petroleum, and hydropower. Since Nepal is not rich in coal or oil it seeks to utilize the one abundant renewable source of energy - hydropower. It makes sense that Nepal would want to exploit this abundant renewable resource since importing coal and oil is expensive, limited and not very environmentally sound. However the big question, and one which will have a severe impact on Nepals economic, social and political future is what is the best way to exploit this energy source? This has been an ongoing debate in Nepal.

Globally, there has been recognition that large dam projects are environmentally and socially damaging, however the trends show that average dam sizes are increasing and currently large scale dam projects in countries such as Brazil, Turkey and Japan are being built (Gardner and Perry, 1995). Nepal too, is considering such projects, even though the risks are extremely high.

There are benefits and problems to implementing any dam project, however, the amount of consumption and degree of degradation are factors that must be weighed in comparing overall effects of different technologies and cultural perceptions of resources may alter with time (Biomedical Environmental Assessment Group, 1974). While uncertainty is an inherent part of any environmental problem, decision makers need to be better informed about the environmental processes and social preferences. In weighing the benefits and detriments of the dam possibilities in Nepal, there is a need to consider and understand the countrys environmental, economic, and political status. Given its relative poor environmental and economic state, as well as the political instability due to a relatively new and struggling democracy, it seems that large dam projects in Nepal are a very high risk.

Large Dams = High Risk

Environmental Conditions

In Nepal the existing environmental status described in the forestry, agriculture and energy transitions, makes large dam projects problematic. The forestry and agriculture have a symbiotic relationship, as is evident by the interdependence of the two sectors. First, the deforested mountainside erodes the topsoil which negatively effects the agricultural productivity of the soil. Also, rain on a deforested mountainside cause this topsoil to be flushed down the hillside and it ends up in the rivers, lakes and hydroelectric reservoirs. This in turn causes the reservoir to fill with sedimentation and hence shortens its life span. Second, such large projects would inundate valuable limited agricultural land. With an increasing population, the cultivated land has already peaked and there are food shortages in the hills. Creating large reservoirs in the hills, where the land is already limited, would certainly impact many farmers lives.

Another option that Nepal has considered is avoiding storage type dams and building run-of -river dams which do not require a reservoir and therefore do not flood as much valuable land. However, these dams need to be built fairly high in the mountains and therefore need road access (anywhere in Nepal), would require building roads or tunnels through the mountainside in order to access the river to construct the dam. In both cases, building roads and tunnels or creating reservoirs will cause many people to be displaced. Nepal does not have large urban centers to absorb these people or a large industrial and/or manufacturing sector for these people to become trained. Moreover, relocating these individuals to the Terai is not a preferred option. There was heavy internal migration to the Terai in the 1960s and 70s, and it is now densely populated and therefore no extra farm land is available.

Large scale projects are designed primarily to sell electricity and to initiate large scheme irrigation projects in the Terai; neither of which are intended to benefit the hill farmer. Given the inequality of the land ownership, whereby the vast majority of farmers are subsistence level farmers, it seems likely that such large irrigation projects would not prove beneficial or even needed by the majority of hill farmers. In the hills the farmers do not have enough land to produce a market surplus, so large irrigation projects would assist a few large landowners who already possess better quality land, yet not realistically addresss the needs of the majority of the farmers. Large dam projects do not make it easier for the hill farmers to improve their land productivity because they do not focus on providing the kinds of irrigation the majority of the farmers need, nor do they put them in a better position to enhance their fertilizer use.

The energy transition is also severely impacted by large dam projects. These large dams are designed to generate energy for export. The high voltage needed to convert this type of energy to be used for domestic energy at the local level is costly, technologically difficult, and therefore unlikely to be figured into the overall budget of this type of project. Moreover, these projects are so costly and have such long gestation periods that they do not provide any means for slowing the heavy reliance on traditional fuels - the forests. There is an immediate need to alleviate forest pressure by generating energy for cooking and heating in the villages but these projects are not designed with this intention in mind. The large-scale projects look at the macro-level impact, yet ignore the village level, where the main forest degradation occurs.

In addition, the larger the project the greater the potential hazards. The Himalaya are considered to be a relatively young mountain range and because of this they are still being actively uplifted and continue to rise each year about 1cm (Shrestha, 1991). This tectonic activity makes Nepal highly susceptible to earthquakes. Given the terrain of Nepal, mostly steep slopes, even minor tremors result in landslides which potentially block rivers to form lakes. Furthermore, given these conditions it is possible for the effects of an earthquake to extend east to west and pose great threat to any large structure; like a large dam ready to burst and wipe out a significant portion of the country.

The powerful run-off from the Himalayan rivers also carry some of the heaviest sediment loads in the world (Terrell, 1991). These sediment loads get deposited in reservoirs and have significant impact on shortening the life of the reservoir. Heavy rainfalls, during the monsoons on deforested land also contributes to landslides and heavy sedimentation. If the reservoirs are taking away precious agricultural lands, then a trade off of receiving increased land productivity is expected, however the people directly effected by the reservoirs do not see these results.

Foreign Aid Dependent

In addition to the environmental risks, Nepal is at high risk socio-economically when considering the implementation of large dam projects. They need to depend heavily on foreign aid development to construct such projects which far exceed their national economy. Nepal already is highly dependent on foreign aid.

During the Rana period before 1950, Nepal was not interested in foreign aid, as it was viewed as an intrusion. However, since the 1950s Nepal has opened up to foreigners and recognized the possible benefits of modern technology. They began to accept foreign aid, and since then they have continued to become increasingly more and more dependent on it. Foreign aid inflow into the country has steadily increased and aid in the form of loans is much larger than grants. In 1988, 69.40% of the total aid was in the form of loans. (NFFAS, 1992). Foreign debt is rapidly accumulating and in 1990-1 Nepals outstanding external debt reached 46% of the estimated GDP (Seddon, 1994). It has been argued by many that while Nepal has been receiving foreign aid for more than 40 years, they have not succeeded in alleviating poverty as is indicated by their economic indicators. If aid is supposed to help a country to overcome the development bottlenecks so that the country can move rapidly from an initial heavy dependence on foreign aid toward self-reliance then Nepal has thus far failed (NFFAS, 1992).

In the past two decades large amounts of money has been invested in the agriculture and energy sectors. Aid aimed at serving large irrigation and hydroelectric projects accounts for a great deal of the aid money in these two sectors. It was estimated in 1987 that a hydroelectric project, Arun III was to receive more than $600 million (World Bank, 1989). Such incredible amounts of money being loaned for these risky projects only enhances Nepals dependence on foreign donors.

Unfortunately, this foreign aid does not appear to be enhancing Nepali productivity. It has certainly been speculated that when projects are planned by experts outside of Nepal, with minimal Nepali institutional support there is widespread economic abuse and corruption (Bista, 1991). Hence, not only is Nepal heavily dependent on foreign aid but it has also become passive in the planning of these foreign initiated donor projects. A large dam project is a perfect example where mega-donors do the macro-planning. It seems logical then, that the Nepali government cannot refuse this kind of project that brings large amounts of money to the country and possibly to their own pockets.

Nepal-Indo Relations

Nepal also needs to consider its relations with India since any large dam project would require Indias cooperation. Currently and historically relations with India have not been great and there still exists a deep rooted lack of trust between the two countries. A most recent example of the general difficulties experienced by the neighboring countries is the trade embargo which India imposed on Nepal in 1989. The trade and transit treaty between the two countries expired and major differences between the two government prevented the signing of a new one and Nepal was deprived of some 80% of goods normally imported from India (Seddon, 1994). This caused economic hardship in Nepal as prices rose and tension mounted. Such conditions provided impetus for the revolution in Nepal in 1990.

Another example specifically related to dams, further illustrates the tenuous relations between Nepal and India. The one completed joint dam project was initiated by India in 1954. The Kosi Barrage, located in Nepal on the southern border, was developed because of a flood in Northern India in 1954. This project has been viewed as disastrous by both Nepal and India. The government of Nepal feels they allowed the dam to be built and only suffered environmentally with losses of arable land, while India benefited from flood and irrigation control. The Nepalese also believe that India has done nothing to repay Nepal for its efforts. Yet the Indian government feels that the prosperity they were to gain has been nonexistent, as the barrage failed to produce the estimated irrigation potential and a Kosi river flood in 1991 reconfirmed Indias suspicion that the barrage in its present state is not an effective means of flood control.

Nepal and India continue to disagree on issues regarding this project, each blaming the other for problems and hazards. Even the new government in Nepal today has not forgotten this project that they felt cheated and included in the new Constitution of 1990 is a statement that treaties dealing with water sharing have to be ratified by a two-thirds majority in the parliament if they are of a comprehensive, serious, long term nature (Aryal, 1995). This deep rooted lack of trust seems to be even more influential in preventing large dam construction than anti-dam activists complaining about the environmental degradation incurred by dams.

Despite such problems, Nepal continues to explore large dam options and since 1987 has been preoccupied with developing a large project in Eastern Nepal, known as the Arun III project. This large scale project, to be funded by the World Bank, was designed to generate revenue by not only for providing electricity to meet the national demand, but also by selling electricity to India. Even with recent changes in the government the project was supported as unrealistic visions of hydro-dollars still permeated the government. The elected Prime Minister in 1990, stated that the problems of trade deficit with India will be overcome with Arun III hydroelectric project (Gyawali, 1991 p. 6).

While the newly developed constitution in 1990 gave people the right to development, it also gave them the right to information (Aryal, 1995). The Arun project became the first controversy about a major development project in Nepal. Also, World Bank, receiving pressure from various projects, established a commission in 1994 to hear complaints from parties affected by proposed dam projects. Arun III opponents in Nepal were the first to address this commission with their concerns (Gardner and Perry, 1995). The project has been opposed for years by many private environmental groups who felt that such a large World Bank project could have more harmful than beneficial effects.

After years of debate the project was finally rejected in August of this year. It was decided by the new World Bank president to cancel the project because Nepal was too poor for the project to succeed (New York Times, August 1995).

Political Instability

In addition to Nepals poor environmental and economic conditions, it also lacks the institutional and infrastructure support to successfully complete such projects. This is mainly due to the political instability found in Nepal. Political stability is an underlying assumption in the transition theory, for without positive government intervention, it is difficult to make it through a transition to a steady state.

Prior to 1990 Nepal had an absolute monarchy. It was a partyless Panchayat (village council) system in which power was exercised from the palace. In 1990 there was a democracy movement, which was not directed at the king, but against the Panchayat system which institutionalized the kings power. The aim was to lift the constitutional ban on political parties. The struggle was painful for Nepal as demonstrations and violence caused casualties, but it was minimal compared to other countries experiencing democratic revolutions. Within less than three months the king dissolved the Panchayat system and a new interim government was formed under a new multiparty parliamentary democracy system.

However, any country struggling to adhere to a new democratic system of government is bound to suffer difficulties and go through a period of instability and thus have difficulty managing its resources. In 1990 the new government inherited a country characterized by extreme poverty, high population growth, and an aid-dependent economy. These conditions are not easy to change in a short period of time.

Moreover, as in any state recently freed from autocratic rule, the society is in a state of confusion as modernity approaches. This is especially true in Nepal because since 1990 the government has changed hands over four times. There continues to be mistrust among people and dissatisfaction with government decisions and the two main parties, the Congress and Communist, continue to fight to control and set the general course for the government. These government decisions effect development activities. Development activities need to be more political, but they need a stronger more stable political framework to rely on for support. In addition, a stable government is needed to ensure that a more broadly defined strategy for the countrys development is achieved.

Small Dams = Low Risk?

Small dam projects are aimed more specifically at assisting the rural farmers and since 94% of the people live in over 30,000 villages and over 90% are farmers, a development project seems meaningless unless it improves their lives. In addition a World Development Report published by World Bank in 1990 stated that several factors were impeding development. Among these was an inadequate participation: inadequate attention was given to sociocultural and political factors in the design and implementation of projects resulting in ineffective projects and a greater reliance in foreign aid. However, it is ironic that World Bank made this statement since it is the main organization that

Nepal has become so heavily dependent on for loans in large dam projects which ignore any local participation. Similarly, in 1992 World Bank report recognized that many of the water projects built in developing countries over the past 25 years have been failures, lack of technical expertise and inability to operate and maintain water systems once they were in place(Brookshire and Whittington, 1993). It was suggested that lack of community participation or local involvement in design and management is a major cause of project failure; a typical example is large dam projects being imposed on the local people who have no decision making power and often only suffer the negative consequences.

Large dam projects ignore rural farmers, while small dam projects specifically aim to improve rural development. The socio-economic benefits are extensive. First, small hydropower plants can be run of river types which means no reservoir or storage space is needed. This important aspect certainly minimizes the potential environmental degradation and loss of arable land by not flooding the lands to create a reservoir. Secondly, small dams are designed to provide the villages with electrical energy. And with this electrical energy comes numerous opportunities for rural development. There is the possibility for local farmers to begin to participate in income generating activities such as small cottage industries. Electricity will also help to improve education standards by making it easier to study and also making radio (and eventually television) available to people who have been fairly isolated and distant from country and world information. Also, electricity available in villages where health clinic exist will enhance the capability of the clinics by allowing for the use of modern facilities such as X-ray equipment and small operating rooms, and refrigeration for storage of medicine.

Electricity in rural areas, provided by hydropower, will definitely help to increase the earning potential of the population and possibly slow migration to the Terai, urban areas, and out migration (primarily to India). Small dam projects are also sufficient to provide irrigation opportunities. Electrical energy can pump the water for lift irrigation. Since the majority of farmers own minimal land, such irrigation schemes would be beneficial to them.

Finally, small dams will definitely have a direct and immediate impact on saving the countrys forest resources. Small dams designed to generate electricity to provide for cooking purposes, will drastically cut back the amount of fuel wood used by rural people. However, simply providing the electricity is not enough to cause farmers to change their behavior and immediately adopt a system of utilizing electrical equipment. Education is needed to instruct farmers of the importance and benefits of changing from their traditional system of exploiting the forest resources. An integrated system of providing education and employment opportunities is essential to make rural electrification beneficial in enhancing the development of the country.

Policy Recommendations

Nepals apparent environmental, economic, and political conditions prevent it from implementing such large scale dam projects, yet it is apparent that something must be done to meet the increasing energy demands of the country. If policies were implemented to restrict immediate focus on small (projects not requiring international cooperation, and not financially exceeding the national economy) Nepal would benefit by improving its economic and environmental conditions. Such focus would give Nepal time for its newly democratic government to stabilize, to work on improving relations with India, and to begin to rely less on foreign aid.

The Nepali government should not focus on becoming an energy independent country, rather it needs to focus on feeding its people, educating its people, slowing the population growth, and protecting its resources. The following are policies for consideration based on evidence presented in this paper:

Population Policy

Nepals population has increased at about 2.1% annually over the last decade (Gurugharana, 1993). In a country with a very limited resource base, this kind of population pressure has severe consequences. It has resulted in increased poverty and environmental degradation, and therefore, curbing the population is necessary to begin to alleviate poverty and improve environmental conditions. The Government has established targets in its population policy which include reducing the total fertility, infant mortality, child mortality and maternal mortality rates but what interventions and specific policies will enable this to become a reality need to be further explored and articulated.

Nepals continued high fertility rates are indicative of the need to incorporate not only a more extensive family planning program, but to improve education and employment opportunities for people, especially for women who remain at the bottom of the economic and social scale. Nepals government is aware of its rising population and recognizes that a fair amount of the poverty found in the country can be attributed to this fact. However, they have not yet been able to devise an extensive program that addresses all the factors involved in controlling population growth. Efforts are being made to improve the education status of women and a number of non governmental organizations have provided financial support as well as training and materials for literacy classes and income generating schemes for rural and urban women. These actions need to be continued, but more importantly they need to be better monitored by the Nepali government in order to maximize the productivity of these programs.

Agriculture policy

Nepals need for a more effective agricultural policy is also apparent by the worsening conditions in the agriculture sector. Nepali government and people, like many countries in the world, maintain a more is better mentality. They believe the answer to improving their lives or developing their country is done by producing bigger and better things. However, it would be more practical and beneficial to focus on better management instead of more facilities. This would include initiating policies aimed at educating farmers, as well as providing assistance such as seedlings and fertilizers, in ways to allow them to maximize their agricultural production.

In addition, often smaller more manageable products are overlooked as viable options. An example of wanting to improve things on a larger scale than necessary can be seen in the irrigation schemes targeted. The majority of farmers own very small plots of land and therefore do not need large costly irrigation schemes. They continue to devise their own small irrigation systems, however these generally are not long lasting. The projects are labor intensive because they are temporary and need to be remade each year. However, if a policy was made to assist farmers in improving their indigenous irrigation schemes, it would prove beneficial to all. As noted by Gurugharana (1993) in his paper Poverty Alleviation and Human Development: The Nepalese Case, The country has water resources for substantial improvement in irrigation which should, however, be of reasonable size under farmers management (p. 96). He emphasizes the need for technologies to be suitable to local conditions and small-scale production. The Government needs to further research and investigate the feasibility of providing assistance with these types of projects, rather than waiting for a more sophisticated system which may not appeal to the local farmer, and not be affordable or easy to maintain.

Water Resource Policy

Nepal is in desperate need of a national water policy that will allow the government and people to decide for themselves how to best utilize their water resources. Currently, Nepal relies heavily on outsiders to come in and decide how to exploit its water resources. A national water policy would cause those in authority to investigate for themselves what exactly needs to be done to meet the national energy requirements, what is economically feasible, and what options are the least environmentally damaging. Again, like the agricultural policy, there is a need to focus on better management instead of more facilities. Nepal needs to thoroughly investigate its existing water projects, including dams already constructed. Such research and action can be used to improve the technology that is available at reasonable costs. It will also serve to avoid local difficulties and excessive costs that have resulted in the past due to lack of investigations done by Nepalese. Furthermore, policies could be designed to provide incentives for better management and better performance.

Finally, if a policy to implement small dam projects, designed to provide rural electrification, was implemented, it would be important to focus on training and working directly with rural farmers to maximize the potential benefits from locally implemented projects that could develop if villages are supplied with electricity. It is not enough to simply provide electricity to the villages. There needs to be direct efforts to bring skilled people to villages to assist in the development of locally designed projects. Proper monitoring and continuous feedback would be essential to avoid replication of mistakes, waste of important resources, and to ensure further progress and development.

Conclusion

All projects seem to be problem-ridden but it appears to be between those that are more or less successful in overcoming their troubles and those that are not (Hirschman, 1991, p.3). This assertion holds true in Nepal. The future direction of the exploitation of its water resources needs to be decided in order to improve the lives of all Nepalese. Nepalese are faced with a situation in which they need to understand the trade-offs involved in potential projects, and then make a well informed decision to implement policies designed to help them achieve a solution that is suitable to their country.

On a micro level small dams seem very beneficial, however, it is uncertain if such projects will allow Nepal to become an energy independent country. The trade-off, however, is to implement large dams that pose such a high risk for the county. Large dams cause arable land reduction when there are already food shortages. They are also much more expensive and would put the country, already more foreign aid dependent than any other developing country, into further debt. These facts coupled with the environmental and social risks posed by such projects indicate that large dams are not the answer for Nepal. Given all the conditions, Nepal may never be ready for large dam projects, but it is clear that the current conditions should direct Nepal away from considering such projects. There are certainly trade offs for both, but given the evidence it seems evident that Nepal needs to exploit its water resource in a manageable way aimed at developing the country at a pace from which they can benefit, and this is not capable by initiating large dam projects.

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CHAPTER FIFTEEN

MARISA A. SIFONTES

A VILLAGE IN TRANSITION : THE CASE OF GANVIE

This paper seeks to examine the state of transitions taking place in the Lake Nekoue region of southeastern Benin. With the majority of the population concentrated in this region, increasing population growth continues to put pressures on an already strained environment. The lagoon system running along the coastline serves as a resource for the artisanal fisherman to find his catch and also provides him with a place to live. His catch has historically provided a major source of protein to the people of southern Benin. To this point, nothing but exploitation of the waters has taken place, but it is becoming increasingly difficult to maintain such a careless view. Changes must be made if the resources of the lagoon are to be maintained.

The transitions that I will be looking at are the demographic, tourism, and fishing transitions. These form the base of the problems that are currently being experienced. Other transitions, such as forestry and urbanization, do not apply to this water-based setting, and others such as the technological transition, are not yet an issue.

GEOGRAPHY AND HISTORY

The Republic of Benin runs due north from the West African coast, extending nearly 700 kilometers inland from the Gulf of Guinea. Benin is bordered on the northeast by Niger and the Niger River, on the northwest by the Pendjari River that runs along the border with Burkina Faso, by Nigeria to the east, and Togo to the West. The country is fairly small, with an area roughly equal to the size of the state of Pennsylvania.

The coastal region consists of a series of small lagoons which connect Benin's major rivers to the sea, the largest and most important of these is Lake Nekoue. Within this lagoon, as well as others, there exists a population that lives on the water, and derives their nutrition and livelihood from it. In the southeast region, the major ethnic group is Toffinu. They have lived on Lake Nekoue for several hundred years. These people were originally mainland inhabitants, living in the central region of Benin, but fearing their more powerful neighbors who had dealt in the slave trade with the arriving Europeans, they fled south. When they were still pursued, they moved into the middle of Lake Nekoue, because the lagoon was too shallow for slave ships to enter, and the customs of their African pursuers did not allow them to cross the water. Thus, they escaped and their life on the water began. Indeed the name of the largest village on the lagoon, Ganvie reflects this history. In the Toffinu laguage, gan neans "we are" and vie means "saved".

THE DEMOGRAPHIC TRANSITION

As with other developing countries, Benin is still in an active period of its population transition. Birth rates within the rural areas continue to rise, while for the entire country, they have begun to level off in recent years and with increased access to health care and safe drinking water, death rates continue to fall. Figure 1 illustrates this process at work. Additionally, Figure 2 shows the dramatic increased life expectancies that the population is experiencing, causing a shift in the age distribution.

Figure 1

Source: World Resource Database, 1994.

Figure 2

Source: World Resource Database, 1994.

Given these factors, Figure 3 illustrates the projected population increase through the year 2025. There is a public contraception policy in place, although it has a lot to do with preventing the spread of the HIV virus, and not as much with family planning. However, most family planning efforts are focused in the cities, and neither information or supplies are readily disseminated in the rural areas. Given the importance of children within the family, as both future legacy and additional manpower, there is no incentive to reduce family size.

Figure 3

Source: World Resource Database, 1994.

Each of these statistical realities is being aided by a number of factors at work within the country. For the village of Ganvie, and the rest of the Lake Nekoue region, the major factors are:

Increased access to health care

Availability of potable drinking water

Imposition of Western religion

Since 1985, the inhabitants of Lake Nekoue have had access to a hospital in the lagoon village of So-Tchanhoue. This hospital is one of the major reasons for the explosion of population within the lagoon. It has given the population much greater access to medicines and treatments than before. (Previously, the nearest hospital was on the mainland.) The hospital has been instrumental in controlling the diseases that have traditionally been self-limiting to the population, such as cholera and malaria. AIDS has not yet made an impact. As of June 1995, only two cases had been diagnosed by the hospital. Additionally, within the last ten years, the government has installed a series of wells to provide fresh, safe drinking water to almost every village on the lagoon. This also has helped stem the historical cholera problem. Both of these factors have helped to cause a rise in the population and put further strain on the ecosystem to provide for the inhabitants that depend on it. As previously stated, family planning projects exist in Benin but have not yet been disseminated to the rural population.

The imposition of western religion has also made an impact on this transition. The traditional belief system in the village instilled a strong sense of morals and values among its inhabitants. It provided rewards for those who abided by it, and penalties for those that did not. Through an elaborate system of deities, rituals, and responsibilities, it helped regulate the villager's lives. For example, polygamy is an accepted practice in the village. It is not uncommon for a man to have more than one wife. Although there is no formal limit to the number of wives, under the traditional system, the number of wives that a man may have has been limited by the number of wives (and children) that a man can provide for. If a man did not provide for one of his wives, she could cast a spell on him, or demand that the deities punish him, and misfortune would befall him.

As missionary activity in the village increased, and Christianity was introduced, the villagers saw that as people left the traditional ways, nothing happened to them, there was no punishment. For many, it took away the incentive to exist by a difficult, and at times expensive, but practical, system. As such, there are currently three types of belief systems at work in the village: those that follow the traditional belief system, those that follow western/non-indigenous belief systems (Christianity, Islam), and those that follow neither of the two systems. This population, who experience no ramification to their actions and have lost faith in the traditional values, but do not believe in the missionary message have made a powerful impact on the population transition. Men of thirty and forty years of age, having grown up in the traditional society usually have one or two wives, and practice some form of religion, traditional or not. However, this is not so with the younger men. Presently, it is not uncommon for a man of twenty years of age to have in excess of ten wives, each with several children. The men do not take care of their families, and as such, the woman is left to provide for her own family unit, thus enabling the man to procreate further. There is no limit to the number of wives that he may have, since he does not provide for his offspring, thus his resources are not limited by his responsibilities. The women seek to have more children, as the children help provide for the family where the husband does not, and the population grows. (See Figures 1 and 3)

This impact is evident by examining age distributions within Ganvie. (Table 1 and Figure 4) In 1979, the majority of the population was under the age of fifteen. It is this group, presently aged 15-30, that is now of childbearing age and is producing significantly more than their replacement amount of offspring that is pressuring the population picture.

Table 1

Age Distribution in Ganvie (1979)

0-5 years	6-14 years	15-49 years	50 and up	Unknown	Total
3,312	2,041	4,212	1,056	196	10,817

Source: Radji, 1991.

Figure 4

Source: Radji, 1991.

Table 2 also shows these factors at work. Between 1962 and 1995, Ganvie has more than tripled its population, and thus its demands on the lagoon and the ecosystem. More importantly, Table 3 shows the total population of the entire district of which Ganvie is a part, to provide a frame of reference for the magnitude of population growth that the area has experienced. By projecting the increase in the population, using the same level of growth that Ganvie has experienced, the strains on the ecosystem become immediately apparent. If the rate of growth in the district parallels that of Ganvie, the district population has almost tripled within the past fifteen years, and the strain on the ecosystem has risen similarly.

Table 2:

Population Growth in the Village of Ganvie

Year (Source)	Total Population
1962 (Demographic Study)	9,300
1979 (Census)	10,807
1989 (Census)	20,000
1995 (Estimate)	30,000

Source: Radji, 1991 and Sifontes, 1995.

Table 3:

Population of Sous-prefecture (District) of St-Awa in 1979

Administrative Division	Total Population	% Men per 100 Women	1995 Projected Population
So-Awa District (total)	37,818	94.38	104,818
So-Awa	4,913	100.12	13,609
Ahomh-Lokpo	5,297	94.39	14,672
Dekamey	2,350	105.42	6509
Ganvie I	6,449	94.54	30,000
Ganvie II	4,358	86.24	(see above)
Houedo-Aguekon	5,096	98.60	14,115
Vekky	9,355	92.25	25,913

[Note: Figures for Ganvie I and Ganvie II should be combined]

Source: Radji, 1991.

Part of the reason for the slow population growth during the late 1960s and early 1970s that is not evident in the tables is the impact of the rural exodus that took place during that time period. Due to the strength of the Nigerian economy and their currency, the naira, many of the Toffinu migrated to Nigerian in search of opportunity. The recent devaluation of the CFA (the monetary unit for a significant portion of West Africa) coupled with the decline of the natural fishery could have a similar effect in the future. However, in speaking with people about such opportunities, most were reluctant to change their current lifestyles.

THE IMPACT OF TOURISM

Another part of the changing picture in all of the lagoon villages, but in particular Ganvie, is the role that tourism has played in the development of the villages. Ganvie is singled out due to its position, as the first lagoon village one reaches when leaving the mainland. It is the closest to Cotonou, Benin's largest city, and other villages are further apart. Because of its novelty, it is described as the Venice of the Africa, tourists come from all over the world to see Ganvie. This has helped lead to the decline in the traditional mores of the Toffinu society. It also has other undesired impacts on the village. People have begun to expect money from the tourists. Children beg and pester until they are appeased. Tourism has also provided a market for prostitution in the village.

Due to the marketing efforts of the Benin government during the Marxist period, Benin saw a large number of tourists during the 1980s. Since the political shift, however, there has not been emphasis on continuing advertising, and the number of visitors has been decreased.

(See Figure 5 and also Appendix A)

Figure 5

Source: Radji, 1991.

It is estimated that 90% of the tourists visiting Benin, make the trip to Ganvie during their stay. (Radji, 1991) Until recently, the national government has had a monopoly on the exploitation of the tourist trade. The price for the trip to Ganvie was strictly controlled by them. Since the liquidation of ONATHO, the national tourism and hotels office, the private tour operators have taken over this facet of the tourist trade. Under both systems, this has meant the exploitation of the Toffinu. They are shown off and paraded n front of tourists, while only a few villagers (the restaurant and shop owners) derive any benefit at all. The current mayor has worked to change this system, however, and now, for every tourist that comes to the village, a portion of their passage goes to a village fund, to be used as the people of Ganvie see fit. Currently, a trip to Ganvie costs 5,000 CFA (~$10 USD) and of this sum, the village is given 250 CFA (~$0.50 USD). The inequities still abound, but the villagers are able to derive some benefit from the tourist incursions on their lives and thus, continue to tolerate them. This idea of compensation has spread, though, and people will not allow picture taking or even polite conversation without some type of compensation. "Cadeau, cadeau" (gift, gift) is the common cry. The villagers have begun to expect such "gifts" from the tourists, and for the most part, the tourists have been quite happy to oblige. The situation is becoming intolerable, however, as every tourist is inundated by begging villagers. The village excursion is becoming increasingly unpleasant, as the so-called traditional lifestyle that one is traveling to see is being marred by crass commercialism.

Tourism provides money for village infrastructure and improvements, but the number of tourists has decreased without the continued government outlay for international advertising. The villagers still do not receive an equitable share of the proceeds gained from their exploitation. However, I do not know how this system could easily be changed, as it is currently controlled by private industries who already have the resources to perform this service.

The continued degradation of the lagoon can have a further impact on tourism. As the lagoon ecosystem becomes increasingly constrained, accumulated waste and garbage in the water will serve to dissuade visits to the sight.

THE DECLINING FISHERY

Evolution of Lake Nekoue

At 160 km2, Lake Nekoue is the largest lake in Benin. Its depth is between 0.5 and 1.5 m during the dry season. This figure increases dramatically during the rains, to approximately 2 to 3.5 m. The lake has two exits, through the Totchi canal which connects the Porto-Novo lagoon with the sea near Lagos, Nigeria, and the canal at Cotonou.

The outlet at Cotonou is not a natural phenomenon, it is an attempt for man to control the works of nature around him. Its evolution can be explained in a series of steps.

First, in 1885, with the repeated flooding of the rapidly expanding Cotonou by the Ouimi and St rivers, an artificial opening was created to relieve this that let the land-locked flood waters in this area escape. The creation of the Cotonou channel allowed the salt and fresh waters to mix in the lake at a much higher concentration than before. The salinity of Lake Nekoue shifted to reflect the additional contact with the marine environment. The ecosystem was dramatically changed by this "first contact". Shrimp, mollusks, and other marine fish were able to exist within the channel and also within the lake. New fishing opportunities were created for certain populations. Fresh water fish sought refuge in the north of the lake where the salinity was still low, and where the phytoplankton from which they derived their nourishment could still be found.

Eventually, due to sediment, a gradual closing of the channel would occur without regular dredging. This gave rise to a cycle of opening and closing, where during the dry season, the closing of the channel allowed the freshening of the water and an environment where phytoplankton could flourish, and provided a substantial source of food for the fish population. Once the flood waters had migrated into the lagoon, the channel would be opened by the movement, and the marine and lagoon environments had the opportunity to mix once again.

With creation of the commercial port at Cotonou (est. 1960), sand from the channel was removed to make cement for the project. This ended the ability for channel to periodically close. The exchange between sea and lake waters became permanent. This has had repercussions on both flora and fauna of lake

The primary flora of the lagoon used to be mangrove. Unfortunately, due to the change in environment and the human devastation of the natural environment (cutting down trees for houses and acadjas), the flora now consists mostly of sea grasses on the small masses of land around as well as within the lagoon which are used to feed animals, and water lilies that dominate the lake during the fresh water period and make travel on the water very difficult.

A barrage was built in the late 1970s, in an attempt to return the lagoon to its pre-port state, by enabling the periodic closing of the channel by artificial means. However, this effort was short-lived and unsuccessful, as groups that had begun to use the channel for their shrimp operations favored the continual mix of fresh and marine water environments. Once the barrage was completed, they destroyed it. After a second attempt, and a second sabotage, the barrage idea was abandoned.

As would be expected in a water-based society, the main occupation is fishing. The people are integrally connected to the water. They derive their livelihood and nutrition from it, and have so since the establishment of the village. Indeed, approximately 88% of males within the lagoon villages are fisherman, as their primary occupation. With the decline in the natural fishery, there are those that have turned to other professions to make a living. Women purchase the fish that the men catch and sell it to the market or retain it for their own use, women also have small shops and sell other commodities as well.

Methods of Fishing

There are a number of different fishing practices within the villages, the ones currently used are:

-LINE (manned)

This is the conventional image of fishing, one line and one hook under the fisherman's control.

-CAST NET (manned)

This is a large net that is cast over the water in areas that are public domain, the fisherman rapidly casts and recalls them, removing anything that has been caught in the net, and casts it again.

-DJOHOUN (unmanned)

This is a method where a number of hooks are hung off of a single line supported on each end by two poles at different lengths. These hooks catch passing fish, which remain caught on the line until the fisherman comes back to remove them.

-BASKETS (unmanned)

There are several types of baskets and/or traps used. They are primarily used for catching crabs and shrimp. The fisherman places the traps in the water, primarily at the end of the day, and returns to claim his catch the next morning.

-ACADJA (unmanned)

Created in 19th century, this system consists of an ensemble of branches usually circular or in the shape of a rectangle anchored in the bottom of the lagoon, covering top to bottom of lagoon, filled with smaller branches and leaves. The area serves as refuge for number of fish, especially tilapia, which feed on the plankton which develop on the decaying branches and leaves. It also serves as refuge for the fry of reproducing fish.

Fishing the acadjas takes a lot of manpower, which favors a communal lifestyle. While only well off members of the community can afford to have them, almost everyone helps fish them.

The number of acadjas is now fixed. Previously the acadjas were taking up a significant surface area in the lake, and the decay of all the extra plant material from branches was causing the lake to fill. The state has now imposed a tax which helps to limit the size and number of acadjas on the lake. The economic pressures facing the people are evident here as well, where the acadjas used to fished twice a year, in order to allow for significant growth of the crop, and allow time for reproduction, they are now harvested after a period of only 3 to 4 months.

-MEDOKPOKONOU (unmanned)

By far, this is the most devastating practice. Only very recently invented, medokpokonou consists of raising a net across a given area in the lake, and placing a large pouch at each end. Given the current condition of the fishery, only nets with very small openings are used. Net size is described by the number of fingers that can fit through one of the holes, thus a fisherman knows how big the smallest of the fish that he will catch will be. The nets for this practice are described as one finger nets. When used, they will effectively remove all the fish from a given area.

The impact of this is clear. By using such small nets, even the fingerlings and non-mature members of many species are being removed from the lake. The species do not have a chance to reproduce and thus, the number of potential as well as actual fish in the lake is reduced.

Figure 6

Source: World Resource Database, 1994.

Figure 6 shows the dramatic drop in freshwater fish production in Benin in recent years. This can be partially attributed to the decline in the Lake Nekoue fishery, as it is the primary source of fish for the metropolitan Cotonou and Porto Novo regions. The specific amount of fish that comes from the Lake Nekoue fishery is not known, however, it has been estimated at over 50% of the total fish catch. (Falana, 1990) Conversations with the local fishermen tell even more about the state of the fishery, however. In listing the approximately twenty different species that have historically flourished during the flood and non-flood periods (see Appendices B and C), only two or three are currently present in any abundance, and for those, the size of the fish caught as well as the total catch weight has been dramatically reduced.

Regulations

There are regulations put in place by the government to protect the natural fishery, such as the regulations concerning acadjas. However, because of the remoteness of the locations, as well as the lack of manpower, they go practically unenforced. Among these regulations is a prohibition on using fishing nets smaller than "two fingers", which if followed would help reduce the damage caused by medokpokonou. People in the village are fully aware of these rules, but knowing that enforcement is non-existent, most choose not to follow them.

The future of the natural fishery is bleak, and the population is very slowly becoming aware of it. But knowledge is not automatically leading to action, as the popularity of medokpokonou suggests. Inherent in the Toffinu culture is an "I've got mine" attitude, which impedes resource preservation efforts. As long as there is enough for today, there is no concern for tomorrow. With the rapidly decreasing fish catches, the tide has begun changing, however, and reality has begun to reach them. Already, families are not able to support themselves from their traditional lifestyle, and must seek other nutritional sources. However, due to the decline in the natural fishery, there is not sufficient money to buy supplementary provisions.

RECOMMENDATIONS

It is a daunting task to change the path that this area is already headed on. There are multiple factors: social, political and economic at work that complicate this process. First, the preservation and protection of the natural fishery needs to be addressed. A primary component of this would entail educating the population of the current situation and its consequences. The people have experienced the dwindling fish catches and have begun to adapt to the decreased productivity. However, their solution is to permanently open the channel to sea, in order to maintain contact with the marine environment, and thus providing a passage for marine fish into the lagoon. This action would serve to devastate the already stressed ecosystem. Instead, we need to look for other ways to allow the Toffinu to continue their historical lifestyle in a way that will preserve the environment for generations to come.

There are several recommendations that can be made to address the issues confronting the Toffinu. The first would involve a strict regulation of the exploitation of the lagoon. Fishing practices and net sizes need to be strictly regulated and monitored. While the current government infrastructure does contain a fisheries ministry, its regulations have not kept pace with the current realities of the ecosystem or economy. As has been explained, the population is desperate to feed and support itself from a resource that is unable to adequately provide for those who depend on it. Medokpokonou is just one adaptation to this reality. It is relatively easy for the government to enact regulations. The more difficult task is their enforcement.

There is an existing government agency that has greater contact with the village leadership, as well as the population on a more frequent basis. The Ministry for Rural Development already maintains close ties with the lagoon villages to aid in their progress. Already, the local representative acts as a quasi-extension worker providing the villagers with information and services, and hearing and addressing their grievances. Aside from the internal village and familial structures, this is the closest contact that many have with the national government. To extend the duties of this office to encompass some of the duties of a fisheries officer, to monitor local fishing practices, would take advantage of the already existing framework to provide a more watchful eye.

Another recommendation involves providing the Toffinu with other activities to support themselves, aside from fishing. This would be a government supported/self-selected effort of retraining. A few people in the villages have already seen the merit of finding non-fisheries based occupations. Others need to be encouraged to do the same and the state can help provide the opportunities for them. Cooperatives can be established along interest lines to promote crafts and trades. Groups to teach such skills as basket making or metal working can be created, and also used to market the goods. These groups can also be used to begin to educate those who have not previously had access to formal education. Public health issues and contraception can be addressed. Such groups would provide greater organization to the population than is currently present. Additionally, to increase village access to food supplies, and to redirect nutritional efforts away from the fishery, the government would be well served to provide land for a "land-based" Ganvie, where agriculture could be practiced.

These recommendations are not entirely new. This type of redirection has already happened in an area of the Zou Province. Faced with a declining natural fishery, residents enacted and enforced a program to save their natural resource. To replace the dwindling fish supply, they imported a species of carp from a nearby river, and to ensure its survival, a ban was enacted to prohibit all fishing in the lake for a period of six months, every year. This regulation was enforced by the village chiefs who would enact a hefty fine from anyone who disobeyed the prohibition. This seems to have worked in this area, partially because the villages were land-based, and thus there were agricultural opportunities present to occupy and sustain the population during periods that the ban on fishing was in place. However, it was not an easy transition for a population who had had continuous access to a fishery. In order for the population to be open to such a drastic change, they had to become aware of the consequences of continuing down the current path. They had to become accountable for the future of their resource, learn how to maintain it and police it when the state did not have the resources to help.

This would be an even bigger step for the lagoon-based villages of Lake Nekoue, where there is no land, to sustain agricultural activities. This is why a comprehensive retraining plan including the help of the Benin government is necessary to complete the transition from reliance on the fishery. However daunting, such broad steps are crucial to preserve the future of the Toffinu and Lake Nekoue.

Tourism has the potential to provide funding for village infrastructure and improvements, as well as economic benefits to the entire country, but the number of tourists has decreased without the continued government outlay for international advertising. If tourism is indeed a priority, money needs to be spent if Benin expects to attract the level of tourists that it has in the past. Additionally, the villagers still do not receive an equitable share of the proceeds gained from their exploitation, but so far have been unsuccessful at increasing their share of the profits. Perhaps a second fee could be charged that the villagers could directly assess and benefit from, one that is more in line with the amount that is currently being charged.

The amelioration if the lagoon environment needs to be addressed for the benefit of the tourist trade as well. The continued degradation of the lagoon can only have a further negative impact on tourism. As the lagoon ecosystem becomes increasingly constrained, accumulated waste and garbage in the water will serve to dissuade visits to the sight.

A final recommendation would be to greatly increase the amount of aquaculture that is currently being practiced. Figure 7 shows the amount of aquaculture production harvested between 1984 and 1991. In 1984, aquaculture consisted of less than one tenth of one percent of the total fish production. In 1991, it had risen only slightly, the increase in 1987 being due to a funded aquaculture program, which has since bee completed . This level needs to be dramatically increased o a permanent basis, as it has the potential to provide supplemental sources of fish protein in the Benin population diet as well as an income source for the Toffinu (by ensuring their involvement in the project). Aquaculture has already been shown to be a viable part of replacing the nutrition gained from the natural fishery. During the late 1980s, an aquaculture project was held outside of Lake Nekoue. It involved raising a non-native species of tilapia. It was successful for study, but when funding ended, it was not continued, and none of its recommendations have been implemented. The infrastructure still exists, however, and if it were used to raise native species of tilapia that can be raised either for market or for village use, it could take some of the pressure off of the natural system.

Figure 7

Source: World Resource Database, 1994.

Appendix A

Number of Tourists visiting Ganvie, by Nationality, between 1983 and 1988

Nationality	Total Number of Visitors	Annual Average	Rank
France	26,170	4,361	1st
Germany	9,320	1,553	2nd
Benin	8,430	1,405	3rd
Switzerland	4,984	830	4th
Italy	3,991	665	5th
Holland	2,050	341	6th
Canada	1,950	325	7th
Belgium	1,862	310	8th
United States	1,829	304	9th
Austria	1,789	298	10th

Togo	1,744	290	11th
England	1,429	238	12th
Russia	1,216	202	13th
China	812	135	14th
Ctte d'Ivoire	655	109	15th
Spain	638	106	16th
Nigeria	605	100	17th
Senegal	405	67	18th
Japan	366	61	19th
Niger	350	58	20th
Mali	325	54	21st
Ghana	299	49	22nd
Denmark	293	48	23rd
Sweden	244	40	24th
Cuba	123	20	25th

Source: Radji, 1991.

Appendix B

Species of fish found during non-flood period and relative abundance:

Toffinu Name	Scientific Name	Observation
Ewh	Tilapia melanotherm	+++++
Djan zavoun	Chrysichthys nigrodigitatus	
Digon	Penaeus duorarum	
Asson	Callinectes latimarus	
Atcha loki		

Tchiki	Ethmalosa fimbriata	++++
Wlhtin applo	Megalops atlanticus	
Agossou fofo	Tiilapa guineensis	
Ogban	Elops lacerta	
Tchhmidi	Eucinostomus gerres	
Assui	Pellonula afseliusu	
Ogoun	Sphyraena guachancho	
Oussa	Trachinotus teraiia	
Adjago	Caranx senegalus	
Ossan	Gimnura micrura	
Adowi		

Appendix C

Species of fish found during flood period and relative abundance:

Toffinu Name	Scientific Name	Observation
Ewh	Tilapia melanotherm	+++++
Djan zavoun	Chrysichthys nigrodigitatus	
Digon	Penaeus duorarum	
Hwa	Heterotis niloticus	++++
Aboli	Clarias gariepimus	+++++
Tonvi	Clarias agboyiensis	
Tchiki	Ethmalosa fimbriata	++++
Allidjo	Kribia nana	
Agbogui		

Adovi	Hemichromis faciatus
Bhbhvou	
Sovoun	Synodontis gambiensis
Ekin	Chromidotilapia guntheri
Agbadja	
Sannoumadou	
Agoutchi	
Ahotoun	Parachanna obscura
Ohouin	

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CHAPTER SIXTEEN

GWO-WEI TORNG

A SPATIAL PERSPECTIVE OF THE INTERSTATE HIGHWAY SYSTEM'S EFFECTS ON SUBURBANIZATION

Introduction

The role of transportation systems in fostering growth and affecting land use structures has been of great interest to academics, planners, investors, and politicians. Peter O. Muller formulated his explanation of urban form in his article, "Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis", by identifying four transportation eras (Figure 1). Figure 1 clearly illustrates the concept of dependency of land use on transportation system changes. Indeed, innovations in transportation technologies in the past have greatly influenced people's travel attitudes, travel behaviors, and then extended the boundaries of socio-economic activities, such as workplaces, residential areas, and shopping. While examining Figure 1, it is important to distinguish the growth effects from the distribution effects. In Figure 1, the distribution effects can be interpreted as the changing shapes of urban forms, while the growth effects are the net change of total areas within the urban boundaries.

Figure 1, Intraurban Transport Eras and Metropolitan Growth Patterns: (I) Walking-Horsecar Era, (II) Electric Streetcar Era, (III) Recreational Auto Era, (IV) Freeway Era.

Source: Peter O. Muller, Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis.

The effects of transportation infrastructure on shaping urbanized areas have drawn significant attention in the past. The relationship between transportation and land use is interactive. Empirical urban development research reveals that land use patterns influence transportation investment decisions, which may later affect further land use changes. In this research, only the effects of highway/expressway systems on urbanized area growth will be explored.

The primary intention in building interstate highways was for "interstate" transportation purposes, e.g., national defense and interstate commerce. Nevertheless, several major metropolitan transportation studies, e.g., a study done by the Chicago Area Transportation Study (CATS) in 1955, suggested that one purpose in developing the transportation networks was to serve travel generated by projected land-use expansions (Teaford, 1986). Demand-driven transportation planning schemes were very much a part of the thinking. Indeed, more than 30 years' experience tells us that those limited-access highways have very significant impacts at the local level, in addition to their impact on land use at the regional or even broader geographical scale. Rapid urban sprawl in the past several decades is perceived to be directly or indirectly induced by the emergence of highway systems. Because interstate highways are relatively "lineal" featured (one dimensional) with respect to overall urban areas, their effects should be considered in terms of directions as well as densities.

This research examines the land use impact of interstate highway investments from a geographical perspective. It begins with a brief literature review which summarizes the objectives, motivation, methodology, and results of previous research on similar issues. In the second section, major research questions are illustrated. Next, the methodologies applied in this research, e.g., grid-cell based raster spatial analysis, are introduced followed by the development of models and discussions of modeling results. Then, the transition of spatial effects is analyzed based on the derived modeling results. In the final section, conclusions drawn from research findings are summarized and some policy implications derived from this study are discussed.

Literature Review

Muller (1986) pointed out that Americans were not urban dwellers by design. Many people live for a dream of owning a private, single family home, near-to-nature, rural, with huge front and back yards. As described by Schaeffer and Sclar (1975), "people have found a way to isolate themselves;... a way to privacy among their peer group;... They see nothing except what they are determined to see." For a majority of urban dwellers, living within large cities was actually not a personal preference but a personal choice given no other viable choices. Starting from 1945, after a long period of economic depression and war, the U.S. showed a great potential for economic revitalization. The automobile was no longer a luxury good but a necessity for commuting, shopping, socializing, and running personal errands. Meanwhile, America's birth rate rose, many young couples left crowded central city neighborhoods and moved to spacious suburbs where their kids could play in their own front or back yards. Two-car families became commonplace. In many aspects, the suburbanization appeared to be an inevitable tendency (Teaford, 1986). The passage of the Interstate Highway Act of 1956 signaled the arrival of the suburbanization era. The booming highway systems acted as catalyst which turned the historic metropolitan cities inside out and reshaped the traditional urbanized areas . This suburbanization phenomenon can be well explained by the increase in people's mobility. People can afford to live outside the central cities by traveling at a much higher travel speed on the newly constructed highways while not increasing travel time. Figure 2 illustrates the concept of the dynamic relationships between population density and urban area expansion from a spatial perspective. The resulting increase in mobility indeed reduced the relative attractiveness of old and crowded central cities.

Figure 2, Type of Urban Area Expansion: (I) Pure Growth (increased population are even distributed), (II) No Growth, Redistribution (no change in total population), and (III) Growth + Redistribution (net gain in population and population redistribution)

Meanwhile, the gasoline cost in the U.S. was low enough to support the highway commute choice. Anthony Down (1992) pointed out that the inflation adjusted price of unleaded gasoline actually went down by 27.4 percent from 1975 to 1987. The gasoline prices in other industrial countries in 1991 were at least 50 percent higher than those in the United States. In some areas, like Italy and Japan, the gasoline prices were three times or higher compared to the prices in the U.S. The relatively lower gasoline cost reduces the auto operating cost and thus indirectly encourages the urban decentralization.

Nevertheless, it is not appropriate to attribute the only cause of suburbanization to the transportation systems. Bradbury, et al. (1982) concluded that several possible causes of urban decentralization exist. The results suggested that national economic conditions, technological change, and federal policies were also responsible for the urban decline in the past decades.

There are some studies concerning highway impacts on land use changes. In the early interstate highway era, the majority of research, such as Adkins (1959), and Mohring (1961), tended to justify the positive effects of interstate highways through economic reasons, such as increase of land value. However, these studies failed to address the difference between growth and distribution effects. That is, whether the land value increases near the highway were simply a distributional shift or a net gain within the region as a whole was an issue. Both researches used the highway length as a indicator rather than using the accessibility measures of the highway interchange. It was recognized later that the highway interchange is a more meaningful and appropriate research unit when exploring highway systems' impact on land use. Finally, both researches were conducted in the late 1950s and early 1960s which might be too early to capture "time lag" effects of the highway investment. Thus an objective evaluation of the effects of these newly constructed highways was virtually impossible.

A more recent and comprehensive highway impact studies was conducted by Payne-Maxie Consultants for U.S. Department of Transportation (DOT) and U.S. Department of Housing and Urban Development (HUD) in 1980. This study was designed specifically to explore the impact of beltways (circumferential limited-access highways) instead of overall interstate highways. It considered influential factors, such as city ages and highway location. In addition, this study applied the concept of interchange density using it as a measurement of highway accessibility. Most importantly, an effort was made to distinguish the distributional impact from the growth impact by controlling regional growth related variables. In other words, the study attempted to control for the regional changes and then identify the "pure" distributional impact. The results unveiled the fact that neither the existence of beltway itself nor the interchange density has consistently significant impact on population growth in SMSA during the study period (1960-1977).

Regarding the spatial analysis of land use change literature, a recent work, BART AT 20: A Preliminary Look at the Economic, Property Market, and Land Use Impact of the Bay Area Rapid Transit System, by John D. Landis (1994), studied the impact of Bay Area Rapid Transit stations on surrounding area land use conditions and evolution. This study analyzed 1965-1990 land use changes at nine suburban BART stations. Grid-cell based analytical methods were used and probability models were developed in the study. The results suggest that the distance to the existing BART stations have significant influences on land use change. The farther a grid-cell is away from BART stations, the less likely this grid-cell would change its land use. In addition, adjacent land use type also stood out as a highly significant and consistently important variable, especially during the 1975-90 period. The positive coefficient for this adjacent land use variable indicates that land use of each individual grid-cell is strongly affected by the land use pattern of its neighboring, or adjacent grid-cells (the existence of the spatial neighboring effect).

Research Questions

As mentioned before, the main purpose of this study is to demonstrate the impact of interstate highway systems on population decentralization since the 1960s. In order to achieve this goal, the following three major research questions are proposed.

1. Spatial correlation: Are the expansions of urbanized areas spatially correlated with the development of interstate highway systems? That is, do the directions of population decentralization match the directions of highway system development? Figure 3 illustrates the spatial correlation effects. The inner shaded circle stands for the existing urbanized area before the highway systems were constructed. The thick black line

represents a radial highway system which goes right through center city area. It is assumed that the net expansion of urbanized area are equal for both types of growth (A and B). Should there be no spatial correlation effect, type A expansion is expected. Otherwise, the new urbanized area would look like type B.

2. Spatial neighboring effects: Do spatial neighboring effects play a significant role in the expansions of urbanized areas? That is, all else being equal, do lands which are closer to the existing urbanized land have a higher chance of changing their urbanization status?

3. Time lag effects: Do time lag effects of highway systems on population suburbanization exist? With other conditions controlled, would a non-urbanized land cell which is closer to a younger highway interchange have a higher probability of turning into an urbanized land cell than that one whose closest highway interchange is older?

Figure 3, The concept of Spatial Correlation Effects

4. Beltway effects: Do beltway systems have any effect on encouraging in-fill type of urbanized area expansion (type A in figure 3) rather than radial expansion along the highway corridors like type B in figure 2?

5. Transitions of spatial effects on suburbanization: Whether two major spatial effects, spatial correlation and spatial neighboring effects, are experiencing transitions in terms of their impacts on suburbanization.

Methodology

Case Study Area Selection: Oklahoma City, Oklahoma

In this study, Oklahoma City, Oklahoma, is selected for longitudinal analysis over three decades (1960-1990) of interstate highway evolution and urbanized area growth. The following information, including some digital map files, about the case study area are collected for research purposes.

1. Urbanized area boundaries of case study area for year 1960, 1970, 1980, and 1990
2. Street center line maps for the case study area (digital format)
3. Interstate highway system evolution from 1960 through 1990
4. Interchange locations and their years of completion
5. Locations of undevelopable lands, e.g., rivers (digital format)
6. Other arbitrarily defined boundaries, e.g., city boundary and county boundary (digital format)
7. Classification of highway types, i.e., beltway vs. radial systems.

Figure 4 provides an overview of the evolution process of urbanized area of Oklahoma City from 1960 through 1990. In this study, spatial models are developed to distinguish the directional effects of the interstate highway system from its density effects on urban decentralization.

GIS Analysis

By using a GIS software (ARC/INFO for UNIX running on IBM RS6000 platform), this research develops several grid-cell based spatial analysis models to explore the spatial evolution process of Oklahoma City urbanized area and its relationships with interstate highway constructions between every observation time period (every 10 years) or every other observation time period (every 20 years) . In the following multivariate logit models, change of urbanization status (dichotomous variable) will be used as the dependent variable throughout all models. Each cell is treated as a research unit and each non-urbanized cell's probability of changing its urbanization status in the next decade is represented as a nonlinear function of its distance to the closest existing urbanized cell, its distance to the closest highway interchange, year of completion of the closest highway interchange, and type (beltway/radial) of the closest highway interchange.

Cell size selection

The urbanized area boundary coverages for Oklahoma City, Oklahoma are determined from census data issued every 10 years by the Census Bureau. Due to lack of precision of the hard copy maps in the census books, the source of the urbanized area data, cell size is set to equal one half square mile per cell (about 3734 feet on each side). In other words, this study employs neighborhood-scaled observations in the models.

The definition of study areas

Empirical evidence shows that the absolute magnitude of urbanized area growth is actually a function of existing urbanized area's size. Larger urbanized areas tend to have larger expansion. Thus, a study area should be defined in a way which is sensitive to the area's size. It is clear that traditional methods for defining study areas, such as using politically defined boundaries, are not appropriate. Besides, the numbers of changed cells and non-changed cells should not be heavily weighted to either side in order to make the forecast model more meaningful. Therefore, only those cells which are perceived by authors to have a reasonable chance of changing their urbanization status are included in the study area. In this case study city, Oklahoma City, Oklahoma, the study area is defined as a 3-mile buffer of 1960 urbanized areas for 1960-1970 model, 3.5-mile buffer of 1970 urbanized area for 1970-1980 model and 1960-1980 model, and 4-mile buffer of 1980 urbanized area for 1980-1990 model as well as 1970-1990 model . Within each study area boundary, areas covered by water body, e.g., lakes and rivers, are regarded as undevelopable areas and thus are taken out of the sample set.

Logit Model Development

Among others, there are three commonly used probability models: Linear Probability Model (LPM), Logit Model, and Probit Model. The difficulty with LPM is its linear assumption which may result in observations with probability greater than 1 or less than 0, a meaningless result in a probability model. Both logit model and probit model belong to the nonlinear probability model family with values always bounded by zero and one. Usually, both models have similar performance in terms of their prediction power and accuracy rate. However, the logit model is relatively easier to be interpreted. In this study, the logit model with dichotomous dependent variable (change of urbanization status during the study period, 0 = no changed, 1 = changed) is used with each grid-cell in the defined study area acting as a unique observation. The basic format for dichotomous logit model is as follows:

P(Y = 1 | X) = exp(sum(bx))/[1 + exp(sum(bx))] where X are observed variables and the remaining unknowns are the parameters b.

Spatial correlation phenomenon

It is commonly believed that the massive interstate highway system construction since the mid 1950s' is one of the major causes for the rapid growth of urbanized lands. The Euclidean distance of each cell's centroid to its closest highway interchange is measured to represent the actual distance between the two. This independent variable (DIST_INT) is expected to have significant negative coefficients throughout all multivariate logit models.

Spatial neighboring phenomenon

By definition, the urbanized area is a cluster of land cells with their population density reaching a certain threshold. It is assumed that the presence of an urbanized area cell can enhance the chance of urbanization of its neighboring cells. Authors assume that the evolution of urbanized areas was affected by interstate highway systems but also by the spatial neighboring effect. The rationale for expecting the neighboring effect is land developers' avoidance of costly extension of urban infrastructure. Using the census definition of urbanized area as places with population densities greater than 1000 persons per square mile implies the need for water and sewer line infrastructures in the newly developed lands. Land developers are inclined to develop land near existing systems to avoid costly mainline extensions.

In order to distinguish the interstate highway spatial correlation effect from spatial neighboring effect, the latter is controlled by adding an independent variable, DIST_UA which measures the Euclidean distance from each observed cell to its closest urbanized area cell during the previous decade. Consequently, significant and negative coefficients for this predictor (DIST_UA) are expected throughout all logit models. That means the farther a cell is away from existing urbanized cells, the less likely this cell will turn into an urbanized cell.

Time lag effects

There remains an unknown issue regarding whether a time lag effect exists in terms of encouraging non-urbanized areas growing along highway corridors. Urbanized area's growth directions may not reflect the influences of nearby highway interchanges until much later than the interchange's completion year. In order to explore this issue, this research includes the closest highway interchange years of completion as another independent variables (INT_60, INT_70, and INT_80). These time lag variables appear as dummy variable formats on cell by cell base.

Beltway effects

As mentioned, beltway systems are believed to play important roles in forming urbanized area boundaries. If a non-urbanized cell's nearest highway interchange is a beltway interchange, it is expected to have higher probability of changing its urbanization status (positive effect). In the following logit models, dummy variable (INT_BELT) is used to explore the beltway effect on urbanization.

<u>Spatial Effects Transitional Analysis</u>

Based on logit modeling results, several curve fitting techniques, such as logistic curve fitting, are used to depict the historical trend and predict the future trend of spatial effects on suburbanization. The probability of changing urbanization status during different time periods are then discussed. The aggregate trend of urbanization area growth (without directional concerns) is used to adjust for the predicted results.

Modeling Results

Logit Modeling

In this study, a framework of the binomial logit model for predicting the probabilities of changing urbanization status among non-urbanized lands is specified as follows:

P(UA_CHANGE=1 / DIST_INT, DIST_UA, INT_60, INT70, INT_80, INT_BELT) =

exp(b0+b1*DIST_INT+b2*DIST_UA+b3*INT_60+b4*INT_70+b5*INT_80+b6*INT_BELT)

/ [1 +

exp(b0+b1*DIST_INT+b2*DIST_UA+b3*INT_60+b4*INT_70+b5*INT_80+b6*INT_BELT)]

where

UA_CHANGE: dichotomous dependent variable, 1 = from non-urbanized area to urbanized area during study period, 0 = otherwise

DIST_INT: distance to the closest highway interchange.

DIST_UA: distance to the closest urbanized cell

The following three dummy variables are used if applicable.

INT_60: dummy variable for testing time lag effect. INT_60 = 1 if the nearest interchange was completed before 1960, otherwise INT_60 = 0

INT_70: 1 if the nearest interchange was completed between 1961-1970, 0 otherwise

INT_80: similarly, 1 if the nearest interchange was completed between

1971-1980, 0 otherwise

INT_BELT: 1 if the nearest interchange is part of the beltway system, 0 otherwise

Three logit models by each decade within the study period (1960-1990) are established and summarized in table 1.

1960-1970 Model

Figure 5 shows the urbanization area expansion between 1960-1970, highway systems as of 1960, and the study area (3 mile buffer of 1960 urbanized area boundary) defined for developing logit model. For this 1960-1970 model, both DIST_INT and DIST_UA unveil significant explanatory power on UA_CHANGE. DIST_UA plays a more important role in predicting the change of urbanized status than DIST_INT. The negative coefficients of DIST_INT and DIST_UA support previous hypothesis which suggest that both the distance to nearest interchange and the distance to the nearest urbanized cell have negative effects on the probability of changing urbanization status for non-urbanized cells. Nevertheless, this 1960-1970 model is not predicting any cell with urbanization status change even though with 90.25% overall fit percentage. My explanation is that the sample set is highly skewed with 657:71 no-change/change ratio and two distance variables can only explain a limited portion of the dependent variable's variance although both of them are statistically significant. The beltway effect does not appear to be significant. In fact, based on the status of the Oklahoma City highway systems as of 1960, as shown in figure 5, no beltway effect should have been expected.

Table 1, Logit Modeling Results: 10-Year Models

Dependent Variable UA_CHANGE	Study Period 1960-1970	1970-1980	1980-1990
DIST_INT	-0.1757(.0000)	-0.0519(.1707)	-0.1834(.0000)
DIST_UA	-0.6911(.0000)	-1.1726(.0000)	-0.6823(.0000)
INT_60		0.0803(.6784)	-0.5089(.0343)
INT_70			-0.1093(.5499)
INT_BELT	-0.1305(.6824)	0.0162 (.9619)	3.4991(.0010)
Constant	.1853(.5875)	0.5575(.0085)	1.0476(.0000)
Observations	728	908	1075
Change	71	208	327
Predicted	0	0	95
% Predicted	0%	0%	29.05%
No Change	657	700	748
Predicted	657	700	696
% Predicted	100%	100%	93.05%
Overall Fit	90.25%	77.09%	73.58%

Note: Numbers in the parenthesis show the t statistics for the corresponding variables. Numbers with bold font are statistically significant at 0.05 level.

1970-1980 Model Figure 6 shows the urbanized area expansion between 1970-1980, highway systems as of 1970, and the study area defined for developing logit model. A total of 908 cells are covered by 3.5-mile buffer of 1970 urbanized area. Similarly, in the second, 1970-1980 model, the signs of coefficients of both distance variables, DIST_INT and DIST_UA, are negative as expected (-0.0519 and -1.1726 respectively). The coefficient of DIST_UA is once again larger than the coefficient of DIST_INT which indicates that the distance to the nearest urbanized area cell (spatial neighboring effect) played a more important role in predicting urbanized area expansion during 1970-1980. In fact, the coefficient for DIST_INT appears to be insignificant with its P value equals to 0.1707. The positive coefficient (0.0803) of INT_60 (time lag effect dummy variable) suggests that a cell would have a better chance to become an urbanized cell between 1970 to 1980 if its closest highway interchange was completed by 1960 (rather than 1970). However, this coefficient is not statistically significant (p = 0.6784). The beltway effect once again does not appear to be significant (b = 0.0162, p = 0.9619). Same as the 1960-1970 model, this 1970-1980 model is not predicting any cell with urbanization status change even though with 77.09% overall fit percentage. The same explanation as mentioned in the previous 1960-1970 section can also be applied here. 1980-1990 Model Figure 7 shows the urbanized area expansion between 1980-1990, highway systems completed by 1980, and the defined 4-mile buffer (of 1980 urbanized area) study area. The total number of observed cells equals to 1075. The signs of coefficients for both distance variables are negative and significant as expected. Consistently, the distance to the nearest urbanized areas continues to act as a more influential factor than the distance to the nearest highway interchange. The strong significance level (relatively high t statistics) of both coefficients reflects that both distance variables are justified to have their own effects on the change of urbanization status. The negative signs of time lag variables, INT_60 and INT_70, shows that the newer interchanges completed between 1970 and 1980 are more likely to be associated with new development. Meanwhile, the coefficients for both time lag effect dummy variables, INT_60 and INT_70, are not proven to be statistically significant. Surprisingly enough, unlike previous two decades, the beltway effect comes up significantly (p = 0.001) with a relatively large coefficient (3.4991). The beltway effect has become as a strong factor along with others that influence urban sprawl directions in the 1980s. Twenty-nine percent (29%) accuracy of predicting urbanized cells is achieved by this model compare to 0% in previous models.

Limitations of 10-year Models and the Concepts of 20-year Models

Because of the inherent constraint of our arbitrarily defined study areas, e.g., 3-mile buffer, 4-mile buffer, etc., it would be unfair to conclude that the widely held expectation that highways encourage urban sprawl has proven to be incorrect. For example, figure 5 shows the change of urbanized area boundaries between 1960 and 1970. It is obvious that south portion of urbanized area growth is well beyond the 3-mile buffer of 1960 boundary. In order to avoid the potential of losing information, we developed another set of models which examine the urbanized status change in every 20 years. That is, two models, one for year 1960 to 1980, the other for year 1970 to 1990, are developed based on a very similar framework. For the 1960 - 1980 model, the distance to the nearest highway interchange is recorded for each cell based on highway networks completed by 1970. The distance to the nearest existing urbanized area cell is measured based on 1960 urbanized area boundary. Correspondingly, for the 1970-1990 model, the distance to the nearest highway interchange is based on highway networks by 1980 while the distance to the nearest urbanized cell is measured based on 1970 urbanized area boundary. Table 2 summarizes the results of both models.

1960-1980 Model

Figure 8 shows the urbanized area expansion between 1960-1980, highway systems completed by 1970, and the defined 3.5-mile buffer (of 1970 urbanized area) study area. For 1960-1980 model, both distance variables coefficients show significant explanatory power. Unlikely previous 10 year period models, the distance to the nearest highway interchange variable (b = -0.1881) becomes a more influential factor in changing urbanization status than the distances to the nearest existing urbanized cell variable (b = -0.0752). Once again, the time lag variables, INT_60, is not a significant factor in this model. As expected, the beltway effect, INT_BELT (b = 0.2775), is not a significant predictor. The accuracy rate of prediction is 68.32%. Apparently, this model is much more reliable when predicting a cell as no change (0 to 0, 96.71% accuracy rate) than it is when predicting a cell as change (1 to 1, 11.68% accuracy rate). However, this is already an improvement in contrast to the 1960-1970 model and the 1970-1980 model where cells with changed urbanization status are predicted with 0% accuracy rate.

Table 2, Logit Modeling Results: 20-Year Models

Dependent Variable	UA_CHANGE	
Study Period	1960-1980	1970-1990
DIST_INT	-0.1881(.0000)	-0.1486(.0000)
DIST_UA	-0.0752(.0044)	-0.4223(.0000)
INT_60	0.1015(.5195)	-0.4539(.0267)
INT_70		-0.2396(.1333)
INT_BELT	0.2775(.3468)	3.3636(.0011)

Constant	0.1672(.2704)	1.3990(.0000)
Observations	1051	1299
Change	351	551
Predicted	41	313
% Predicted	11.68%	56.81%
No Change	700	748
Predicted	677	597
% Predicted	96.71%	79.81%
Overall Fit	68.32%	70.05%

Note: Numbers in the parenthesis show the t statistics for the corresponding variables. Numbers with bold font are statistically significant at 0.05 level.

1970-1990 Model

Figure 9 shows the urbanized area expansion between 1970-1990, highway systems completed by 1980, and the defined 4-mile buffer (of 1980 urbanized area) study area. In this 1970-1990 model, both distance variables appear significantly with negative coefficients as expected. The distance to the nearest urbanized area cell, DIST_UA (b = -0.4223) is a more important factor in terms of its impact on urbanization status change than DIST_INT (b = -0.1486). Table 3 compares the coefficients of two distance variables derived from both 1960-1980 model and 1970-1990 model. On one hand, the decrease of coefficient value of DIST_INT indicates that the impact of highway systems on suburbanization is declining. On the other hand, the increase of coefficient value of DIST_UA suggests that the spatial

neighboring effects on suburbanization is growing. A further discussion regarding this phenomenon will be made in the concluding section. The coefficient of INT_BELT unveils the same information as previous 1980-1990 model that beltway effect has tremendous predict power (b = 3.3636, p = 0.0011) during the last 10 to 20 years or so. The negative and significant coefficient of INT_60 suggests that having a more than 20 years old highway interchange as the nearest interchange, a non-urbanized land cell would have less chance of changing its urbanization status than others.

Table 3, Comparison of Distance Variables' Coefficients between 20-year models

Variable	1960-1980 model	1970-1990 model	% change
DIST_INT	-0.1881	-0.1486	- 21%

DIST_UA	-0.0752	-0.4223	+ 462%
Stronger Predictor*	DIST_INT	DIST_UA	

* Predictor's strength is decided by its absolute value of coefficient

Interpretation of Models' Coefficients

Because logit model is a nonlinear probability model, the influence of each predictor is not constant. In other words, the interpretations of coefficients are not very straight forward. Using 1960-1980 model as an example, each mile increase in the distance to the nearest highway interchange is estimated to decrease the odds of changing from non-urban to urbanized cell by a factor of 0.829 (= exp(-0.1881)), or about 100 (1-0.829) = 17.1 %. Similarly, each mile increase in distance to the nearest urbanized cell is estimated to reduce the odds of changing from non-urbanized to an urbanized cell by a factor of 0.924 (= exp(-0.0792)). Coefficients in the 1970-1990 model can be interpreted accordingly. For example, one is examining a non-urbanized cell in 1970 which is 1.25 miles away from existing urbanized cell, 2 miles from the nearest interchange. Its nearest highway interchange was completed by 1970. The value of odds is e (0.1979 - 0.19008 * 2 - 0.0792 * 1.25) = e -0.28126 = 0.7548. For the case of logit model with dichotomous dependent variable, P / (1 - P) is equal to 0.7548, and therefore P equals to 0.4301 < 0.5. The predicted value for this land cell would equal to 0 (no change). Correspondingly, in 1970-1990 model, a cell with identical conditions (1.25 miles to urbanized cell and 2 miles to interchange) would have odds equal to exp (1.4357 - 0.13728 * 2 - 0.45936 * 1.25 - 0.2167) = 1.4481. P is then equal to 0.5915 (P / (1 - P) = 1.4481) which is greater than 0.5. The predicted value for this land cell would be 1 (change).

Spatial Effects Transitional Analysis

Based on previous modeling results, I conclude that the spatial neighboring effect is playing a more important role than the spatial correlation effect, which was a dominant factor during the massive highway construction era. In order to explore this phenomena more clearly, I use curve fitting techniques to depict this transition graphically, as well as to predict the future urbanization probabilities for non-urban lands with different physical properties, e.g., distance to interchange. Twenty-year modeling results are used as the base of this transition analysis.

Figures 10 and 11 illustrate the probabilities of urbanization of lands with various distances to the existing urbanized area and the nearest interchange. As indicated, the impact of the two spatial effects can be examined through the differences of slopes. A larger difference between the slope of the axis and the slope of observed probabilities, when controlling for the other axis (effect), reveals a greater impact of that spatial effect. We can see in Figure 10 that the slope facing the Y axis (spatial correlation effect) is steeper than that facing the X axis (spatial neighboring effect). Once again, a stronger spatial correlation effect for the 1960-1980 period is confirmed. In Figure 11, the opposite result is observed. The slope facing the X axis is much steeper than that facing the Y axis in the 1970-1990 period. Clearly, a spatial effect transition took place between the two time periods. If there are no other major technological and policy changes in the near future, the spatial neighboring effect is expected to play a more important role in population suburbanization in the next few years.

Figure 12 shows the probabilities of changing urbanization status for lands 1) five miles from nearest interchange and one mile away from existing urbanized area (UA1INT5, solid line in the Figure), or 2) one mile from nearest interchange and five miles away from existing urbanized area. Both types are controlled for the age of the nearest interchange as "1970" and the type of the nearest interchange variables as "beltway". Time period 0 reflects the probabilities during the 1960-1980 period while time period 1 stands for 1970-1990 period. In other words, curve segments beyond time period 1 are the predicted probabilities. The logistics curve fitting model is used due to its desirable bounded growth property (probability * 0 and * 1). As expected, distance to the existing urbanized area is becoming more and more decisive in terms of influencing the urbanization probabilities. Any developable land which is close to the existing urbanized lands, e.g., UA1INT5, has a tremendous potential to become urbanized land in the near future.

Figure 12, Transitional Trend of Probability of Urbanization

Note: UA1INT5 stands for lands with one mile away from existing urbanized area and five miles from the nearest interchange. UA5INT1 stands for land with five miles away from existing urbanized area and one mile from the nearest interchange.

Conclusions

1. In the late sixties and early seventies, most people, including some planners, proposed opening up the suburbs to achieve most American's dreams. Experience has taught us that unless properly planned, urban sprawl is very costly and detrimental to our society in a variety of ways. For example, utility lines were extended to provide services; more roads were constructed to support travel needs, and more police forces were put on the streets to protect people's security Obviously, an enormous amount of public money has been used to pay for some peoples' decisions to live in the suburbs. Most people believe that interstate highway systems are responsible for the population suburbanization since the 1960s'. This research provides readers with a clear picture showing how and the extent to which highway system development can be geographically related to urbanized area growth. The consistently negative and significant coefficient for distance to the nearest highway interchange variable suggests the existence of spatial correlation between highway construction and urbanized area growth. Non-urbanized areas close to highway interchanges have a better chance of "urbanizing" than areas far away from highway interchanges. This spatial correlation effect was relatively stronger during the massive highway construction era (1960s' -1970s') than the neighboring effects represented by the distance to the nearest urbanized land. As the interstate highway system approached its thirtieth birthday, its geographical effects on the expansion of urbanized areas were fading, and the neighboring effect becoming a stronger determinant in the probabilities of non-urbanized lands being "urbanized". I propose the following two reasons to explain why the highway effects on suburbanization have been fading since the 1980s'.

A) According to urban development theories and past experiences, we know that American people tend to live and work in low-density areas. From the lessons we learned from opening interstate highway systems, we conclude that many people are willing to trade travel time savings for a suburban living environment. In other words, people are willing to move as far away from high density areas, especially the central city, as they possibly can, if the commuting time remains unchanged. The combination of the above two facts suggests that travel time, not distance, is the key in deciding the directions of suburbanization. During the massive interstate highway construction era (1960s' and 1970s') when people were able to travel on the highway at a relatively high speed, living in a low density suburban neighborhood became affordable as long as the neighborhood was close enough to a highway interchange. Not surprisingly, this research found that the shapes of urbanized area expansion were heavily influenced by the directions of interstate highway systems during this period of time. However, since the 1980s', when many metropolitan areas started suffering traffic congestion problems, the daily commute between suburbs and central cities became a nightmare for many commuters. Interstate highway systems were mostly overloaded, with the average vehicle travel speed down to about 30mph or lower during peak hours. Apparently, the travel speed and travel time advantage for interstate highway systems no longer exists. This may explain why the highway effects on shaping urbanized areas are fading.

B) The other possible explanation for this phenomena is suburbanization of employment since the 1980s. As mentioned, during the massive highway construction era, residential suburbanization was the major tendency. During the 1980s', the local economic climates, e.g., labor force supply and transportation accessibility, and the emergence of telecommunication technologies made the suburban environment attractive to many employers. American businesses began to show a preference for low-density workplaces. Nodal development around the traditional center cities is a common land use development pattern since the 1980s. (Levine, 1992) The development since then tends to infill those vacant lands between center cities and new town centers rather than moving further out.

2. The beltway effect has become a dominant factor in predicting urban area boundaries since the 1980s. With all other predictors in the model controlled, any non-urban land cell with a beltway interchange as its nearest interchange would increase the odds (P/1-P) of changing its urbanization status by a factor of 28 (= e 3.36, based on 1970-1990 model) or more. This conclusion is consistent with the conclusion derived before the urban sprawl during the 1980s had a tendency of in-filling the surrounding non-urban land, rather than stretching along the radial highway corridors.

3. Even though both spatial correlation effects and spatial neighboring effects appear to have significant prediction power, there still exist some other crucial determinants which are influential factors in predicting urbanized area growth, but are not included in the models. Throughout all developed models, the accuracy rates of predicting changed cells (dependent variable = 1) are consistently much lower than the accuracy rates of predicting non-changed cells. All five models tend to over predict non-changed probabilities. The skewed sample distribution is the fundamental cause of this tendency. The combined prediction power of the two distance variables appears to be insufficient to detect those underrepresented cells correctly under this circumstance.

4. The 10-year time lag effects are consistently insignificant through all logit models. The signs and magnitudes of the 10-year time lag variable also vary from model to model. However, the 20-year time lag

variable shows negative and significant coefficients in both the 1980-1990 and the 1970-1990 models. It seems that having an older highway interchange as the nearest interchange makes a non-urban land cell less likely to urbanize. Unfortunately, from a modeling point of view, there exists less than 40 years of history about the interstate highway system. And my observation time interval is limited to every ten years due to the limited availability of census data. The inherent limitation also keeps us from exploring any time lag effect of less than 10 years. The results must be viewed with caution.

Policy Implications

Intelligent Transportation Systems (ITS) is considered by some as a major contribution to transportation technology as we move toward year 2000. The deployment of ITS technologies is expected to influence people's travel behavior in the near future. Among various ITS goals, saving travel time, both individual time and commercial time, is one of the most important components. Many time-saving related technologies, such as adaptive traffic signal control systems and dynamic route guidance systems, are either commercially available or under field test status. From the lessons of interstate highway development in the past forty years, we have already learned that people show their willingness to trade travel time savings for greater travel distance to meet their desires for low density neighborhoods and low density workplaces. Urban sprawl in the past decades has indeed caused enormous social and environmental costs. We have made mistakes and have paid for them. We want to make sure that ITS can be deployed in such a way that people are encouraged to preserve the benefits of travel time saving rather than substitute them with any other potentially detrimental decisions, such as moving further away. While we are lucky enough to see that the driving force for suburbanization is getting weaker, we have to prevent other causes from emerging. The potentials of some ITS technologies, such as Automated Traffic Management Systems (ATMS) and Automated Traveler Information Systems (ATIS) for encouraging urban sprawl should be properly addressed. And the benefit cost analysis of ITS deployment should also be conducted with extreme caution so as not to overestimate ITS benefits, e.g., travel time saving, with the assumption of current travel patterns remaining unchanged.

From experiences, our society has learned that a net increase in people's mobility tends to enhance the magnitude of urban sprawl, i.e., the amount of urbanized area expansion. An unbalanced distribution of social resources, e.g., income and mobility, will contribute to the sprawl of urban forms. The combination of rapid and unbalanced urban area expansion causes enormous problems, such as traffic congestion and some derived environmental problems, such as air pollution. Many transportation-land use studies in the past explored many different solutions, such as job-house balancing strategy, to cure the urban sprawl problems. According to Levine (1995), one extreme of thought argues that we should let the market mechanism work by itself. In contrast, the other extreme of thought, in contrast, proposes that a stricter land use control procedure should be enforced. Both ideas have proven to be inefficient solutions. If the market could work by itself, we would not have had this urban sprawl problem in the first place. There exist negative externalities associated with the residential location decisions which create the improperly distribution of social resources. We saw richer people moving to the suburbs, with the social costs of their relocating behaviors burdening the whole society. This distorted market then creates some inefficient results. On the other hand, local land use control seemed to serve richer people better than it did to the poor. In many cases, we saw clearly that richer people moved to the suburbs and then used land use control as an excuse to keep poor people from following. Even the job-house balancing policy does not appear to be an effective solution to this sprawl problem for several reasons, such as the fact that many household have two or more workers going in various directions.

Considering the fact that the highway effect on suburbanization is diminishing and ITS technologies are emerging, I am proposing the following four policy suggestions to cope with the current transportation problems and related issues.

1. Internalize suburbanization externalities

People who move to suburban areas and generate negative externalities should be paying for the "true social cost" of their choice. The higher cost would have the effect of discouraging urban sprawl.

2. Re-prioritize ITS deployment procedures

Many social policies, such as taxation, aim at income redistribution. In many respects, mobility can be treated as another type of property owned by individuals. Most ITS development efforts in the U.S. seem to focus on the private and commercial transportation services. It is important that public transportation applications of ITS are also promoted in such a way that public transit users are not discriminated against by this technology. This is very crucial in the sense that unbalanced distribution of mobility is also a major cause of urban sprawl. The potentials of ITS for private transportation are expected to enhance the users' mobility significantly. The deployment process of ITS user services should be scheduled in such a way that public transit users (usually having less mobility) can receive the benefits of ITS at the same time as private mode users, if not earlier.

3. Equip people with resources and provide them with more options

The major reason why job-house balancing did not work well is that no one knows how to meet people's needs better than people themselves. Instead of offering people the "assumed" best choice, people should be given the power to make their own choices. In this case, people should be allowed to live any place they want (of course, with certain restrictions), as long as they are willing to pay the "true cost". Government's role is to provide people with similar resources, e.g., income, education, etc. so that they will have adequate knowledge and information to maximize their personal utilities.

4. Let market run by itself when the situation "matures"

In most cases, government interventions became the biggest cause of inefficiency and society loss. I agree that to a certain extent government intervention is necessary. But the goal of government intervention should aim at maintaining a healthy environment and social justice (i.e., prevent the more powerful from ripping off weaker people), instead of providing people with "end products" that government believes are best. In the ITS-transportation case, the government should make sure of the existence of equal opportunities in terms of selecting house and workplace locations. Then, let the market mechanism generate the optimal solution.

It has been 38 years since the passage of Federal-Aid Highway Act of 1956. The passage of Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 authorized $21 billion out of its $151 billion total budget over six years for national highway system construction and maintenance. As a response to the ISTEA, the Secretary of Transportation, Federico Pena, brought the proposed 158,000-mile National Highway System (NHS) before Congress in December 1993, giving birth to the National Highway System Designation Act of 1994. In other words, tremendous attention to and action on the interstate highway system is foreseeable. Being urban planners, we have observed the profound impact of highway systems on urban forms. We have recognized the problems with certain types of urban sprawl. Hopefully, this research will contribute to clarifying factors influencing social benefits of highway investments.

Future Study Suggestions

Expand the Scope of this Study

This research can be expanded on three different dimensions: issue, space, and time. On the first dimension - issue, I would like to explore the transitional dynamics between interstate highway systems and other social phenomenon, such as population, migration, and environment dynamics. On the second dimension - time, I intend to include a longer period of time, e.g., starting from the pre-auto era to the present. Finally, on the third dimension - space, I wish to extend the study to examine more cities in the U.S. or even the rest of the world, in order to categorize transitional patterns. This study should be treated as a pilot study, to be followed by a series of further in-depth explorations. The final goal of this study is to develop a comprehensive methodology which is replicable to other urbanized areas in/out of the U.S.

Accommodate Multi-Level Model Structure

Apparently, the proposed model would encounter the dilemmas of a hierarchical data structure. The Level-1 units are grid-cells, which are nested within the Level-2 units of highway completion year. As indicated by A. S. Bryk and S. W. Raudenbush (1992), the most common concerns regarding hierarchical data analysis include aggregation bias, misestimated precision, and the "unit of analysis" problem. Nevertheless, this study would still use a conventional dichotomous logit model to predict the probability of urbanized status change due to the following two reasons:

1. First of all, unlike a hierarchical linear model, which is substantively developed, there is not yet any hierarchical nonlinear model which is universally accepted.
2. Empirical evidences, e.g., school effects on teacher efficacy study by Bryk and Driscoll (1988), show that there is no significant difference between results from hierarchical linear models and these from

conventional single level models in terms of the magnitudes of coefficients.

Add Zoning/Land Use Information to Exclude those Undevelopable Lands

In this study, only water body is excluded from the sample set. In the real world, many types of lands are not developable due to limitations, such as unsuitable soil type, and environmentally sensitive and preserved areas. The forecast accuracy rate would be improved, if, before establishing models, future studies excluded these non-qualified areas from the sample set.

Use Discrete Network Distance to Measure Real Travel Time rather than Making Continuous Space Assumption

This study uses a simplified distance measurement method, Euclidean distance, to acquire distance information. An effort to apply the discrete network concept to measure actual travel time hopefully would improve the models' prediction capability.

Conduct Residual Autocorrelation Analysis for each Prediction Model

This study relies on the "eyeballing" method to examine modeling residuals' spatial autocorrelation phenomena. In fact, there are several spatial autocorrelation models available to explore the intensity of autocorrelation in a quantitative manner, e.g., Moran's I statistics and joint-count statistics (Upton and Fingleton, 1985). It is desirable to apply these available analytical tools to justify the models' assumptions and to improve their

Definition of Beltways

The most commonly used method to define and label a beltway is to base it on the highway numbers, such as found in Payne-Maxie Consultants, 1980. For example, I-96 is a main line while I-696 is a beltway. The same is true for I-75 vs. I-275. In this study, I also used this intuitive way to define beltway for the case study area. Nevertheless, I recognize that a set of objective and scientific criteria are necessary for academic research purposes, especially for a geographic analysis like this. I am currently developing a method of defining beltway from a geometric perspective. Hopefully, the follow-up study can apply this new method to objectively defined beltways.

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NOTES

CHAPTER SEVENTEEN

RICHARD A. TRACY

SUSTAINABLE BUILDING MATERIAL TRANSITION IN THE UNITED STATES:

TOWARD A SUSTAINABLE FUTURE

Not so long ago Buckminster Fuller reminded us that we are all travelers on Spaceship Earth. Since that time there has been a growing concern and awareness about how we manage the natural environment and resources within that environment. One need only look at the increase in fuel efficiency in automobiles to see evidence of this trend. Evidence of this trend may also be found in the building industry. That industry is constantly looking for new technology to save energy. The explosion in the number of materials with increased insulative capacities is just one example of this search for better technology.

It is important that planners, architects, engineers, builders, and governmental bodies realize the necessity for responsible use of natural resources. The building industry uses these resources in both the construction and the operation of buildings. In addition, the industry uses vital resources at the end of the life of a building. These resources are used for the demolition and disposal of materials from a building. As fuller reminded us, we are part of an intricate system. That system has its limitations and advantages. Some of the resources within the system can be regenerated, some cannot.

While it is important to understand that technology plays an important role in the building industry, it is equally important to realize that money may play an even bigger role. Clearly these new technologies come at a cost to the consumer. Thus, in addition to the building industry's responsibility, there is a large measure of responsibility placed on the consumer.

It is the focus of this paper to deal with the issues of resource use in the building industry. Specifically, this paper will deal with the topic of renewable and nonrenewable resources as they apply to the materials used for the structure of buildings. Of interest are the choices people in the United States make with regard to the way they build in the context of the environment as a whole. Of particular interest is the comparison of the impact of traditionally popular methods/materials of construction and "Green" or "Sustainable" methods/materials of construction.

It may be of some great use to define sustainability in terms of its use within this paper. In this paper sustainability is best defined in the words used by the Rainforest Action Network to define sustainability for their home page on the World Wide Web. "Sustainability is when the functions and processes of an ecosystem can be maintained (or sustained) while the needs of the present are met without compromising the needs of future generations."(Rainforest Action Network, 1995)

This notion of sustainability has a great deal of importance in the discussion and evaluation of new technologies. There are many new building materials and methods of construction developed each year. What is important to evaluate is not just the performance of these materials and methods, but the impacts these materials/methods have on the environment. The manufacture of new materials can have profound ecological ramifications. Too often these ramifications are not weighed in the overall evaluation of new materials. The example of asbestos insulation comes to mind. We are now faced with finding ways of removing and disposing of a health threatening material used in hundreds, if not thousands, of buildings here in the United States. It is now clear that the costs of manufacture, removal, and disposal (or recycling) of building materials must be taken into account when evaluating building materials. Another cost to consider is the cost involved in developing a sustainable replacement.

Life Cycle Assessment

At this point it is useful to bring up the issue of life-cycle assessment. Life-cycle assessment is a means of applying a "cradle-to-grave" or "cradle-to-cradle" approach to looking at buildings and building materials.(Wilson, 1995) In other words, it is looking at buildings and their components from their origins to the eventual demise and/or the potential reuse of specific components or the building as a whole. How are materials obtained? What types and amounts of pollutants, if any, are given off during manufacture? Are there health concerns during manufacture, installation, use or disposal? What happens at the end of the material's useful life?

It is important to note the difference between life-cycle assessment (LCA) and life-cycle cost analysis (LCCA). "Life-cycle costing applies economic principles for the specific purpose of improving design and management of resource allocation decisions by considering the total long-term costs of facility ownership."(Johnson, 1990) In other words, life-cycle cost analysis allows us to consider purchase, operating, and maintenance costs of a piece of equipment. This enables one to make the choice between several options and potentially justifies the selection of an initially more costly system, such as compact fluorescent lights, over an initially cheaper alternative, such as incandescent lights. The key difference being that LCCA takes into account only traditional economic factors. Brandle (Brandle, 1995) expresses the following concerns:

"1) The prices of nonrenewable resources are low. They do not reflect the real costs, only the production and marketing costs. The costs of depletion are not included.

2) The burden of paying for inefficiencies and waste, mostly as pollution, is often not carried by those who cause it. This is most evident in the difficulties of assigning responsibility for the pollution of air, water, and earth.

3) The dangers from depleting nonrenewable resources and the benefits from using renewable resources for overall society are not well understood by the general public."(Brandle, 1995)

It is apparent that some form of ecological currency is necessary. Some have argued that ecological currency is a part of economic currency. These individuals usually point to the example of gasoline. Currently gasoline prices in the United States hover somewhere around $1 per gallon. In the United Kingdom the cost is over $2 per gallon. In Italy the price is nearly $4 per gallon.1 In his course Energy, Entropy, and the Environment, Rycus argues that as accessible reserves are diminished the cost of oil will increase. This price increase, in turn, is evidence of ecological
currency being a factor of economic currency. However, Rycus is quick to point out that the point at which this price increase begins to affect the general populace's thinking and buying habits can be at a point beyond that of sustainability.

It is evident that some means of translating ecological cost into economic costs at earlier stages may be necessary. However this is not without certain risks. Classical economic theory holds that correct prices are an essential factor for maximizing economic benefits. Some may argue that this may also hold true for prices reflecting the truth about external costs. This does not necessarily hold true at all times. Unforeseen or abrupt changes, even for the better, may cause massive upheavals and economic losses. The painful restructuring of the economies of Eastern Europe are a good example of this.(Dutch Committee for Long-Term environmental Policy, 1994) Great care must be taken in introducing ecological costs at earlier stages of the proposed building materials transition.

One can also see that it is necessary that better systems of accountability for pollution should be devised. Those parties wasting materials should bear the burden of doing so. This burden should also be heavy enough so as to encourage the reduction, if not the elimination, of inefficiencies in material usage.

It is also apparent that the general population should be made aware of the dangers of depleting nonrenewable resources. As the general population in the U.S. elects the officials who control many resource management policies, the education of the general population would aid in obtaining governmental officials who are sensitive to the very same issues.

Another pitfall of conventional life-cycle cost analysis is that it traditionally considers the life of a building to be 20-40 years. There are wood structures all across the United States with ages exceeding 100 years. Within the confines of conventional thinking a building becomes disposable after a 20-40 year lifetime. This is somehow appropriate coming from the land of disposable diapers. This type of thinking cannot exist if sustainable development is to occur. Greater attention must be given towards the adaptive reuse of structures.

In addition to the reuse of structures, Brandle (Brandle, 1995) encourages the exploration of design for recycling. He states, "the concept of recycling must become as much a part of building design as the other concepts of design that we are so familiar with, such as functional integrity and aesthetic appearance."(Brandle, 1995) He points to the work of the German auto manufacturer BMW as an example. BMW is pushing for as near complete recyclability of an automobile as possible. They are literally designing some of their cars for disassembly. Brandle points to the obvious transfer of this type of thinking into building terms. He points to the graduate level design studio he recently conducted as an example of this type of thinking. Students were encouraged to design such structural systems as pre-cast concrete panels with bolt connections to enhance the reusability of these elements. Traditionally these systems are connected by welding or site-cast concrete joints. These types of joints make recyclability very tenuous at best. Brandle also encouraged students to specify components made from recycled wood, automobile tires, and aluminum or steel.(Brandle, 1995)

Life-cycle assessment is clearly necessary. It will develop somewhat differently than traditional life-cycle cost analysis. Though LCA may development differently than LCCA its development is necessary for both sustainable design and for the successful building materials transition proposed by this text.

Conditions and Trends

Over the years building construction methods in the United States have gone through a series of changes. Early methods used timber framing for structural support. Later, brick and stone were used. Then came an interesting system called "balloon framing". This system uses a series of repeated small dimensional structural members. This method has been popular for quite some time. The major application of this building system has been in the arena of housing. It appears that this method of construction became popular for several reasons. First, with increased population the supply of stone and brick materials was too small to meet building needs. Secondly, the new system of building was less economically expensive than the prior systems. However, recently there has been a trend away from this system of building structure. The use of steel and pre-engineered wood structural products seems to be increasing.

It appears that the United States is in a transition of building materials. As mentioned above, one of the options is steel. Another option is pre-engineered wood products, some of which use recycled wood materials. As prime dimensional lumber is used up, there may be an increased use of laminated and recycled wood chip products. The following two graphs show and project the growth of roundwood production and the decline of steel production.

From the two graphs (graph; next graph) one sees a steady decline in steel usage and a steady increase in sawnwood production. This is somewhat different than what is occurring in the architectural world today. Presently, in some markets in the U.S. it is cheaper to use residential scale steel structural members than it is to use wood. This is an alarming trend when put in the total ecological context. Steel is a nonrenewable resource. We should carefully consider how we use this resource. In light of the more environmentally friendly option that engineered wood products offer, the application of steel on the residential market seems a bad move in the long run.

The graphs bear witness to the economic pressures put on the market. With decreasing steel production the demand appears to be low and the price must therefore be low. With the steadily increasing sawnwood production we see an increased demand and an increased price. Current national average prices bear out this line of thinking. As an example, a typical wall assembly consisting of 2x4 stud with 5/8 fire resistant drywall on both sides of the stud costs roughly $2.98 per square foot of the wall assembly. A comparable assembly substituting a 35/8 metal stud for the wood member costs roughly $2.80 per square foot of the wall assembly. However, we should also bear in mind the ecological as well as the economic costs involved.

Building Materials

At this point it may be useful to discuss the definitions of some of the terms that will be used frequently in this paper. First among these terms is "dimensional" lumber. Nearly everyone has heard of a "two-by-four".2 This is a piece of wood with nominal dimensions3 of two inches thickness and four inches width producing a simple rectangular cross section.

The same follows for other pieces of dimensional lumber: 2"x6", 2"x8" and so forth. The largest pieces used in typical house construction are 2"x12". These are used primarily for the support of floors on long spans.

Traditionally, these pieces of wood were cut from the large, old trees of the forest. These trees yielded better quality lumber than smaller, faster growing trees. In addition to quality there is also the factor of quantity. The larger the tree cut for lumber is the greater the dimension of the lumber cut from that tree.

Two-by-four cross section

Glue-laminated timber

Once spans stretch beyond the capacity of a 2"x12" a different type of lumber may be necessary. This type of lumber is the glue laminated timber. This type of lumber is constructed of a series of 1.5" wood laminations.(Wright, 1994)

This type of structural member can be manufactured in a variety of different sizes to fit various spanning conditions. These timbers are manufactured under tightly controlled conditions. Another important type of wood based building product is LVL or Laminated Veneer Lumber. This type of lumber generally consists of a series of thin wood layers affixed to one another with a resin of some sort. The fibers of each layer can be oriented so as to give the structural member the greatest strength. LVL construction is similar to plywood except that the grain of alternate layers is not oriented at right angles to that of adjacent layers.

Laminated Veneer Lumber

This type of lumber can be manufactured in any number of sizes. It can be used similarly to plywood and is an important component in the next type of wood structural member. Again, this type of lumber is manufactured under tightly controlled conditions.

The next type of wood structural member is the wooden I-joist. This element, like LVL is manufactured under rigidly controlled conditions. It consists of two flanges made up of a series of 1/10-inch wood veneers or stress-rated (high quality dimensional) lumber. The other component of I-joists is the web which is commonly made with plywood or oriented strand board (OSB). Oriented strand board is a panel type material made from wood strands that have face wafers oriented in the long direction to provide additional strength in that direction.(Wright, 1994)

OSB/Plywood Web

One may ask why it is important to manufacture the above mentioned elements under tightly controlled conditions. The answer lies in the fact that when these controls are in place, the load bearing capacity of the member can be more precisely determined. This allows for a savings in the amount of wood materials used. With traditional dimensional construction only "mother nature" controls the production of the materials. The load bearing capacity of a member can thus vary significantly from one 2"x4" to the next. This then requires a large margin of safety in the structural design process and leads to a greater degree of overdesign of the structural systems. Clearly this has an environmental impact.

The last structural building element this paper will deal with is the metal (or steel) stud. This is a piece of metal, usually a roughly hollow tube-like construction, that is often used in place of traditional dimensional lumber in wall assemblies. The load bearing capacity of this type of material is even better known than the manufactured wood products mentioned above. Thus these elements can be used with even greater structural efficiencies. This type of material is seen as a significant competitor to wood. Such thinking could have serious repercussions on the environment. In addition to being a nonrenewable resource steel is also a good conductor of heat. The application of steel/metal members in an exterior wall structural system leads to an increased loss of heat through the buildings skin.

Engineered wood products have a few drawbacks. They pose potential off-gassing hazards as well as potential chemical pollution from their manufacture. This leads to potential health and ground water problems. In the past one of the biggest pollution problems was the use of formaldehyde as part of an adhesive in manufactured wood products. The use of this material is being quickly phased out. In fact, some of the newer products use a process or pressing wood scraps under great pressure to form a beam. The pressure and resultant heat release chemicals in the wood scraps that form a binding agent.

Pre-engineered wood products have some potential benefits as well. First, as mentioned above they can be made using recycled wood materials. A quick look at construction site waste is very telling.

Survey of Construction Waste (GBB, 1995)

Concrete	32.9%
Dimen. Wood	15.1%
Roofing	9.6%
Metal	8.8%
Other	8.1%
Cardboard	7.5%
Brick	6.7%
Drywall	6.6%
Pallets	2.6%
Asphalt	0.6%
Plastic	0.5
Plywood	0.5%

Clearly dimensional wood is one of the top contributors to construction waste. It is estimated that as much as 11% of traditional lumber may be thrown away on job sites due to poor quality. When engineered lumber is used that number drops below one 1%.(Wright, 1994) The use of finger jointing this scrap wood, formerly put into landfills or burnt for fuel, into larger pieces is a viable solution to the waste problem that leads to an additional saving of wood.(Loken, Miner, Mumma; 1994)

In addition to the waste at the job site there is waste at the manufacturing site of all wood products. One company, Trus Joist MacMillan, claims that its manufacturing process for engineered wood I-joists converts 43% more of a log into structural lumber than does solid-sawn (dimensional) lumber.(Wright, 1994) Traditional sawmilling converts 40.6% of any given log, by weight, into dimensional lumber. Trus Joist MacMillan says that its process converts 58% of a given log into its TJI/15 joists, in addition to yielding a small amount of plywood.(Wright, 1994) It is apparent that some headway is being made towards the more efficient use of our forests.

Secondly, engineered wood products can provide structural lumber from fast growing, small trees. This would add great value to the smaller diameter trees of second and third growth forests.(Loken, Miner, Mumma; 1994) With a dwindling supply of straight, dimensionally stable heartwood it may be argued that builders will turn, more and more, to other options such as engineered wood and metal products.

Finally, engineered wood products allow for a greater efficiency in structural design. This directly translates into a savings, both in the number of elements used per project versus dimensional lumber and less lumber per element versus dimensional lumber. That means that not only are you using fewer pieces of wood, you are using less wood per piece.

At this point it may be of particular use to look at a series of transitions that affect and interact with the proposed building materials transition. The other transitions examined will be the demographic transition, the forestry transition, and the urbanization transition. Each of these transitions has potential consequences for the building materials transition.

Demographic Transition

Drake (Drake, 1993)characterizes the demographic transition as follows. At the onset of the transition the numbers of births and deaths are high and are in relative equilibrium with each other. During the transition death rates drop dramatically. After a period of time the birth rates begin to fall. If these two rates track on another then growth may be significant, yet manageable.(Drake, 1993) The graph below roughly shows the crude birth and death rates tracking one another. Clearly, the United States is in a period of relative equilibrium following a demographic transition. The U.S. is in a position of manageable population growth and thus has some hope of being able to sustainably manage its natural resources. If the birth and death rates do not track one another there can be a population explosion. The second graph below shows the birth and death rate for Africa. Clearly Africa is in the midst of a demographic transition. Africa has little hope of being able to sustainably manage its natural resources while it is in the grip of a demographic transition.

Crude birth and death rate for the United States

It is important to note that all data in the graphs beyond 1995 is projected.

What impact does this have on the proposed building materials transition in the United States? One obvious relationship is drawn from the population. A greater population size means a greater usage of resources. More specifically, a greater number of buildings are built and thus more steel, concrete, wood, and other materials are used. This puts a direct stress on those resources. With a manageable population, i.e. one that has gone through the demographic transition, there is hope of managing those resources sustainably. A prolonged demographic transition could lead to a collapse/depletion of natural resources. In that situation the population would be growing at a great rate and using an ever increasing amount of natural resources. A population undergoing a demographic transition has very little, if any, hope of managing its resources sustainably in the short term.

Included directly above is a graph showing the demographic transition for the continent of Africa. On the whole the graph shows a wide gap between the crude birth and death rates. This is an indicator of rapid population growth for the continent. The graph is included to show a region undergoing the population transition. Any country, continent, or geographical region at a similar point in the demographic transition would not be in a position favorable to the proposed building materials transition. The population growth pressure would put great pressure on building material resources. People would be looking to obtain whatever building materials they could, as cheaply as they could.

This could potentially slow or even halt a transition towards sustainable building materials.

Forestry Transition

The forestry transition is similar to the demographic transition. At its outset a large percentage of a region is covered with forest. During the transition rapid deforestation occurs. At the end of the transition forest cover stabilizes at a level lower than was previously the case.(Drake, 1993) The graph below shows an increasing gap between the total forest cover and the extent of the natural forest cover. The gap shows that the extent of natural forest cover as a portion of the total forest cover is decreasing. This is significant for two reasons. The first is that the United States is continuing to use up its old growth forests. The second significance of this graph is that there is an attempt being made to replace wood harvested, although the decline of total forest cover is evidence that this replacement is not on a one for one basis.

Total Forest vs. Natural Forest Extent in the United States

With respect to the proposed building materials transition, the forestry transition has several implications. First is the eventual necessity of using faster growing, smaller diameter trees form second and third growth forests. This shift occurs either because of the total depletion of old growth forests or it occurs as a result of conservation efforts. As noted earlier in this text this shift towards the use of smaller, faster growing trees is occurring in the United States. This is evidenced by increases in the use of glue laminated lumber, LVL, and engineered wood I-joists.

Roundwood Production--industrial

The graph above clearly shows the link between increased population and increased demand for roundwood. A shift towards utilization of smaller, faster growth tree species could aid in meeting this demand while slowing or reversing total forest area depletion. This can be an important factor with respect to the environment as a whole. As forest land is depleted, there is more soil erosion. This erosion can lead to ground water contamination and the reduction of arable land. Both of these factors directly affect the lives of the population in terms of drinkable water and the amount of food produced. This can put the population (human, plant and animal) at risk.

What bearing does this have on other countries? Certainly any country at the start of, or midst of, a sustainable building materials transition should look to information about their forestry assets and practices. If large numbers of old growth trees exist the price of products made from these old trees may be smaller than the prices of sustainable materials. In turn, this could slow or halt a transition towards sustainable building materials. Attention must also be paid as to what is being done to replace the trees harvested. Are the species being planted the same as the ones that are harvested? Perhaps faster growing trees are being planted. If the latter is the case it must be made clear that the same building materials are not obtained from the two different types of trees. There is a reduction in size and quality of materials that can be obtained.

Urbanization Transition

As with the above transitions, the urbanization is characterized at the outset by a large rural population and a small urban population. This transition is driven by two factors. The first is the rural to urban migration of the population. The second is the growth of the existing urban population.(Drake, 1993)

Rural vs. Urban Population in the United States

In the later stages of the transition urban population growth declines and potentially reverses itself.

The above graph shows that the United States is in a period following an urbanization transition. Urban population growth may be slowing. With the rapid growth of the suburbs, some may argue that the trend is reversing.

The graph below shows the beginnings of an urbanization transition in Africa. Currently the urban population is increasing at a rate that is beginning to surpass the rural growth rate. Again it should be brought to the readers attention that all post 1995 data in the graphs is projected data. From this projected data it appears that the rural and urban populations of Africa will reach the turning point somewhere near the year 2020.

Rural vs. Urban Population in Africa.

Again, what does this information mean in terms of the proposed building materials transition? As with the demographic transition there are obvious connections between the number of people and the number of dwelling units. This, as before, impacts the natural resources of the region. However, the urban transition is likely to lead to higher population densities. The graph below clearly represents the occurrence of this trend in the United States. Higher densities also usually lead to different building materials. These are traditionally nonrenewable materials. The significance of this is that there is some savings in the amount of materials used for construction in high density construction although those materials may be nonrenewable. Higher density construction means a potentially smaller total exterior building surface area. This not only saves materials, and thus natural resources in the form of building materials, but also allows for a savings in energy usage.

Population Density in the United States

Policy Implications

There are several policy implications fostered by a proposed transition of building materials. First, forest management policies will be impacted. As evidenced in the graph entitled "Total Forest vs. Natural Forest Extent in the United States" which appears in the Forestry Transition section of this text, the amount of total forest cover in the United States is decreasing. Steps must be taken to halt this reduction of forest cover or a transition to sustainable building materials may not be possible. Great care must be used in halting this forest cover reduction. Sandra Postel and John C. Ryan point out that, "When diverse populations of trees are replaced with genetically uniform stands, future timber harvests are put at risk."(Postel & Ryan, 1991) Efforts must be made to maintain biodiversity.

Secondly waste disposal policies must be changed. The cost of disposing of materials in a landfill should carry some weight in the decision of discard materials. An example of this is the formal plan to recycle wastes during the construction of the $262 million Portland Trailblazers' Arena project in Portland, Oregon. All contractors' bid specifications included a section on waste management. With 62% of construction complete, nearly 97% of construction debris was sent to recyclers. This saved and estimated $141,000 in landfill dumping fees.(Building Design and Construction, 1995) The fact that this recycling program was prompted by high dumping fees shows that this type of policy change can be an effective way of channeling ecological costs into economic costs.

Lastly, the general public and governmental bodies must be made aware of the ramifications of their choices of building materials and policies. While this may be difficult, it is a worthwhile endeavor. One need only look at the spiraling national debt of the federal government of the United States to see the consequences of ignoring future costs. That government is facing substantial cuts in its programs of elderly health insurance and student financial aid. The short sighted approach to policy can clearly have drastic, long term repercussions.

Recommendations

1) A transition towards sustainable building materials/methods should be encouraged. This could be the encouraged use of potentially renewable materials such as wood. It could also take the form of adaptive reuse of structures. In addition, it could also take the form of reuse of specific, nonrenewable building components. Certainly this should become a part of the education of every designer and builder.

2) As the earlier discussion of Life-Cycle Assessment suggested, the early merging of ecological and economic costs should be studied and striven for. This has been described by others as a series of phases:

Phase 1: Environmental pollution as a side effect.

Polluters regard environmental problems as a minor irritation for which authorities sometimes make unnecessarily strict regulation. Many of the legal measures are cost-raising emission restrictions(end of pipe approach).

Phase 2: Environmental pollution as a cost factor
Polluters begin to see that it may be beneficial to reduce pollution levels (adaptations at process level).

Phase 3: The environment as a boundary condition
Polluters incorporate the environmental factors when planning new investments, and are thereby forced to produce or consume differently (adaptations at process and product levels).

Phase 4: The environment as a policy-determining factor
The environment factor plays a role for polluters when optimizing their activities, and this leads to different system designs (adaptation at system level).

Phase 5: The environment as an objective
Society incorporates the environment as a logical factor and goal in

social and economic policy. As a result of this, there will be changes in the pattern of production and consumption as well as in the mental attitudes (adaptations at structural level){Dutch Committee for Long-Term Environmental Policy}

Currently the United States is in Phase 2. The example of the Portland Trailblazers project clearly demonstrates that environmental pollution is beginning to be seen as having a cost. This train of thought leads directly to the next recommendation.

3) The cost of dumping materials in landfills should be raised to a level which encourages builders to minimize the amount of materials they dump. Certainly this should go hand in hand with an increased recycling effort to re-use those items that are, at present, thrown away on a construction site.

4) The widespread use of sustainable materials should be encouraged through governmental actions. This could take the form of building design standards that specify the amount of nonrenewable materials that can be used in a building. Several states already mandate the maximum amount of energy a building can use during one year. Similar thinking and legislation could apply to nonrenewable building materials.

5) An effort should be made so that all people, from the business executive to the factory worker, are aware of how their decisions about building materials affect the environment. This may sound like grand, abstract thinking. However, each of us spends countless hours of our lives in buildings of one sort or another. Our use of these structures implies a responsibility for these structures: for their design, use and eventual demolition, recycling, or reuse. We all make decisions regarding our responsibility, whether it be to take an active role in the decision making process or to ignore the decision making process entirely. Those decisions are of vital importance to the continued existence of humankind on the spaceship Earth.

NOTES

1. All dollar amounts are in U.S. dollars.
2. Common designation 2x4.
3. It is important to note the difference between nominal and actual dimensions. For example; a 2x4 has actual dimensions of 1.5x3.5.

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RELATIONSHIPS AMONG PAPERS NOTED BY AUTHORS

Aishton

During the lecture portion of SNR&E 545 the students were exposed to a variety of topics, which included the use of transition dynamics, mathematical applications such as curve fitting and Geographical Information Systems (GIS). The students comprising the class came from several different academic disciplines, most commonly Public Health, Natural Resources & Environment and Urban Planning. Class members had a broad range of interests and expertise about topics relating to many different parts of the world. I understood, conceptually, how these subject areas overlapped, yet to write how the students semester projects were similar seemed nearly impossible. My first impression ascribed to the notion that we were linked through the usage of similar evaluative techniques. Perhaps we also have a connection which relates to policy-making strategies, since we were encouraged to propose policy formation or modification schemes. My initial concept is about the association of material is accurate, but only at a superficial level. To fully understand the correlation between papers there is a need to investigate the underlying structure and purpose which binds the class members at a more fundamental level. demonstrate

Until the official end of the Cold War, signified by the collapse of the Soviet Union and the tearing down of the Berlin Wall the world centered on the concept of nuclear proliferation and the constant threat of mutual, nuclear annihilation from the two Super Powers of the world, the United States and the Soviet Union. During the last 5 years this veil of fear has lifted only to reveal the fact that we are exposed to a threat equal in the magnitude to that of nuclear war but slower in its effect on mankind. The term overshoot means to go beyond limits inadvertently and this definition relates about overshoot on a global scale according to chapter 1 of Beyond the Limits, (Meadows, Meadows & Randers, 1992). Global scale overshoot refers to dynamics among the human population, global economy, resource extraction and the waste produced by these actions. It is possible that human society has overshot and the environment may no longer be sustainable. In either case there is immediate need to initiate remediation strategies. At the root of this remediation is the concept of incremental policy change. This is the fundamental level about which I spoke in the previous paragraph. Although our research papers consider a myriad of topics in various parts of the world they are interconnected just as is the modern world. While the world focused its attention on a potential nuclear showdown world economics, through technological advances in communications, computer applications, transportation, finance and numerous other areas wrapped themselves in a network whereby the world is currently inextricably intertwined. This new world community places huge demands on our global ecosystem. Humans interact with each other and with the environment in which they live. LeChatliers chemical principle states that a vapor system under stress readjusts itself to limit or neutralize this stress.

Our planet is nearing the point whereby it cannot regulate its systems naturally to accommodate its inhabitants. Therefore, people of our world must combine intellectual resources to devise strategies to reduce the stress on the planet and simultaneously allow for continued growth, change and development. According to Beyond the Limits, (Meadows, Meadows & Randers, 1992) population and industrial capital are the driving forces behind exponential growth in the world system. Population and capital draw materials and energy from the earth and return wastes and heat, a normal function of the law of conservation of matter and energy. The exact limits to which we can extract resources is such a complicated dynamic that it is virtually impossible to predict. Evidence from depleted energy supplies, population growth and environmental conditions would suggest, however, that we are approaching those limits and presumably at an increasing rate if, in fact we have not reached that point already (overshoot). It is appropriate to add a principle from Institutions for the Earth (Haas, Keohane, Levy, 1992). The authors stated that non-renewable resources will never be completely used up but renewable resources will be used to their virtual end. They contend that non-renewable resources will be extracted until it is monetarily feasible to extract any longer and presumably there will be a small amount of the resource left. Since renewable resources are simply that then there will be exploitation but most likely at a rate exceeding the natural replenishment, subsequently rendering the renewables, at least for some finite term, virtually extinct.

In order to insure a sustainable human population and sustainable existence on this planet it is necessary to adopt a comprehensive policy which is mutually agreeable and adopted by all the leaders of the world community. As I review the complicated problems currently occurring in the world community the task of establishing a viable policy to insure the survival of the planet appears formidable. The theoretical and practical solution to this problem is evinced in the SNR&E 545 course. The changes which will take place do not originate from one particular office or happen all at once. The type of change required will occur from many different sources and at different administrative, economic, academic, technological and intellectual levels. These changes will occur incrementally. Our class is a microcosm of the world community. We have seen presentations which not only reflect different geographic areas of the world but these presentations also address policy decisions at various levels of the respective intra-governmental or inter-governmental hierarchies which exist in the world today. No one person or country will, alone, be able to solve the serious environmental remediation facing the global community. Fundamental changes in environmental policy must occur. The strategy behind these changes will come from a concerted, world-wide effort. Presently I have an even higher-level understanding of this task. Twenty students conducted research in twenty specific subject areas and each topic delineated specific and serious environmental implications requiring policy changes. When viewed from the perspective of our class the global problems appears insurmountable. However, I believe that an individual can still make a difference in the world. Individual or groups of individuals can identify problems, implement remediation strategies and incrementally influence the movement of a global process. By focusing on one specific problem at a time an individual will not be as apt to be overwhelmed by the enormous task ahead. This is the valuable lesson I have learned from my project and the projects of my colleagues.

Birkelund

The obvious connection between all of the chapters in this volume is population. As the global population continues to rise, the pressures to utilize environmental resources increases. In this respect, the Birkelund Chapter could benefit from following some of the policies advocated in the Cheatham Chapter on reducing fertility rates in India. The forestry transition in Indonesia and Malaysia (Birkelund Chapter) is directly tied to the demographic transitions in these countries. The demographic transition in India is similar to both that of Indonesia and Malaysia. All three countries are still developing and have a long way to go before their demographic transitions are completed. Cheatham proposes a unique solution to reducing fertility rates; increasing the employment opportunities available to women has a significant negative effect on fertility, this implies that private industry has the opportunity to affect positive social change in the course of normal profit-seeking operations. By employing women and creating economic growth, Indonesia and Malaysia could reduce fertility rates. This would help alleviate the problem of landless peasants who follow logging companies into the tropical forests and convert land into agricultural fields.

Deforestation problems are a common link between the Birkelund, Heydir, and OConnell Chapters. Heydir deals specifically with tropical deforestation in Indonesia. His approach focuses on agriculture as the main cause of deforestation while the Birkelund Chapter focuses on trade. However, both papers are interrelated and do recognize that there are numerous factors (a web of causality) contributing to the destruction of forests in this region. The Heydir Chapter gives mention to commercial logging and the Birkelund Chapter states logging practices can be seen in conjunction with agriculture as the first step in permanently removing trees in many of these areas. Both papers recognize the problem of government corruption, the role of population pressures, and the need for new forestry management strategies. The two Chapters differ in their proposals for changing the existing forestry management. Heydir advocates bottom-up (local level) solutions to deforestation while I advocate top-down (domestic and international government) solutions to deforestation. Correcting the problem of deforestation could involve a combination of the two proposals. A more comprehensive approach might combine the bottom-up and top-down solutions to attack deforestation from all levels.

The OConnell Chapter on Costa Rica is an interesting contrast to the problems in Indonesia and Malaysia. Costa Rica has almost passed through its forestry transition and today, Costa Rica is widely regarded as a model for other tropical nations in the area of conservation (OConnell Chapter). Thus, Indonesia and Malaysia could benefit from examining the past successes of Costa Rica in preserving its tropical forests. More precisely, the extensive system of national parks and reserves in Costa Rica could be modeled as part of the solution to deforestation in the countries of Indonesia and Malaysia.

In regards to the trade and environment nexus, there are ties between deforestation in Indonesia/Malaysia; hydropower in Nepal; and aids in Thailand. In all these situations, international demands can provide an incentive to destroy the environment and human health. As seen in the Birkelund chapter, tropical forests are being destroyed for the economic profit of selling timber to foreign countries. In Nepal, one of the primary reasons to build large hydroelectric dams is to trade energy to India in exchange for income. However, this would expose Nepal to numerous environmental risksflooding, landslides, and seismic hazards. Ultimately, Rowe advocates small dams over the large dams. It will be interesting to see how Nepal deals with this issue in the future and how international trade pressures will effect the outcome.

A more tenuous link exists with the Landweber chapter on aids in Thailand. One of the major causes for the rapid spread of aids in this area has been the infamous sex trade. Policy towards prostitution on the national level does not help matters either, since it is intertwined with the booming tourist industry (Landweber Chapter). In this case, the international community could deem aids in Thailand a global problem and provide financial support to help stop the spread of this disease.

As a whole, all of the Chapters deal with population-environment issues that are in some way related to the international community and trade. The nexus between trade, the environment, and population could be further refined by examining trade and the different environmental problems faced in each one of the Chapters presented in this Volume.

Cheatham

I feel that my paper is most closely related to that of Ajay Gupta. In his paper, Ajay presents a clear view of the pressure that the sheer size of Indias population places its on resources and its people. His outline of a number of transitions and current and past government economic policies provides a detailed account of Indias current economic and political environment that is missing from my paper. Although I hope that at least some of my theorizing is generalizable across the developing world, I have chosen to concentrate on India as a case study; unfortunately, in an attempt to be concise, I may have dealt with the characteristics of Indias population in too cursory a manner. Ajays paper compensates for this by describing Indias situation at length, setting up the environment in which my model works. Ajays paper, to a large extent, may be required for those less familiar with India to truly understand the purpose of and the thinking behind my paper.

Similar, also, to my paper is that of Lilly Lombard. Much like my own paper, Lillys is concerned with family planning issues. I feel that Lillys paper works nicely with my own, as they both address exogenous means of increasing the demand for contraceptive technologies. By reviewing cookstove programs as they exist today and discussing their potential to reduce fertility, Lillys paper suggests that private enterprise can effectively reduce birth rates in the developing world. While my paper concerns itself with increasing the opportunity costs of large families by providing more financially beneficial alternatives, Lillys paper considers increasing the temporal efficiency of cooking to free up more time for other tasks as a means to increase the opportunity costs of large families by reducing the benefits associated with large numbers of children. Lillys paper is valuable to mine because it shows that my paper is but one of a broad range of approaches to a single, overriding goal in family planning: Engineering currently low opportunity costs of high fertility so that they might increase to a level at or near the associated costs to society.

Cunningham

The chapter I wrote on the effects of Global Warming on the South Sahel region of West Africa fits in with many of the other chapters in several ways. Most simply, it fits in geographically and helps to flesh out the information available here about Sub-Saharan Africa. Alice Nambalamba, Erin Perry wrote about Uganda, Tanzania, Kenya and Southern Benin. Time and space did not permit us to cover all of the countries or even regions of Africa, but together we provide a good overview of several aspects of the dynamic across the continent, most especially the population transition.

My work fits perhaps especially well with that of Marisa Sifontes. She covers in detail the transitions effecting the fisher people of Southern Benin who are experiencing lower and lower fish catches every year in much the same way as the cultivators of the north of Benin who I investigated are experiencing lower crop yields each year. Not surprisingly, many of the reasons for the decreasing yields of both fish and crops appear to be the same: increasing population placing greater pressure on the available resources, decreasing time allowed for the replenishment of those resources, and a deep desire by both groups of people to remain in their homes and the continue the work that they traditionally do.

My chapter, unlike many of the other chapters on either Africa or other parts of the developing world deals with the effects of an external condition (global warming) on the region. Since many of the people in the developing world live in tightly constrained ecosystems, and are therefore highly influenced by any changes in the environment, an eternality may influence a population in much the same way that any change in the environment does whether it is created elsewhere or caused by the government or other people within the country. In this way, my paper is related to deforestation in Indonesia as described by James Birkelund and dams in Nepal as described by Karen Rowe who explore in detail the effects of environmental changes, or potential changes on people living in highly constrained ecosystems.

Lilly Lombards chapter on improved cook stove potentials in the third world may provide a partial solution to some to some of the environmental

problems described in my own chapter. Micah Cheathams chapter on

fertility in India offers a theoretical model through which to view

overpopulation in many settings and may be applicable to the people of

the South Sahel in many respects. Similarly, Michael Landwebers chapter

on Malaria and AIDS in Thailand offers ideas for improved health care at

the village level which may be applicable to the problems arising in the

epidemiology transition in the South Sahel.

All of the chapters are highly related in that we focused our attention

on policy and ways in which the potential negative trends caused by

transitions could be slowed or reversed. As my chapter points out, in

todays interdependent world, the action or lack of action of the people

of one region can and do highly influence many other regions of the

world. This fact alone is a strong link between all the chapters in the

monograph since the policies enacted in any region are important not just

for that regions people, but for the world.

Frank

Franks work on the population dynamics and urbanization transition is

related to many of the other projects in one form or another. However there are some projects that are more closely related and help to emphasize the complexity of the urban-environment dynamics and urbanization transition; these projects are Perrys Urbanization - Environment Case study of Kenya, Nabalambas comparative urbanization study of Uganda and Tanzania, Torngs study on the effects of the Interstate Highway System on Suburbanization and Guptas study of the economic transition and its implications in India.

In her work Frank studies the different effects of technology on urban shape. It is suggested that there is a link between urban shape and available technology (especially transportation) at the time of urban growth. Two American cities serve as example - El Paso and Boston. El Paso experienced a major growth period post World War II and the introduction of automobile. Urban density is fairly low with 2216 persons/square mile in comparison to other cities of comparable in size such as Boston, MA (11398 persons/sqm) or Seattle, WA (6193 persons/sqm).

El Pasos urbanization pattern traces the paths of the three major Interstate Highways in the area. Torng studied the effects of highway/expressway systems on urbanized area growth. His analysis supports the dependency of land use on transportation system changes and the relationship between transportation and land use respectively. However the modeling results show that there is no single causal relationship between Highway interchange proximity and urbanization of land. The factors leading to urbanization are manifold and their interactions are complex - as suggested by Frank. They seem to change over time in their importance. Torng points out that the spatial correlation of Highway interchange and likelihood of urbanization of adjacent land is decreasing from the 1960-80 model to the 1970-1990 model. Instead the importance of the neighboring effect for predicting future land use changes and urbanization is increasing in the more recent model.

Perry discusses the dilemma of urban-environment dynamics in the case of Kenya, a country at the beginning of the urbanization transition (Pattern B). Urban growth and development often degrades the environment in adjacent rural areas due to an increased demand of high quality produce and food, energy and water. Some research however indicates that urbanization in combination with education for women could successfully reduce fertility and thus reduce population growth. In terms of urban growth pattern Frank is content that urban shape has a major impact on the efficiency of an urban system. Spread out urban areas tend to increase individual transportation and thus pollution. A more compact city shape might help minimize the negative effects on the environment while it maximizes the benefits from urbanization such as reduced fertility. The optimal shape of a city will depend on many variables such as size, level of technology, topography etc. An improved understanding of the optimal shape of cities could help to mitigate or prevent negative environmental effects form rapid urbanization in lesser developed countries (LDCs).

Gupta however cautions that urbanization, decreasing birth rates and decreasing population growth will not necessarily stop pressures on natural resources and the environment. His premise is that affluence will increase consumerism and thus will increase the demand of natural resources, energy and food. So, the carrying capacity of a landscape is defined by culture and the level of technology. Hence urbanization policies must promote efficient energy and resource use in order to reduce overall energy and resource demand offsetting higher demands created by affluence.

Nabalambas work is interesting in respect to devising policies to control or manage urbanization. Despite an anti-urban policy in Tanzania, urbanization continued steadily since liberation of the country. This means that policies hardly can reverse the trend of urbanization. In fact, it seems that the redistribution of funds to rural villages had no long term effects at all. Since little or no money and planning effort went into managing urbanization, living conditions in cities and education have not been improved much. As a consequence, the fertility rates in urban Tanzania have not declined as observed by Perry for Kenya but increased. Thus, influencing urban pattern by policy will be a difficult task. Policies cannot stop natural trends such as urbanization, only modify them in favorable ways. If used intelligently urban land use probably can be managed by providing services at the desired places to attract settlement, for example.

Gupta

My colleagues, in their papers have dealt with many of the same transitions I addressed in my paper on India, focusing, however, on different regions of the world. Reading their papers, I have been struck by the similarity of situations faced by countries throughout the world. Although regions differ, and policy responses also differ, most of the transitions are exacerbated by poverty, inequities and population pressures. A set of papers written by Andrea Frank, Erin Perry, Maureen Cunningham and Alice Nabalamba discuss issues and transitions in different parts of the world very similar to the ones India is undergoing. Urbanization pressures in Kenya and Uganda, for example are very similar to pressures India is facing. Since it can be argued that India is further into its transitions than most African nations the case of India could be used to predict the effects of the transitions Africa is undergoing. Similarly lessons from transitions in developed parts of the world can be applied to India. A potentially exciting topic is the similarity of changes and pressures buffeting both India and Russia, both countries started reforms around the same period in the nineties. However, although reform in Russia seems to be virtually an unregulated free for all, India is proceeding more cautiously. The outcome remains to be seen

Another series of papers deal with transitions which are in a more advanced stage than India is currently undergoing. Papers by Diane OConnell, James Birkelund, Michael Landweber provide a predictive glimpse of how the transitions which have started recently, may turn out. Lessons from these papers can be invaluable policy tools in order to avoid making the same mistakes, or to take advantage of the experiences of other nations.

Finally a third set of papers, notably by Micah Cheatham, Lilly Lombard, Richard Tracy analyze transitions and offer suggestions into methods of alleviating pressures on transitions through resource saving methods, and innovative techniques. Lilly Lombards paper on fuelwood efficiency through improved cookstoves presents a short term solution to alleviating forest degradation which is prevalent in many parts of the world. Micah Cheathams paper on private sector solutions to fertility reduction presents an innovative way that might lead to strategies for decreasing the population growth momentum.

Han

The world is big. It would be ludicrous for any one study to proclaim global authority over any topic. However, it is possible to present a piece to the overall puzzle. This is how both research and the people it effects work. This attempt to link twenty such pieces created by fellow colleagues will undoubtedly reinforce this concept.

Using Transition Theory as a Tool

Transition theory was a major driving force for many of the studies conducted. Each researcher used transitions in slightly different ways, emphasizing that transition theory can be a very flexible method that can adjust to various needs given the proper perspective. Landweber, by studying one epidemiological topic, malaria, with the expressed intention of applying the basic concepts discovered to another topic, AIDS, has somewhat paralleled the intention of this paper, Energy Recovery from Landfill Gas. Similarly, the motive was to study the situation of the United States and extrapolate the information globally. And just as natural gas production was used to approximate the state of infrastructure for distributing natural gas, indirect relationships were also used in Shaffers study of Northern Iroquois origins [a possible late entry not included in this volumeeds.]. In fact, it was perhaps the crucial technique used to study civilizations far removed. There is, naturally, always room for expansion. A few examples of transitions were used in this paper, but they were by no means all inclusive. Savarino used an interesting technique to study the rapidly developing country of India [another possible late entryeds.]. The method of examining transitions of bordering countries to obtain a clearer perspective and to predict transitions in India is a method that may be quite effective when attempting to apply energy recovery technology to various countries of the world. Its a solid method to find information for a particular site when information on that site is sketchy or unreliable.

Looking for a Need

Some of the pool of research topics can be applied to this paper in terms of the particular example transitions used. As was stated, urbanization is a key in determining whether an energy recovery project can be economically sited nearby. In terms of shear growth by numbers, Preston found that urban population in Sikkims East section was in the midst of a positive feedback loop. Therefore, population continued to boom although the boom created scarcer resources. General urbanization trends showing these types of population changes may be used, but two studies in particular, by Frank and Torng, delved into urban morphologies. Torng noted that cities are no longer expanding along the highway corridors, rather they are filling in the gaps equally expanding all around. This centralizes a population even more so within the context of urbanization. A more centralized population is advantageous for energy recovery as a result of the increased amount of waste produced in a more concentrated space. The more the waste, the more the gas that will be produced by its decomposition. The more an urban center is centralized, the less the distance there is to transport the waste to the landfill, and the less the distance there is to transport the energy to the urban center. Frank separated urban morphologies into three categories, each with distinguishing characteristics. These three categories along with the supposition of the effect of automobiles on the urban growth pattern may be applied to probable sites around the world to determine if the urban morphology complements a recovery project. Nabalambas dual study on urbanization and policy in both Tanzania and Uganda provided an example of how policy can have a serious impact on urbanization.

Policy Implementation

The feasibility of energy recovery projects can be immensely influenced by governmental policy with the most profound example being the Section 29 tax break that enables landfills to theoretically recover more than 75% of methane instead of just 50% without it. Birkelund and Shaffer warn us of facets that may incorrectly be overlooked. Birkelund suggests that a ban on Indonesian and Malaysian wood exports is probably not the answer to their deforestation problems, although a study of just the surface of the problem would seem to suggest so. Therefore, seemingly quick and direct answers may not always be the correct course of action.

Shaffers study emphasizes the importance of history to obtain a solid background of the situation and to possibly forecast future trends.

As is the case with the vast majority of the world and the way it works, it is not only important to determine what needs to be implemented but also how it is implemented. Government is not always a constant, exemplified by Aishtons study on Komi, a location recently subjected to tremendous political upheaval. However, if a stable government is achieved, a positive structure must be found. OConnell suggests the organizational structure of Costa Rica as a model for other countries. Costa Ricas hierarchy of regional, national, and local authorities seems to work brilliantly in curbing the countrys deforestation. Landfill construction and operation is, by nature, a local issue, just as the enforcing of anti-deforestation policies is ultimately a local issue. However, policy for both energy recovery and deforestation must be issued

from a larger, federal level with a better general perspective. Other countries may possibly adopt Costa Ricas structure, which would presumably be advantageous to successfully implementing policies affecting landfill energy projects. It is important to note that not all stable governments are capable of implementing stable policies. The case of Lahat, presented by Heydir [not includededs.], highlights a unique problem. A successful landfill energy project insists upon an organized, long term commitment. If the government is essentially controlled by the whim of one individual, such as the case for Lahat, chances of a solid, long term commitment are quite slim.

On the positive side, it is still possible. Even if institutions act in self interest as opposed to public interest, energy recovery will still create a beneficial situation. Tracys study on the use of greener materials in construction had the same inherent obstacle as widespread use of landfill energy. Both attempted to convert to newer technologies. People often view new technologies as risky with a high cost potential. However, Tracys example of the Portland construction showed that greener technologies may cost a bit more up front, but will save money in the long run. It can work as long as the overall picture is taken into account from the beginning. Similarly, landfill energy recovery projects have a more expensive capital cost compared to a total absence of recovery, but the deficit can be more than compensated for in the long run through a positive operational cost when revenue from sale of the gas is included.

Possible Effects of Landfill Energy Recovery Around the World

These twenty papers exemplified a large portion of the globe. Some of the information discovered brought to light situations that may be impacted by a landfill energy recovery project. Both Cheatham and Gupta focused on the country of India, which was one of the example countries in this paper. It was surmised that India is poised for a situation that would encourage energy recovery. Both Cheatham and Gupta reinforce this supposition. If Cheathams economic theory of lowering fertility is successful, overall population growth may be retarded, but urban growth will still climb because women would migrate into the city workforce. In this theory, income for many people would also increase which implies more people would be able to afford a more processed type of energy such as landfill gas. This aspect was expanded upon in Guptas study. He not only hinted on what would shape the urbanization transition in India, but also its impact on energy demand; The urbanization transition in India will be determined primarily by economic and agricultural transitions...Urbanization tends to create more demand for all forms of energy.

Although urbanization is beneficial through the landfill perspective, care must be taken not to let this fact blur the detrimental effects. Everything in this world is in a balance. The possible environmental destruction by urbanization illustrated in Perrys study warns of such consequences. Still, in this case, energy recovery projects can assist in dampening these harmful effects. Perry states that pressure for coal and fuel resources from rural areas will increase due to urbanization. In the U.S., 50% of all landfills are sited in rural areas. Therefore, landfill energy may be used to supplement the solution for this increased energy need. Furthermore, industry tends to grow alongside urbanization. Industry is, far and away, the main user of medium grade BTU fuel, the most cost effective product of landfill gas. Perry also sites growing carbon dioxide emissions as a concern. As has been stated, burning landfill gas greatly reduces CO_2 emissions since the main constituent other than methane is CO_2.

This emphasizes the important issue of global warming, an issue researched by Cunningham with respect to the effects on Africa. She illustrated the detrimental effects on the population, agricultural, and epidemiological transitions. Both main constituents of landfill gas, methane and carbon dioxide, are major players in the greenhouse effect. With 70% of methane emitted by anthropogenic sources, the majority of which emanate from landfills, recovering these gases can have a great effect on global warming.

Rowe described a more localized situation in Nepal. She emphasized Nepals need for energy independence, advising local hydroelectric power over large, national dams. The local electricity could then be used to create light industry, thus decreasing the effect of traditional fuels and farming on the environment. It may be beneficial to explore solid waste as another possible resource Nepal may exploit for its energy needs. Granted, Nepal does not have the technology to implement such a project at this time. However, more industrialized countries, such as the United States, could offer the know-how required for Nepal engineers to develop the technology. These recovery facilities would most likely be small, but large enough to support light industry.

The world is not uniform. Different areas are experiencing different changes at different times. Landfill energy is not the start of the solution to anybodys energy needs, nor is it the final solution. Rather, it is one solution in a serious of steps. Lombards examination of the use of cook stoves as an alternative for open fuel wood consumption is a preliminary step most countries must probably take before converting to more processed forms of energy. However, once this has been accomplished, it may be advantageous to examine in greater detail the transition from using one type of energy source to another. This and a multitude of other research topics must and will be researched in the future. And one more piece may be found and fitted to the puzzle.

Landweber

At first glance, this paper on AIDS and malaria in Thailand does not seem to have a great deal in common with the others in this publication. Although some of them touch on the epidemiological transition, it is rarely more than a passing mention. Also, only one other paper in this monograph deals with the region of Southeast Asia, focusing on the forestry transition in Indonesia. However, beneath the surface, the underlying presumptions of this paper and the others provide an interesting juxtaposition to keep in mind. For most of these papers, population growth is a factor contributing to various problems. However, in the case of epidemiology, the problem at handdiseaseis actually a limiting factor for population. In terms of AIDS, an epidemic of the proportion foreseeable could have devastating effects on the population in many of the countries discussed. While such epidemics are not unavoidable, it is an interesting factor to consider, particularly in regards to the papers in which burgeoning populations are pegged as a major problem. Although it is not desired by anyone, it must be realized that in many of these countries AIDS may end up controlling population to a greater extent than many of these monographs policy recommendations. Specifically, some of the connections to other papers are clearer. Deforestation in Indonesia could help the spread of malaria as people come into contact with previously unknown strains of the disease. Also, the papers on urbanization in India raise important epidemiological issues. As mentioned, disease is a major problem within the squatter colonies in crowded cities. The extensive health infrastructure in Thailand may be taken as an example of how to deal with such epidemiological concerns. Finally, and probably most crucial, many of these papers deal with countries where population issues and AIDS will be

intertwined over the course of the next twenty years. Particularly, in many African countries and India, the epidemic appears to be spreading unchecked. For this reason, it is probably crucial for many of these papers to consider the ramifications of AIDS in their area of study, especially when making any projections about population.

Lombard

Among those students who chose topics related to developing countries, I asked myself two questions while reviewing their research: 1) How would cookstove diffusion projects fare in their regions of interest? and, 2) What about their research furthers my understanding of effective cookstove diffusion in light of broad population-environment dynamics and sectoral transitions? While my answers were as inconclusive as they were varied, this was nevertheless a valuable exercise in looking beyond the narrow confines of my topic.

The South Sahel , for instance, (Maureens focus) suffers indeed from acute fuelwood shortages. Given the poor, agriculturalist population that she describes, it seems unlikely that widespread diffusion of market-produced/consumer-purchased stoves would take place. In Mali, for instance, (as I uncovered during my research) the government last year officially banned the use of three-stone fires in a desperate attempt to lower fuelwood consumption, but has had little success in promoting fuel-efficient stoves. Can cookstove diffusion play a part in the No Regrets policies that Maureen outlines? I believe so, although initially only to wealthier pockets of people. Given the poverty of most governments in this region, here is where international organizations may play a valuable role. They might, for example, test the acceptance of the inexpensive, rurally adapted Maendeleo stove (from Kenya) , modify it to meet local needs, and seek out indigenous artisans to see to production.

As Maureen noted, however, issues such as global warming seem far removed in countries struggling with few resources and more pressing issues of survival. So too, unfortunately, must fuelwood shortages reach unbearable levels before populations of the Sahel are capable of addressing the issue.

Certainly Alices countries of interest, Uganda and Tanzania, with their rapid urban transition, as well as Tanzanias economic liberalization, seem likely candidates for the welcoming of improved cookstovesespecially within their growing urban centers where woodfuel is commercial. In fact,

Kenyan jikos have already been introduced into these countries. Given the cultural similarities of these East African countries, few major modifications may need to be made to stoves disseminated in Tanzania, although areas of higher elevation may need to be adapted for the purpose of heating.

India, the topic of Ajay and Micah, was discussed in my paper at length. Nevertheless, Ajays assessment that structural reformincluding the commercialization of public enterprisesis underway in many parts of the Indian economy, helps explain why India is currently revolutionizing its formerly government-run cookstove program and turning it over to private hands. Micahs argument that diffusion of contraceptive technology in India will not take place until women become wage-earners (so that their opportunity cost for fertility becomes unacceptably high) paralleled my outlook for cookstove diffusion in rural areas. Until womens labor is recognized monetarily, so that the opportunity cost for collecting wood is unacceptable, this technology will not reach many populations that may need it.

Most of the populations in Costa Rica and the Newly-Independent States, with higher income levels than in most developing countries, have already climbed the fuel preference ladder and are now using other forms of fuel with which to cook (for I was not able to identify any cookstove projects in these areas). And Thailand, as mentioned in my paper, is already equipped with its own improved cookstove, the Thai bucket, although I do not know to what extent this stove has been diffused.

Finally, although climatically opposite from the South Sahel, impoverished Nepal shares similar traits in terms of cookstove diffusion. Fuelwood scarcity in select regions is becoming critical, but households are unable to afford the investment of efficient stoves. Worse, Nepalese rely on fuelwood for heating much more than people in the Sahel, making the attractiveness and benefits of cookstoves all the less. As Karen noted, Nepal is still very early in the energy transition, and faces the choice between building a massive national dam, or several smaller regional dams in order to supply the nation with a new form of energy. Since the probability of widespread diffusion of cookstoves in Nepal seems so unlikely, I agree that small dams that can provide household energy, may be the best solution for this country.

Cookstove projects, clearly, are not appropriate for all the developing countries that my peers have studiedeven those countries suffering from significant fuelwood deficit. Improved cookstoves may be tossed into the bag of policy options available to help regions progress through transitions of energy, urbanization, and perhaps deforestation. But they should be swiftly expelled if there does not appear to be a significant population eager to diffuse and employ them.

Nabalamba

The various papers presented had one inherent elementthat there is a direct relationship between people the environment they live in and that environmental resources that sustain people were depleting at a rate faster than they could reasonably be replaced. A considerable number of papers were prepared on Developing countries or newly industrializing nations, an indication that these countries were experiencing far greater danger of environmental depletion than their Western/industrialized counterparts. The various population and environmental transitions discussedforestry, epidemiology, economic, water resources, agriculture, and urbanization indicate a very complex world we live in. These papers also showed that, regardless of size, the greatest danger that Developing nations were faced with was manageability of environmental resources and changes. Many economies examined have limited resources and far too many other priorities to restrain environmental degradation. In addition, the majority of Developing societies discussed are only recently beginning the democratization transition such that the people whose lives are affected by environmental degradation/changes have had little no effect on policy formulation that would reverse trends or that have had positive effects in the more democratic societies. The papers on Forestry transition in Indonesia and Waste Landfills in the United States are a case in point two comparable examples of the significance of liberalized political systems on environmental protection.

My paper which examined political choices made by two African governmentsUganda and Tanzaniaand the effects of these choices on population and environment dynamics appropriately provides the linkage between the developing and developed country cases presented. The developing country focused papers all directly or indirectly identify the state as the principle actor involved with decision making and thus have directed policy recommendations to this entity. Policy recommendations have ranged from a request for a change in forestry management in Indonesia to include the people whose lives are affected by environmental shifts in the decision making process to an appeal to the international donor community in order to reverse deforestation in Costa

Rica. These are the same issues I highlight in my paper as well.

The exercise was intended to be data intensive and thus in an effort to

make sense of a complex situation, all papers examined important

demographic variablesbirth rates, death rates, population growth ratesand

linked them to the changing environment in the various world regions.

Most papers concluded that population numbers more than economic growth

had the most adverse effects on the natural environment.

OConnell

Transition theory provides a model to describe changes in sectors, such

as the agricultural, industrial, urbanization, energy, forestry, and

epidemiological sectors, over time. The most challenging part of a

transition is when the rate of change is exceptionally fast, and the

society must adapt immediately to these changes. Since all societies

experience change in one or more sectors, transition theory can be

applied to any society. The papers presented in this monograph

examine transitional changes in many sectors, and for both developed and

developing societies. Sectors analyzed include demographic,

epidemiological, toxicity, urbanization, forestry, agricultural, and

energy sectors for societies located in South Asia, Southeast Asia, Latin

America, Europe, Africa and North America. Despite the apparent variability in the papers that follow, several common themes can be found.

The papers can be categorized by either geographic similarity or sector analyzed. Six papers focus on the Indian subcontinent, including Nepal, India, and the State of Sikkim. Four papers look at transitions in the African countries of Benin, Kenya, Uganda, and Tanzania. The Southeast Asian countries of Thailand, Malaysia, and Indonesia are described in three papers. Three papers examine sectors in North America. The Republic of Komi and Costa Rica are each the focus of one paper. Many different sectors are covered in the monograph papers. Urbanization transition is the model applied to papers covering the growth of urban areas in Oklahoma City, policy impact on urbanization in both Uganda and Tanzania, urbanization trends in Kenya, and changes in global urbanization trends. The forestry transition is the focus of papers on Sikkim, Costa Rica, Indonesia, Malaysia, and India. The epidemiological transition is applied to both Republic of Komi and Thailand. One paper examines the energy transition for the United States. All of the papers incorporate some aspect of the demographic transition in the analysis. All of the countries, except the United States and Komi Republic, are in

Stage 2 of the Demographic Transition Model, which is the fastest growing

stage. Rapidly growing populations often magnify the problems associated

with rapid change in many sectors.

All of the papers examine the relationship between human societies and

the environment. This is a very complex and dynamic relationship, and is

difficult to simplify for the purposes of analysis. A further

complication is that many societies go through several transitions at one

time, which makes it more difficult to analyze the effects of one

transition, and make appropriate recommendations for that society. The

Republic of Komi is currently going through both the epidemiological and

toxicity transition. Nepal is experiencing rapid change in the

agricultural, forestry, and energy sectors. India is going through

multiple transitions, including the forestry, agricultural, and energy

transitions. Costa Rica has completed the forestry transition, but is

experiencing rapid change in the energy, agricultural, and toxicity

sectors. Sustainable building materials are directly related to the

demographic, forestry, and urbanization transitions. The Sahel is going

through the agricultural, epidemiological, and demographic transitions.

Societies experience multiple sectors at once, which makes it difficult

to implement policy measures that adequately address the problems associated with rapid change.

The outcome of rapid change depends upon the way the society chooses to manage change in any sector. Public policy can mitigate the negative impacts of rapid change, if policy measures are quickly and effectively implemented. The governments of Costa Rica and Thailand responded with public policy measures to ease the crisis in the forestry and epidemiological transitions, respectively. However, both of these countries may enter into a second transition; Costa Rica may see deforestation of protected forests if the population continues to grow and stresses related to deforestation increase, and Thailand may enter into a second epidemiological transition because of the current spread of HIV infection. These national governments must be constantly alert to any changes in sectors, and develop a new response plan. However, some countries, such as India, Indonesia, Benin, have not yet developed and implemented appropriate policy measures to address problems associated with transitions. The environmental, economic, and social problems may be enhanced if policy measures do not address problems related to rapid change. Some papers recommend a local solution to environmental and social problems resulting from transitions, such as bottom-up management in Indonesia, biome-related policy in Republic of Komi, and watershed management in Costa Rica. All of the papers include policy recommendations; however, the challenge is create policy recommendations with the paucity of data available.

Many papers recognize the increasing importance of global factors in the analysis of transitions for a country or region. Global demand for tropical wood and other products has a direct impact on the loss of forests in Indonesia, Malaysia, India, and Costa Rica. Many developing countries, such as India and Costa Rica, suffer from a massive external debt. The pressure to service this debt plays a key role in economic choices made in the country. The International Monetary Fund and the World Bank initiated a structural adjustment program for nations with poor economic performance. Costa Rica, Uganda, and Tanzania are among those countries that must make significant changes in their national governments under the structural adjustment program. National policy measures can be instrumental in mitigating the harmful effects of rapid change; however, all nations must recognize the powerful role of the international community. Implementing policy on an international scale may be the ultimate challenge for the worlds nations.

Transition theory is a powerful tool that can be used to analyze sectors that are experiencing rapid change. This information provides decision-makers with important feedback about areas in the society that may benefit from public policy measures. The papers in this monograph describe transitions for many different geographic locations, and yet there are similarities among the topics. Human populations have a dramatic impact on the environment, and the demographic transition plays a key role in all of the papers. Every paper presents policy recommendations designed to mitigate the potentially harmful impacts associated with rapid change, and most papers must make these recommendations without adequate data. Often, countries need to think beyond their borders when addressing social, economic, and environmental problems. The world is increasingly moving towards a global village, and impacts associated with some transitions may require an international rather than a national solution. Longitudinal analysis of multiple sectors completes a picture of what is occurring in the society and where potential problems may be found. Decision makers can be guided by this analysis, and develop and implement policy measures directed to sectors experiencing rapid change.

Preston

Despite the wide array of research topics, there is a surprising amount of overlap and interrelationships among them. Each of us has used Dr. Drakes transition theory as the basis of our hypotheses. Using this as a fundamental tool to show change over time we have been able to analyze population and environment changes in other countries and our own. The focus has been on using this tool as a way to develop more effective policies. Only by looking at a phenomenon over time can policy makers even attempt to make predictions about the future. Such an approach, however, is often not used when policies are needed immediately to deal with a specific problem.

My project was particularly relevant to those projects that either deal with South and Southeast Asia or those projects that deal with deforestation. The combination of these two aspects include a variety of research projects. Karen Rowes paper deals with a very similar mountainous environment and therefore involves similar variables and factors. She has focused on rivers and hydropower dams while I have focused on trees and deforestation. However, her research is entirely applicable to all the issues in Sikkim. In fact, a large dam project was recently rejected in Sikkim because of many of the factors outlined in Karens paper.

Lillys project is also very relevant in that she deals with a potential solution to the deforestation dilemmathe use of cook stoves. Policy makers in Sikkim could greatly benefit by the information obtained in her

study.

Another relevant project is the one on forestry issues in Southeast Asia by James. He looks at deforestation from an entirely different perspective, yet one which may be very relevant to policy makers in Sikkim because Sikkim has discussed harvesting its timber if it can find the appropriate technology to do so given its mountainous terrain. Ajays project, although not directly related to forestry, is also of particular importance because it would be beneficial for Sikkim to conduct a similar economic analysis at some point. Being part of India, I am sure that Sikkim has very similar statistics to those that Ajay presented.

There are plenty of other projects which, although they do not deal with forestry or South Asia are very related. Maureens project on global warming probably applies to all of our research since global warming is occurring all over the world and the actual effects of this are still largely unknown. In developing environmental policies in the future, global warming will have to be considered as an important factor. Even the two papers on urbanization in Africa are very related to Sikkims

situation because urbanization has been a major threat to deforestation in Sikkim. Similarly, the research on diseases and epidemiology is applicable to Sikkim in the same way that it would be relevant to almost any developing nation who does not have high quality health facilities. Since all the research projects discussed the relationship between human populations and environmental conditions, each one provides valuable insight into the dilemmas facing our future generations. The population - environment nexus is finally receiving the attention and study that it deserves by academics. However, although some of the relationships are being established, most of the complexity of population environment issues are still largely unknown and debated. Thus, by using a variety of research endeavors, such as is presented in this document, researchers will continue to put the pieces together and not only understand the population-environment problems, but also work toward interdisciplinary solutions to these problems.

Rowe

In examining Nepals potential for exploiting its one renewable energy source - hydropower, it was necessary to examine conditions in other relevant sectors such as agriculture, forestry, and energy. It was also important to understand Nepals demographic situation. A number of other papers in this class have also examined the demographic situation and have used the information to illustrate its importance in the population-environment dynamic. Nepals poor demographic situation, characterized by high population growth rates and high total fertility rates (TFR), can be compared to those in other developing countries such as Kenya, Uganda, and India, discussed by Perry, Nabalamba, and Gupta and Savarino respectively. These countries too, are looking for interventions to slow the population growth rate and TFR so that the population total does not continue to grow at exponential rates. The population pressures found in these countries has caused an increase in poverty and environmental degradation. In addition such poor demographic situations have made it difficult for these countries to complete successful transitions in other sectors. In contrast, Heydir highlights the benefits of a strong Family Planning program in Indonesia that have been effective in lowering the TFR and overall population growth rate. Three additional papers in particular can be directly related to Nepals situation. First Lombard discusses the importance of fuel-efficient cook stoves and she argues that they not only benefit the environment by decreasing deforestation, but may also trigger a positive feedback loop of lowering population growth and lowered prevalence of poverty. This is certainly relevant to Nepals situation where deforestation rates are high and there continues to be an overexploitation of forest products. While the government debates over other energy alternatives, the people in

Nepal would benefit immensely by using their fuelwood in a more efficient

manner. In fact, mud made cook stoves are now being promoted in Nepal.

Lombard also provided a rationale for the importance of targeting womens

groups in initiating these projects, and Nepal is currently making this

effort, as a number of NGOs have been involved with small smokeless stove

projects in the rural areas. Nepal too, will benefit by using more

energy efficient stoves that also reduce the amount of open fire and

smoke in the kitchens. Again as Lombard points out, there are a number

of health risks, such as reducing respiratory diseases and reducing

burns in children, that make the idea of promoting these stoves even more

appealing.

A second area directly related to Nepal is the forestry situation in

Sikkim, India. Preston investigates deforestation in Sikkim and clearly

points out that causes for deforestation are directly linked to increased

population growth, increased tourism and additional factors. The

situation is very similar in Nepal as both population growth and

increased tourism are contributing factors to the deforestation occurring there. Her analysis and conclusion to implement a more comprehensive forestry policy to account for such factors would also prove beneficial to Nepal.

Finally, Guptas examination of the current situation in India can be both compared and contrasted to Nepals situation across sectors. Gupta asserts that India still has a significant number of people working in the agricultural sector. Yet he explains that the country is aiming to shift workers from less productive rural farmers to more productive urban jobs. He acknowledges that there is debate over the feasibility of accomplishing this without worsening conditions. This government action of shifting workers points out the fact that India is striving to industrialize and urbanize at a much faster pace than Nepal. Also Savarino, in her paper addressing forestry and agriculture in India, acknowledges that India has expressed a definite need for better irrigation to improve the agricultural productivity. These facts; Indias desire for major irrigation schemes, and high commercial energy needs due to its fast increasing urbanization and industrialization, cause it, like Nepal, to consider large dam projects as an alternative to meet the countrys demands and needs.

Torng

In this section, I explore the connections between my own work, A Spatial Perspective of the Interstate Highway Systems Effects on Suburbanization, and other colleagues works. But first, I wish to define my work as a study which examines a small part (both in space and time dimensions) of the whole population environment dynamic system in a little greater detail. In this class, Africa and many other third world countries seem to be the most popular case study areas for issues of transitional dynamics. In many respects, these developing or underdeveloped third world countries and areas are currently following the steps which the U.S. went through several decades ago. In terms of urban-rural population migration dynamics which is the major focus of my work, many of these countries, such as India (discussed by Ajay and Theresa), Benin (discussed by Marisa), Kenya (discussed by Erin), Nepal (discussed by Karen), and areas, such as South Sahel region (discussed by Maureen), are experiencing large scaled population in-migration into urban areas because of significant population and environment transitions. People move toward urban areas for better economic opportunities and quality of life. In the U.S., several major cities, such as Detroit, have been facing intensive population out-migration (suburbanization) phenomenon over recent decades. This is hitting the local government with various kinds of social problems, e.g., unemployment, crime, etc. If no major policy adjustment is made, I foresee that these third world countries future urban-rural transition patterns will be somewhat similar to the ones which U.S. had experienced. As a population transition pioneer, the U.S.s and other developed countries experience is a very valuable reference source for those countries approaching the transition stages. Being a world community leader, it is important for the U.S. to conduct research regarding we learned from the past experience. Then we can make this knowledge and information available to other countries in the world.

Finally, in terms of individual papers, I think my paper is very well connected to Andreas work about population dynamics and urban growth patterns. In her paper, many direct (e.g., infrastructure, topology, and climate) and indirect (e.g., culture and income) factors are identified as having potential influences on urban forms. I regard her paper as an overview of the general trend of population dynamics and urban growth patterns in the world. Each relationship, as identified in the figure Influences on Urban Forms in Andreas paper, is a single research topic for further investigation. My work can then be defined as a more detailed discussion of a small part of her analysis. That is, the relationship between transportation systems and urban form. As a matter of fact, one of my future research suggestions is how to three-dimensionally expand the scope of this study to examine more identified influential factors (1st dimension, factors), regions (2nd dimension, space), and study time period (3rd dimension, time), in order to conclude the research with more clear transition patterns, which hopefully can help other countries in their population and urban development policy making.

Tracy

The research of my paper links to the work of others in the form of two groups. My research links fairly well with the research of the following individuals: James Birkelund, Lynelle Preston, and Diane OConnell,. My research also has some links to the work of Andrea Frank, Karen Rowe, Lilly Lombard, and Erin Perry.

The first groups research deals primarily with forestry practices and deforestation. There are several obvious links. The first is to OConnells work. Her research focuses on the forestry practices of Costa Rica. In her paper she clearly demonstrates the dwindling supply of old growth trees in Costa Rica. Certainly if the technology can be obtained by Costa Rica they should implement the manufacture of some of the wood products I recommend in my paper. The same can be said of the work of Birkelund and Preston.

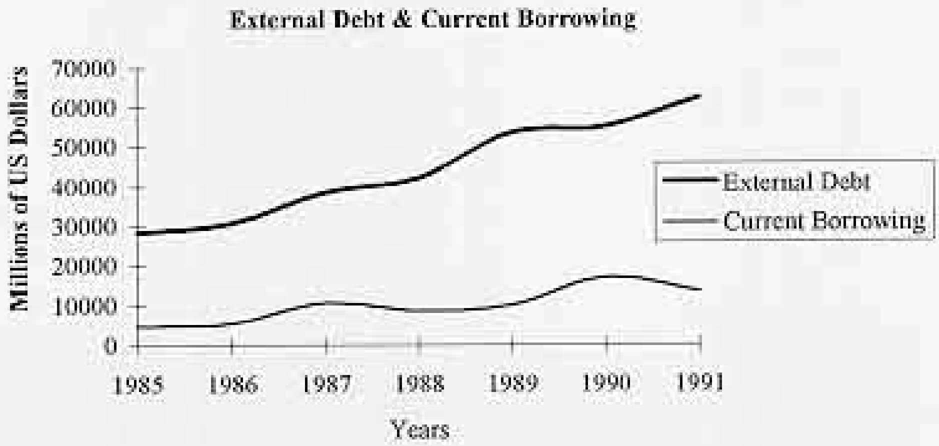
Another connection is that if the developed countries of the world would implement the strategies I recommend, there would be less of a demand for the timber of Indonesia, Malaysia, and Costa Rica. While this may have severe economic repercussions for these countries, it could go a long way toward helping those countries preserve a large portion of their biodiversity.

Yet another link is in the trend towards urbanization. As I state in my paper this trend usually increases density and therefore increases the efficiency of building resources. However, this increased efficiency may apply to predominantly nonrenewable resources. In turn this has implications for the sustainability of such practices and pollution from such practices.

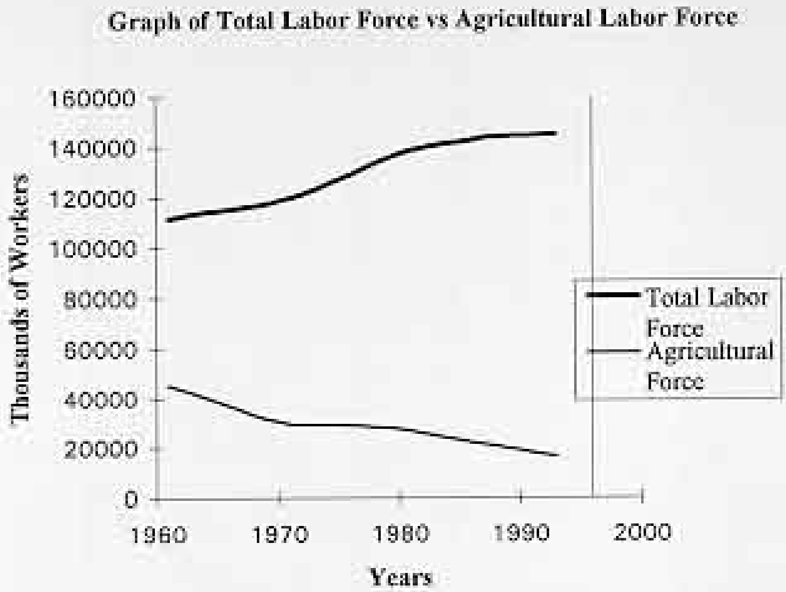
The second group's research research is a little more wide spread and the connections are a little more indirect. Frank writes about population dynamics with respect to urban growth. Perry writes about urbanization and the environment in Kenya. In my paper I point out the implications of urban growth on the sustainable building material transition. The papers of Frank and Perry serve as examples of how other transitions affect the urbanization transition. This in turn helps to validate the connections of transitions I make in my paper.

Rowe touches on the topic of Hydropower in Nepal. As she points out the construction of hydroelectric projects has profound implications on the neighboring environment. Certainly the decision to build a hydroelectric project should have impact upon a government's forestry policies.

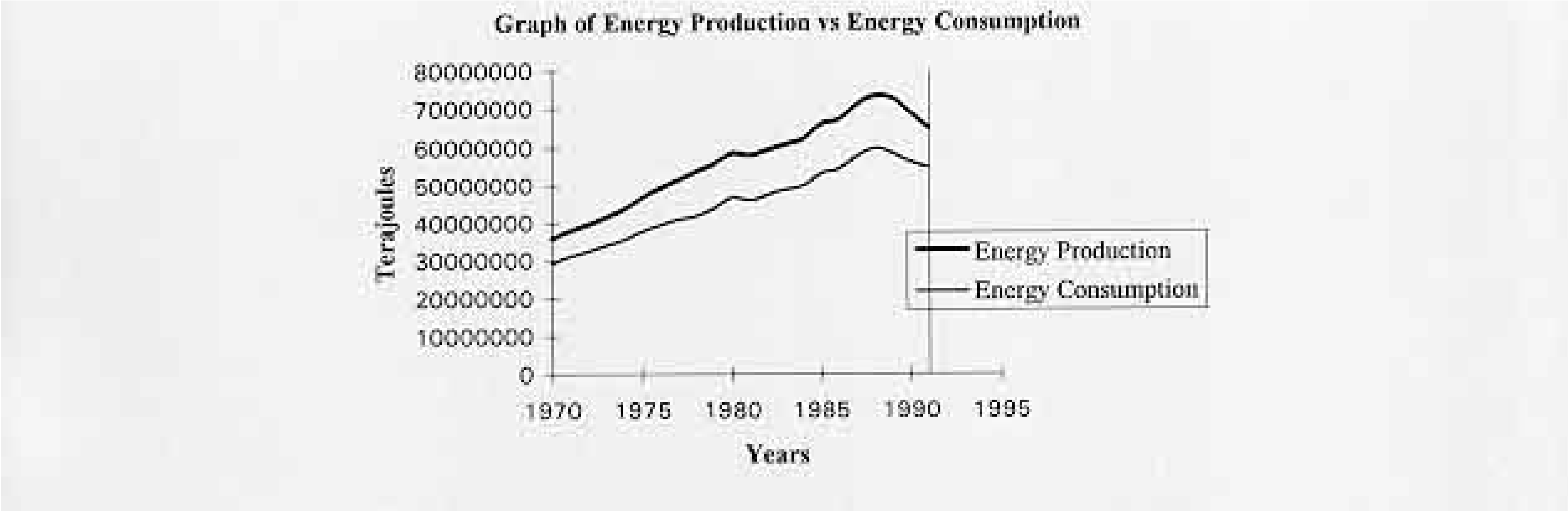
Lastly, Lombard's paper deals with the topics of improved cook stoves, women's education, a fertility in developing countries. Lombard clearly makes a case for improved cook stoves on the basis of reducing cooking time. Clearly the productivity of women is increased. This allows those women to increase their economic potential and thus helps lower fertility. The link with my paper is that these stoves increase the efficiency of the use of wood resources.



(Information taken from the World Resource Database - WRD) Figure #1



(Information taken from the World Resource Database - WRD) Figure #2


Graph of Energy Production vs Energy Consumption
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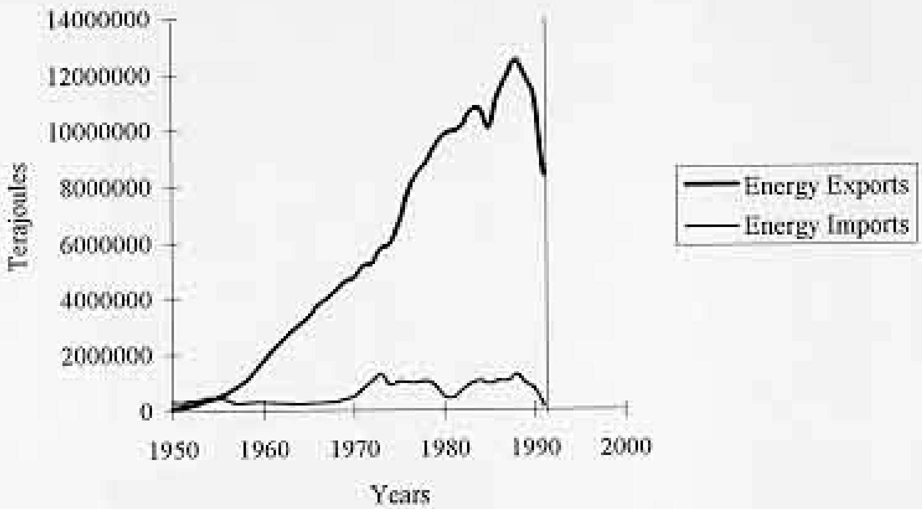
Energy Exports and Imports



(Information taken from the World Resource Database - WRD) Figure #4

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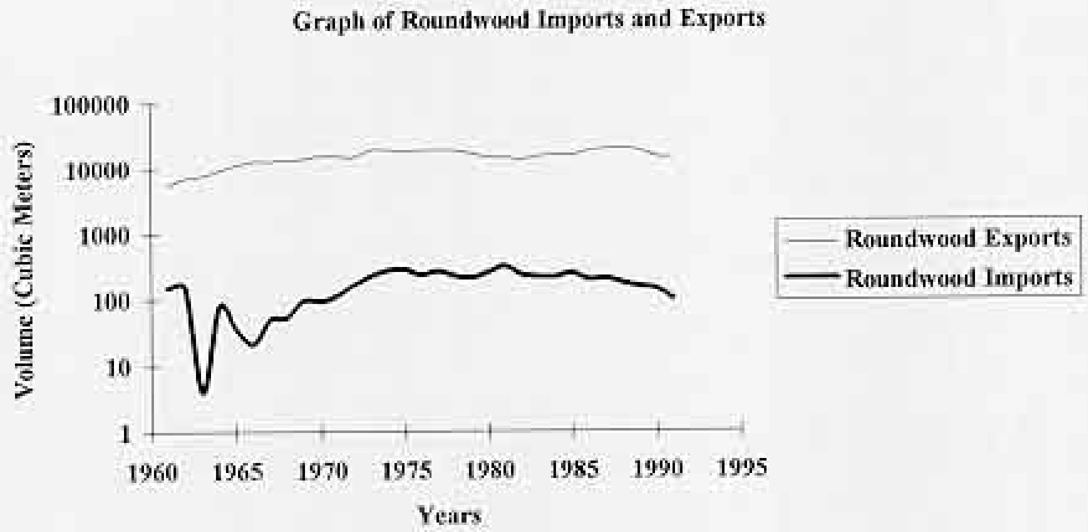
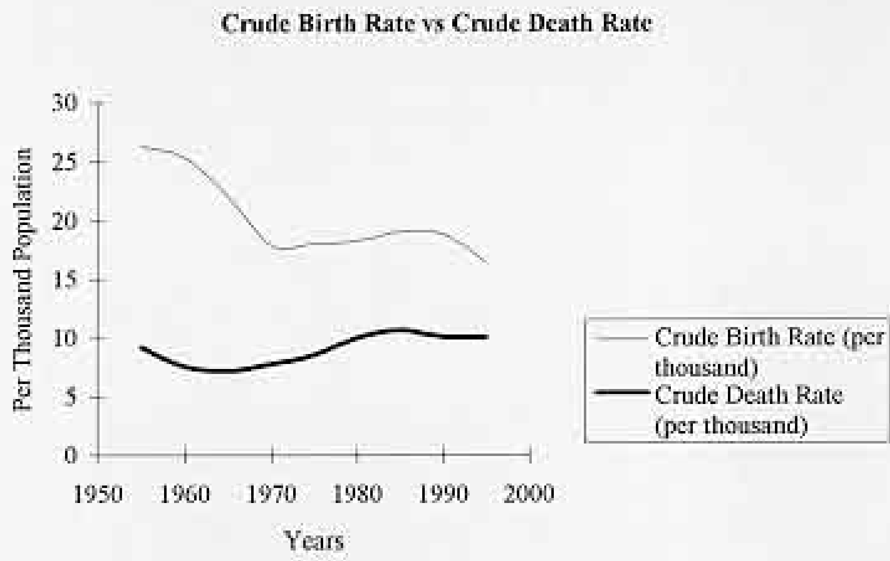
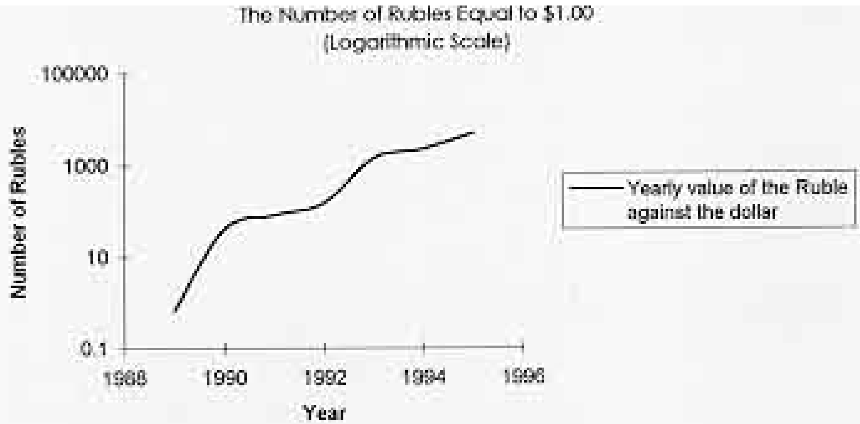


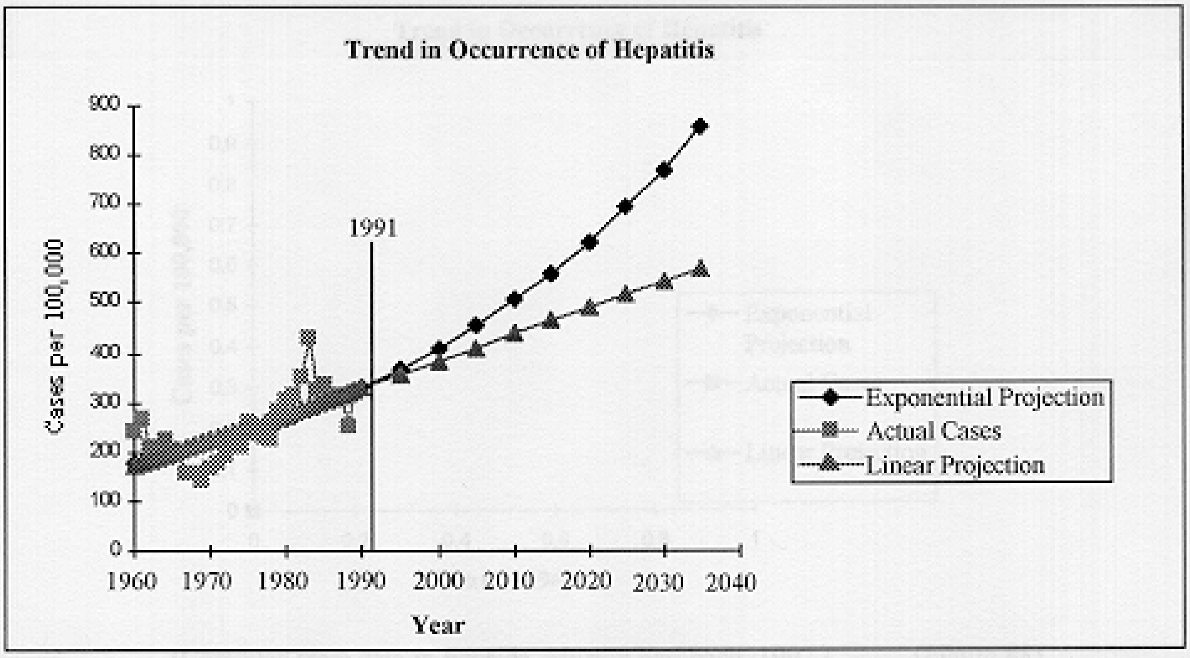
(Information taken from the World Resource Database - WRD) Figure #5



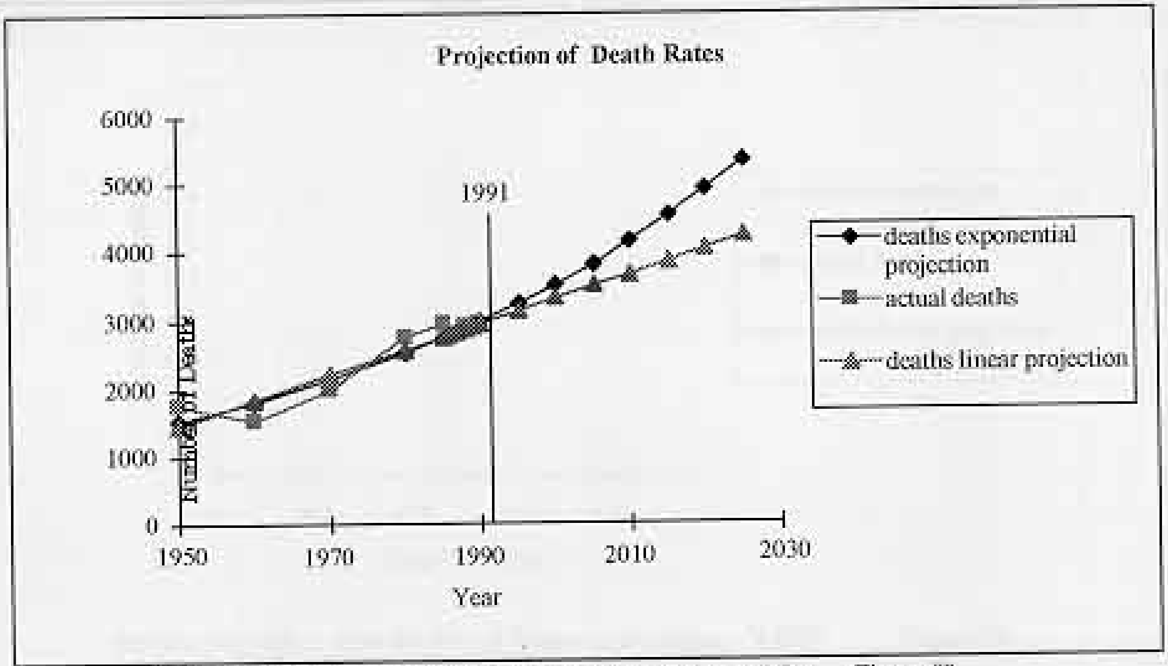
(Information taken from the World Resource Database - WRD) Figure #6



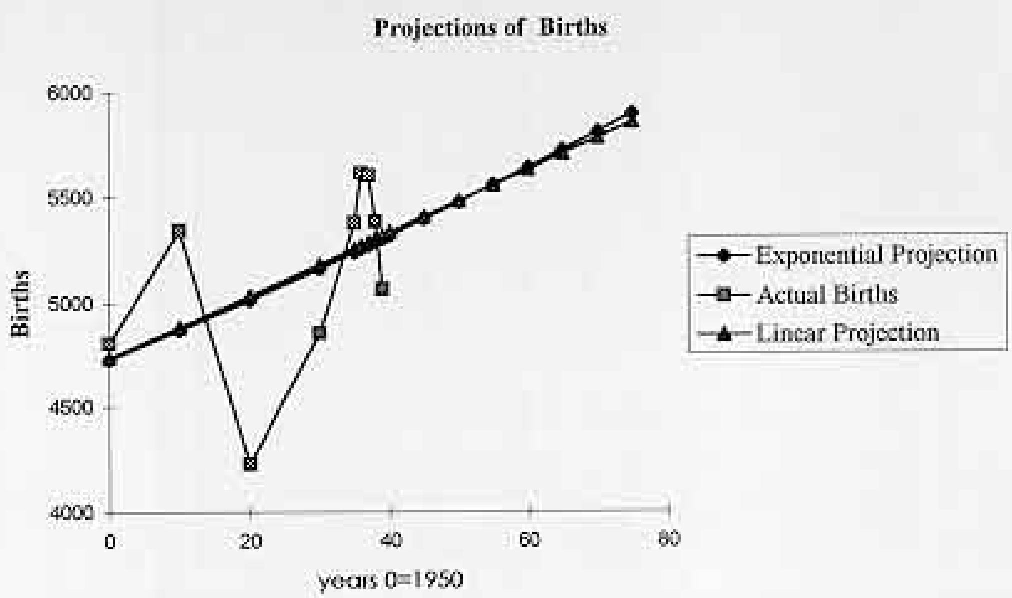
(Compiled from yearly trips to Russia by the Richard W. Aishton) Figure #7



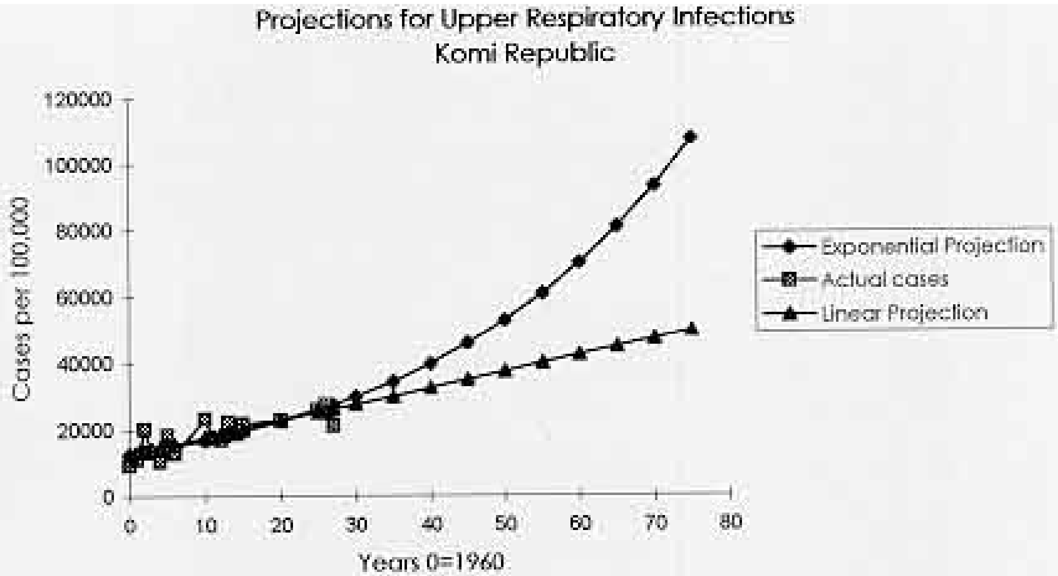
(Compiled from data in Ecocide, Murray Feshbach, 1992.) (Figure #8)



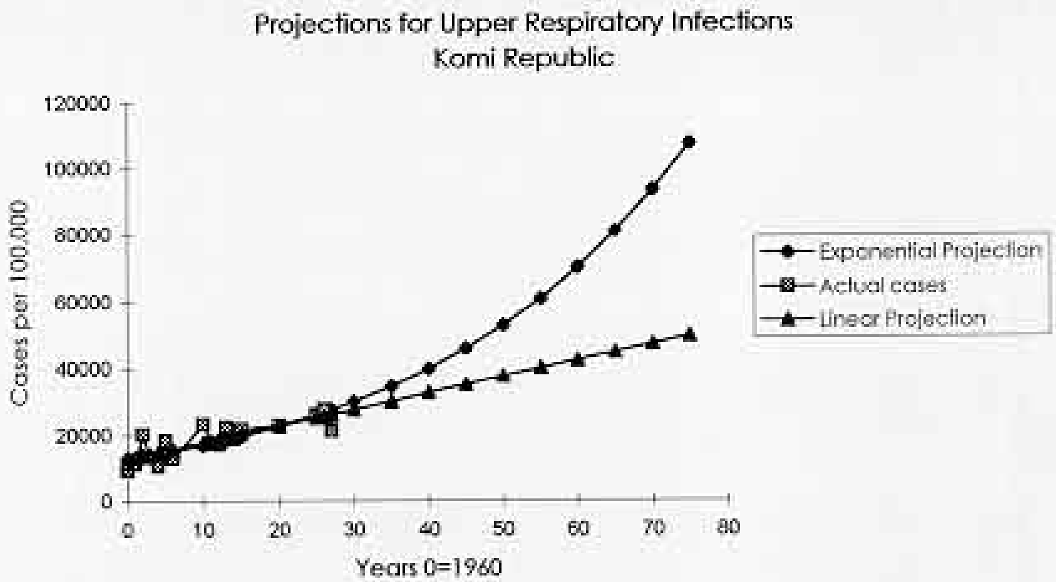
(Information taken from the World Resource Database - WRD) Figure #9



(Information taken from the World Resource Database - WRD) Figure #10



(Information from the Komi Government - Tentakov, 1995) Figure #11



(Information from the Komi Government - Tentakov, 1995) Figure #12

Map #1

Map #2

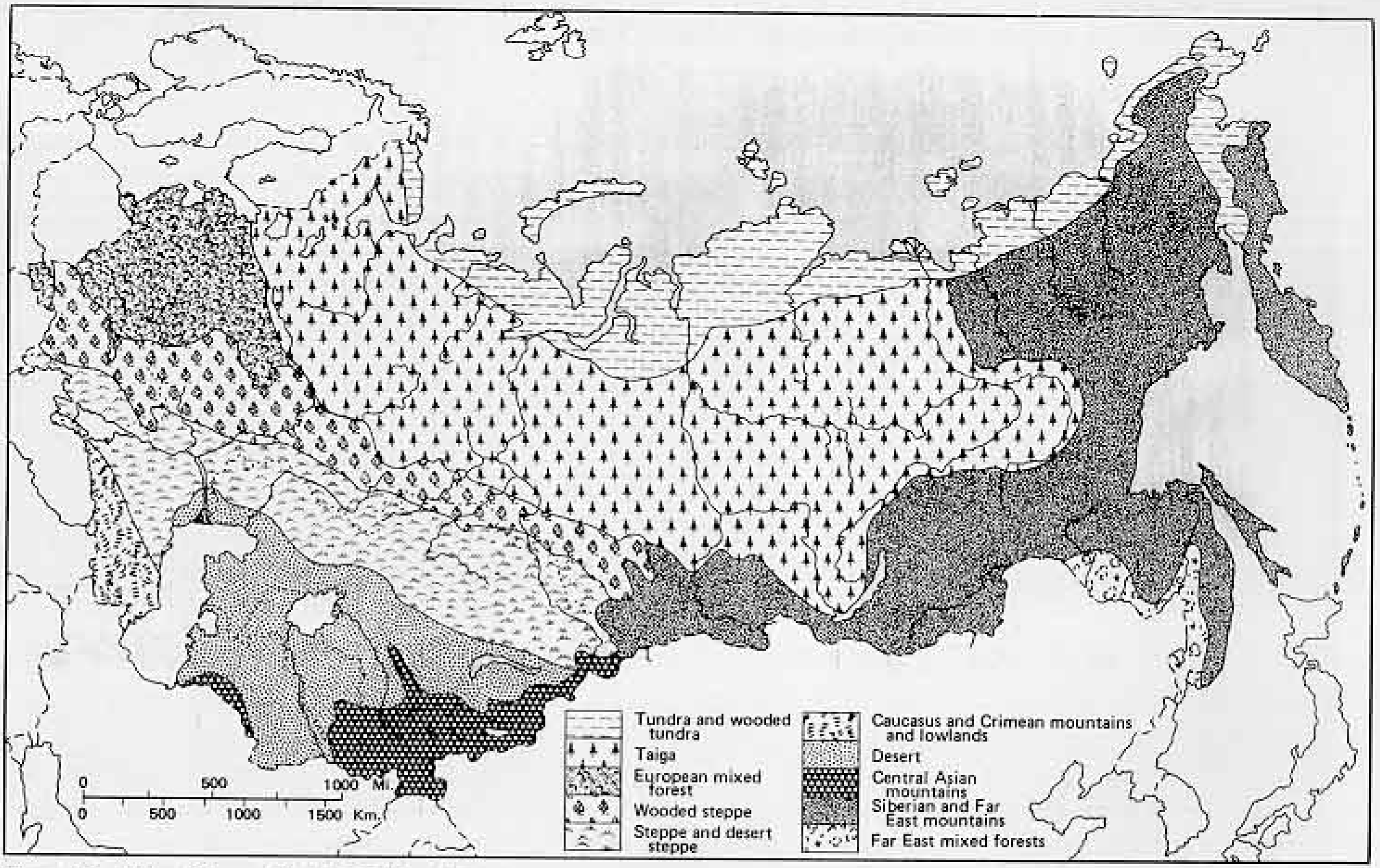
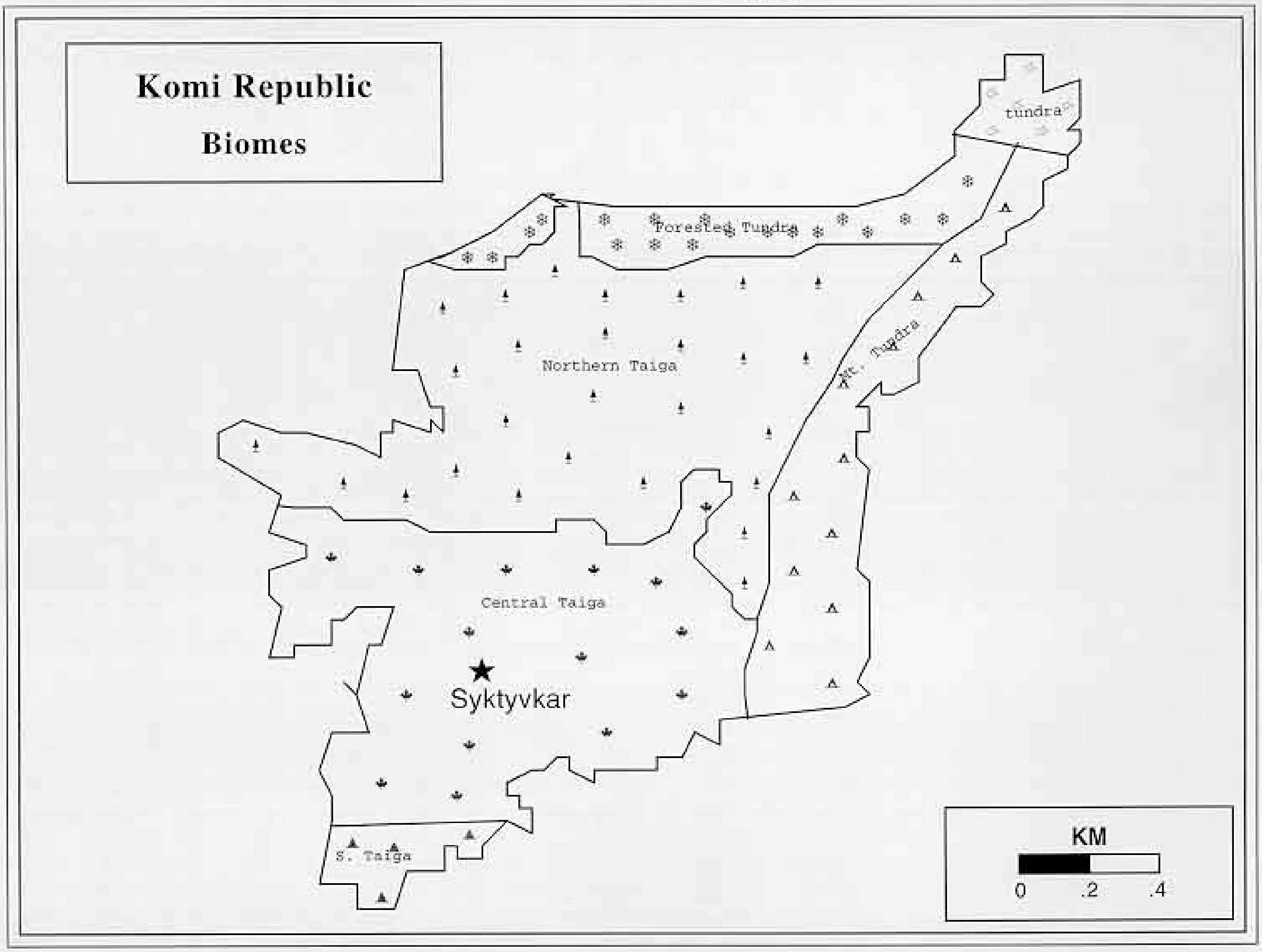
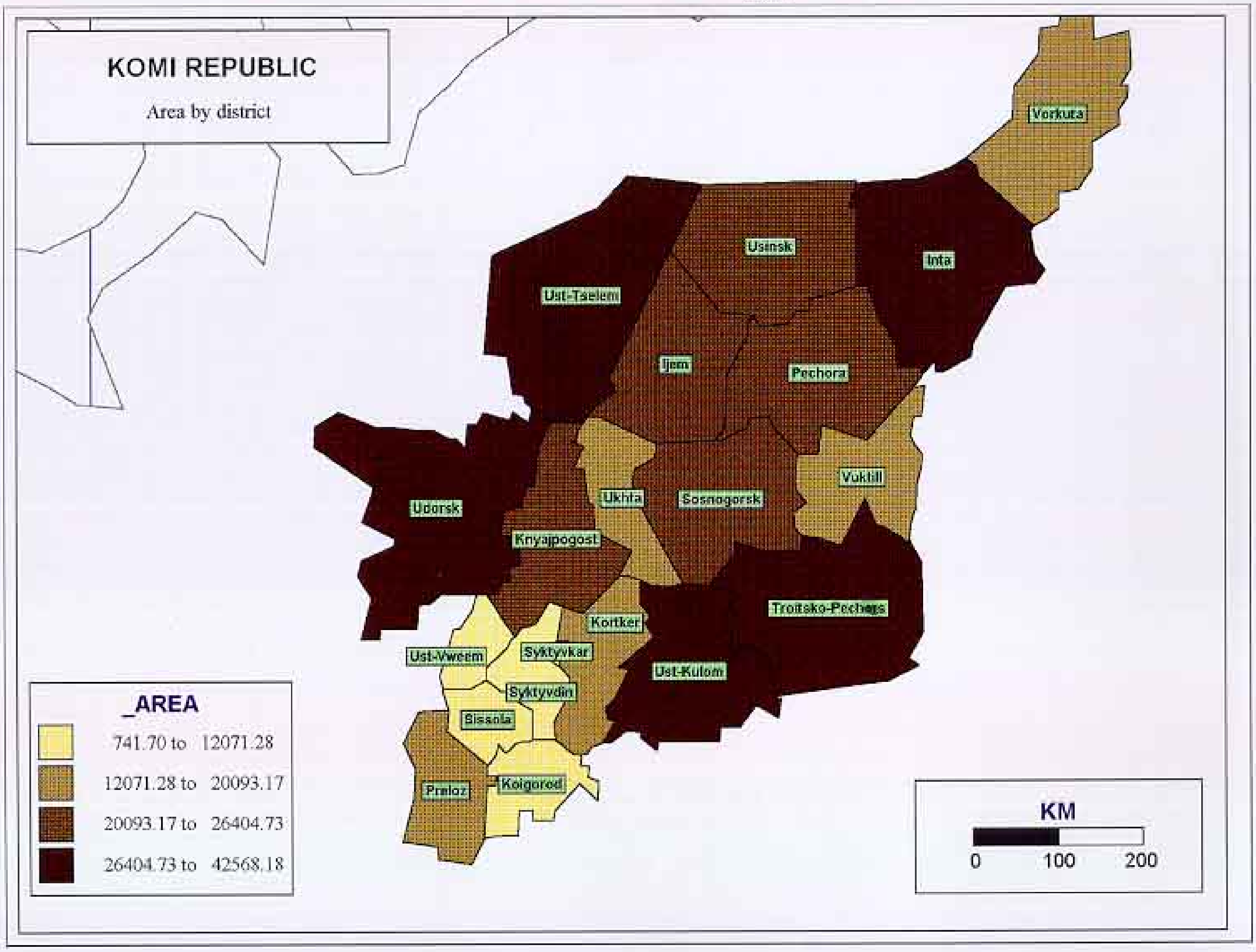


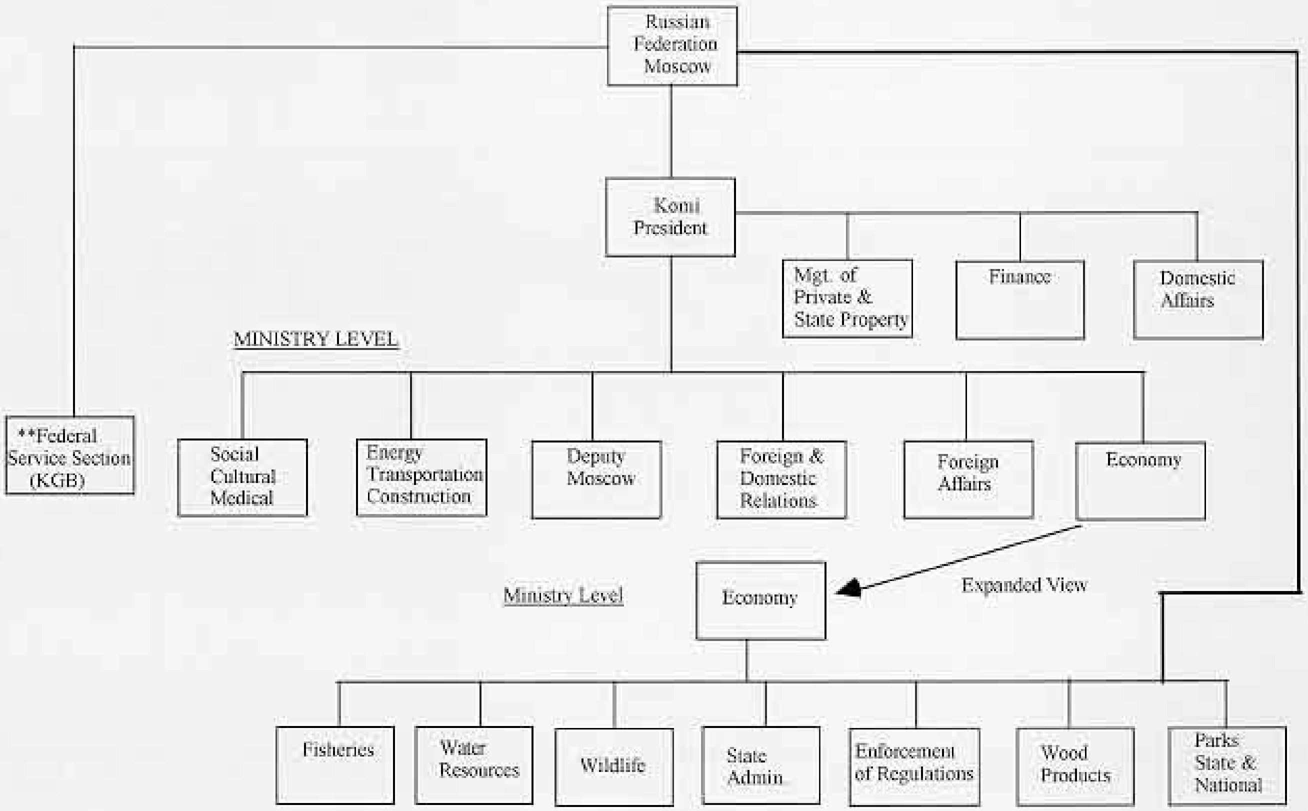
Figure 1.2 Natural Zones of the USSR (after Mil'kov)

Map #3


Komi Republic
Biomes
tundra
Forested Tundra
Northern Taiga
Mt. Tundra
Central Taiga
Syktyvkar
S. Taiga
KM
0
.2
.4

Map #4


KOMI REPUBLIC
Area by district
Vorkuta
Usinsk
Inta
Ust-Tselem
Ijem
Pechora
Udorsk
Ukhta
Sosnogorsk
Vuktill
Knyajpogost
Kortker
Troitsko-Pechors
Ust-Vymeem
Syktyvkar
Ust-Kulom
Syktyvdin
Bissola
Priloz
Koigorod
_AREA
741.70 to 12071.28
12071.28 to 20093.17
20093.17 to 26404.73
26404.73 to 42568.18
KM
0
100
200



**Each of the 20 Districts in Komi has an identical structure from the MinistryLevel down.

Personal interview with the minister of Natural Resources, Alexander Pavlovich Borovinskih. May 29, 1995.

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World Resource Database:

Forestry........................Roundwood Imports and Exports
Economics.....................External Debt and Current Borrowing
Energy..........................Energy Production and Energy Consumption
Agriculture...................Total Labor Force and Agricultural Labor Force
Energy..........................Energy Exports and Energy Imports

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Notes

[1] Pryde, Philip. Environmental Resources and Constraints in the Former Soviet Republics. Westview Press. Boulder. p. 47.

[2] Ibid. p. 55.

[3] Personal Interview with Yvan Koligov, Minister of Commerce, Republic of Komi. May 23, 1995.

[4] CONSTITUTION of the Republic of Komi. Article 64, subsection (e). page 15.

[5] Hosking, Geoffrey. The First Socialist Society. Harvard University Press. Cambridge.1992. p. 516.

[6] Robinson, Neil. Ideology and the Collapse of the Soviet System. Edward Elgar Publishing Limited. Hants, England. 1995. p. 95.

[7] Hosking, Geoffrey. The First Socialist Society. Harvard University Press. Cambridge.1992. p. 457.

[8] Ibid. p 463.

[9] Ibid. p 463.

[10] Ibid. p 495.

[11] Dallin, Alexander. Gail W. Lapidus. The Soviet System. From Crisis to Collapse. Westview Press. Boulder.1995. p. 30.

[12] Ibid. p. 34.

[13] Ibid. p. 107

[14] Aishton, Richard. Personal trip to Russia. 1989.

[15] Bull, Hedley. "Society and Anarchy in International Relations." in Herbert Butterfield and Martin Wight. eds. Diplomatic Investigations. Allen and Unwin. 1966. p. 39.

[16] Evans, Peter B. Harold K. Jacobson. Robert D. Putnam. Double-Edged Diplomacy. University of California Press. Berkeley. 1993. p 443.

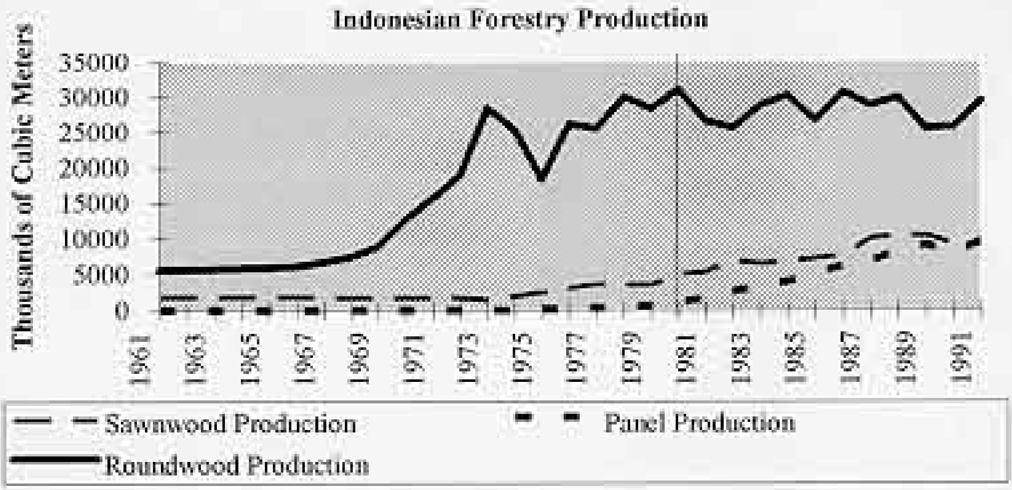
[17] Feshbach, Murray. Alfred Friendly, Jr. Ecocide in the USSR. Basic Books. New York. 1992. p. 1

[18] Ibid. p 10.

[19] Kalish, Susan. "Life Expectancy Falling, Morbidity Rising in Former USSR." Population Today. January 1993. p.1.

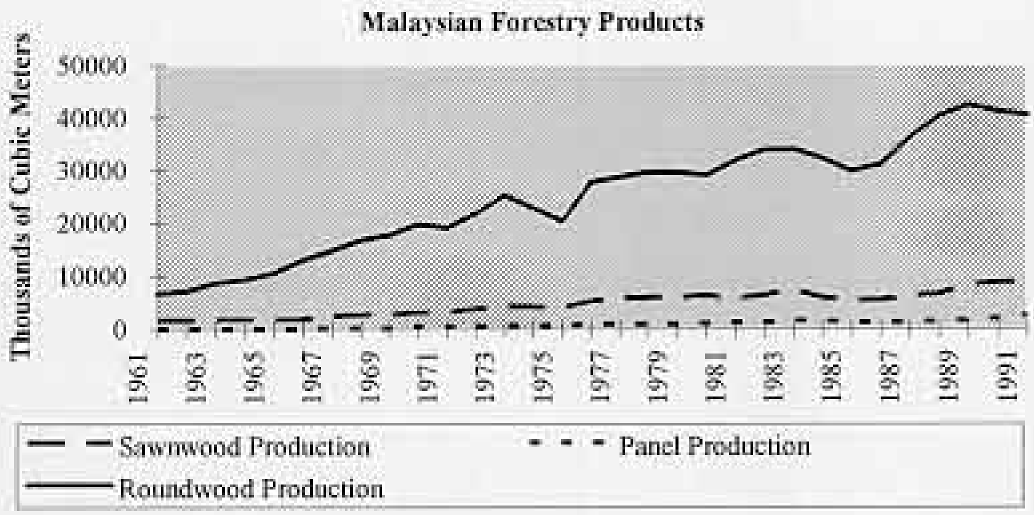
[20] Political Science 444. Dr. Kate Schecter Lecture. Classroom notes. April 5, 1995.

GRAPH #1

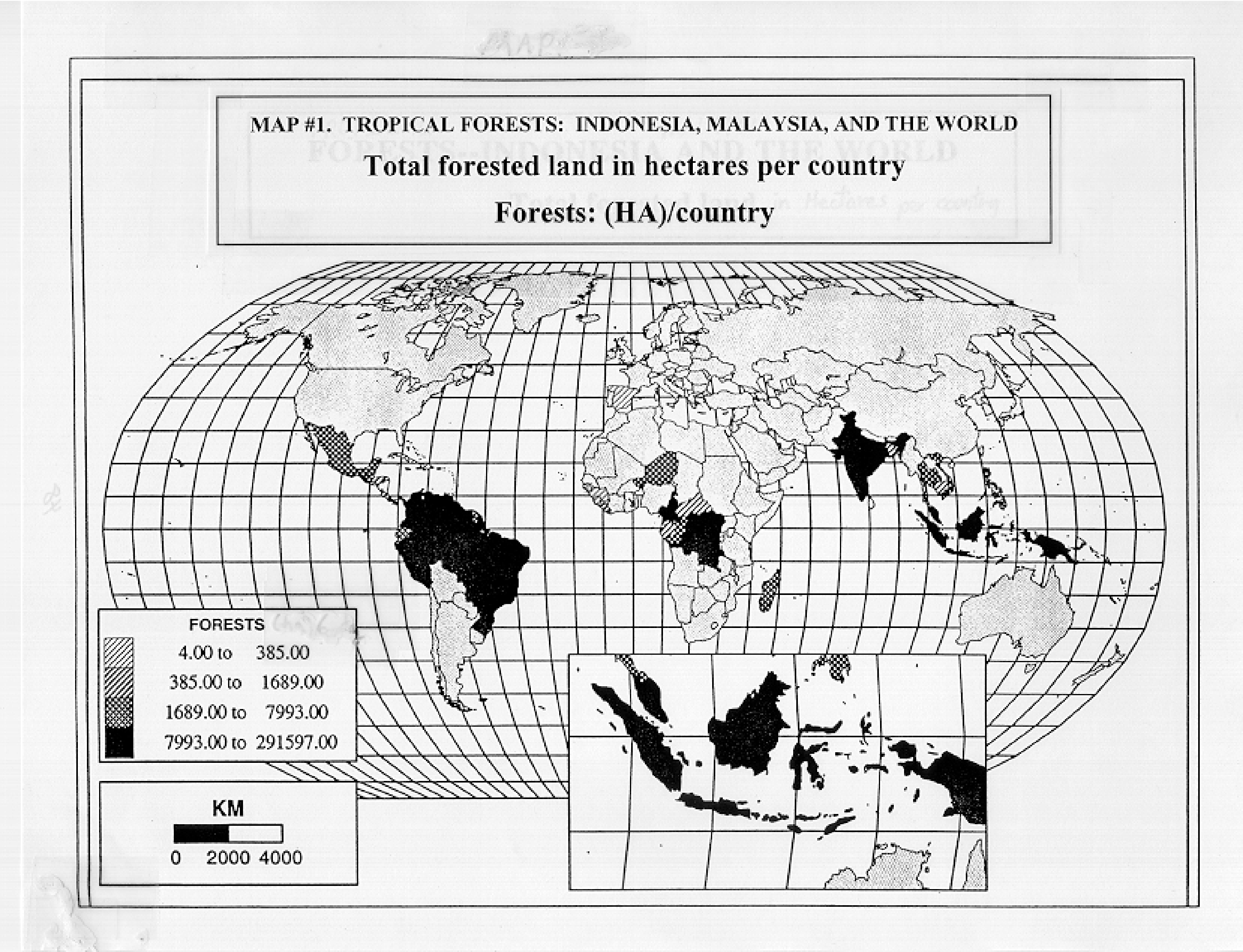


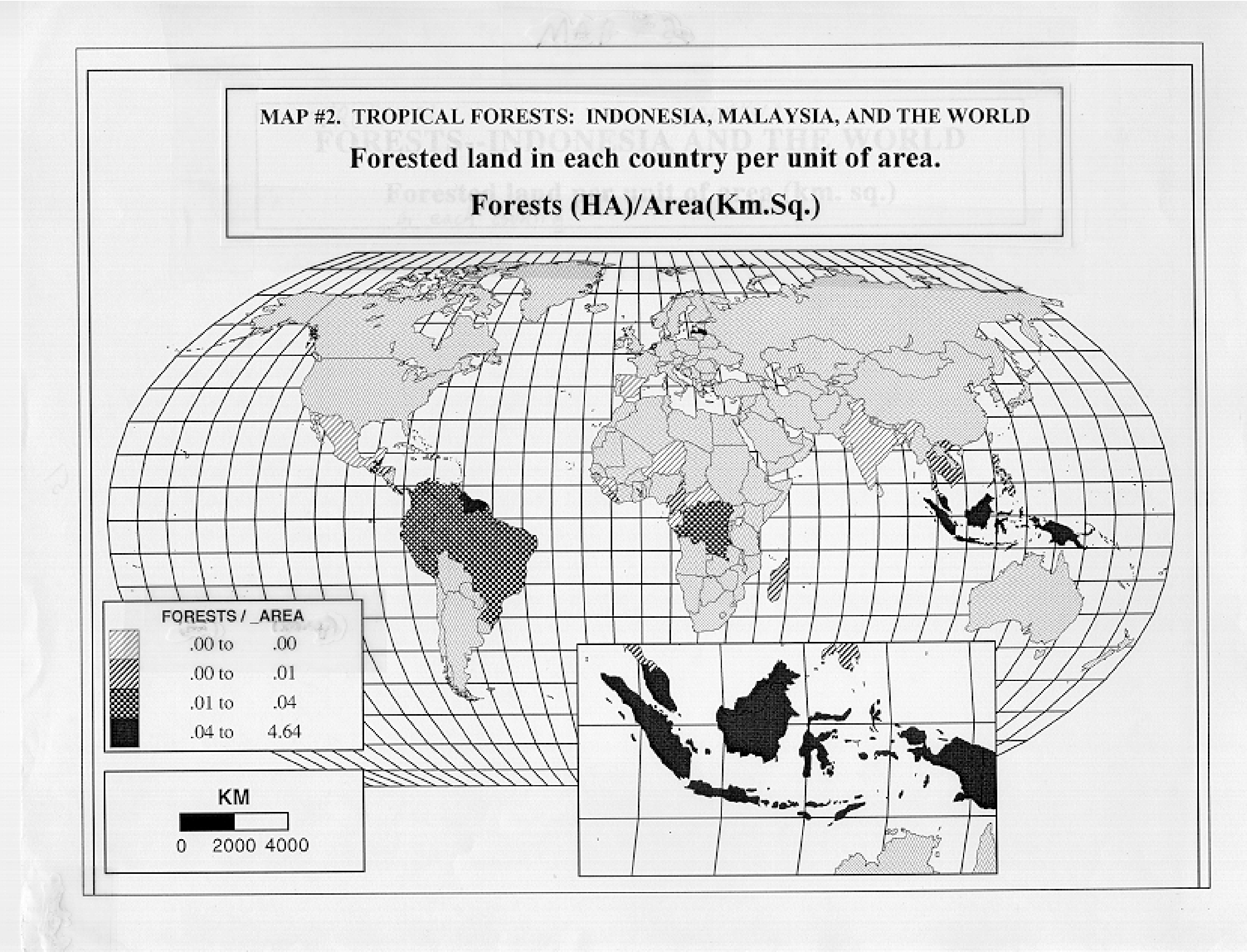
Source: World Resources Database (1994-95).

GRAPH #2



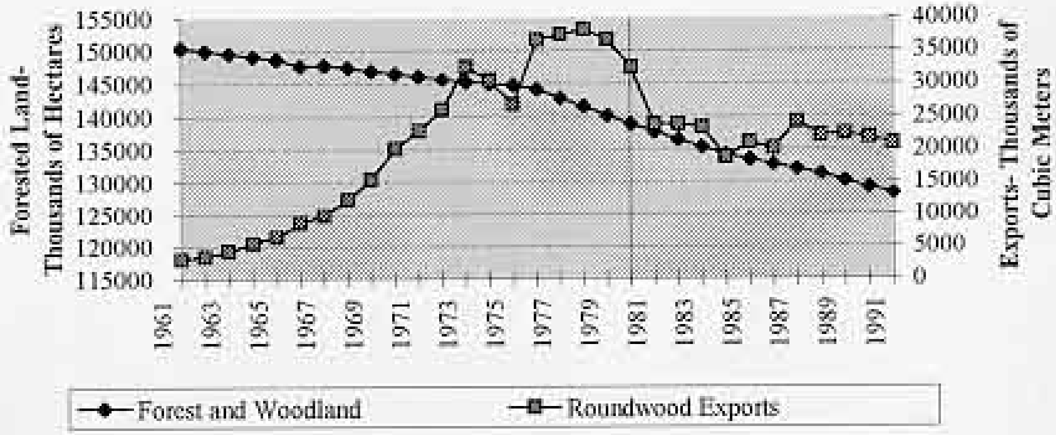
Source: World Resources Database (1994-95).


MAP #1. TROPICAL FORESTS: INDONESIA, MALAYSIA, AND THE WORLD
Total forested land in hectares per country
Forests: (HA)/country
FORESTS
4.00 to 385.00
385.00 to 1689.00
1689.00 to 7993.00
7993.00 to 291597.00
KM
0 2000 4000


MAP #2. TROPICAL FORESTS: INDONESIA, MALAYSIA, AND THE WORLD
Forested land in each country per unit of area.
Forests (HA)/Area(Km.Sq.)
FORESTS / _AREA
.00 to .00
.00 to .01
.01 to .04
.04 to 4.64
KM
0 2000 4000

GRAPH #3

Exporting Roundwood from Indonesia and Malaysia



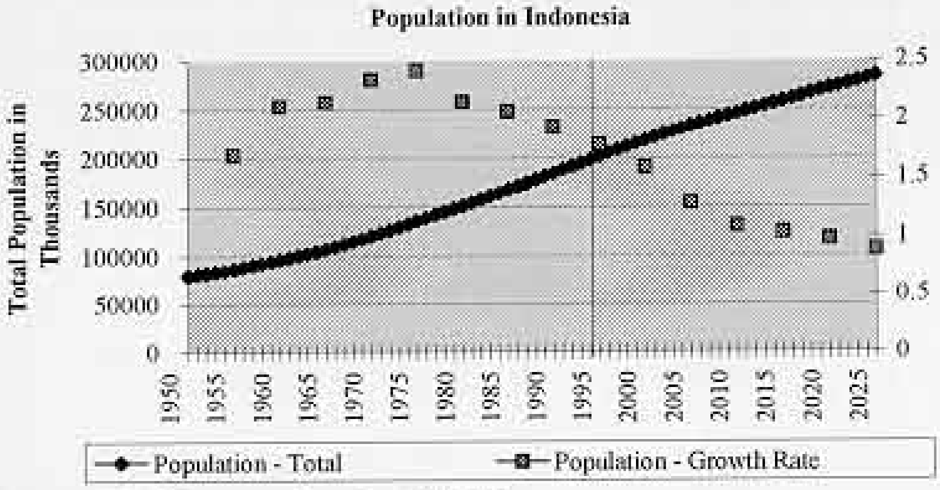
Source: World Resources Database (1994-95).

While this only includes roundwoods, there is a strong correlation between the increase in roundwood

GRAPH #4

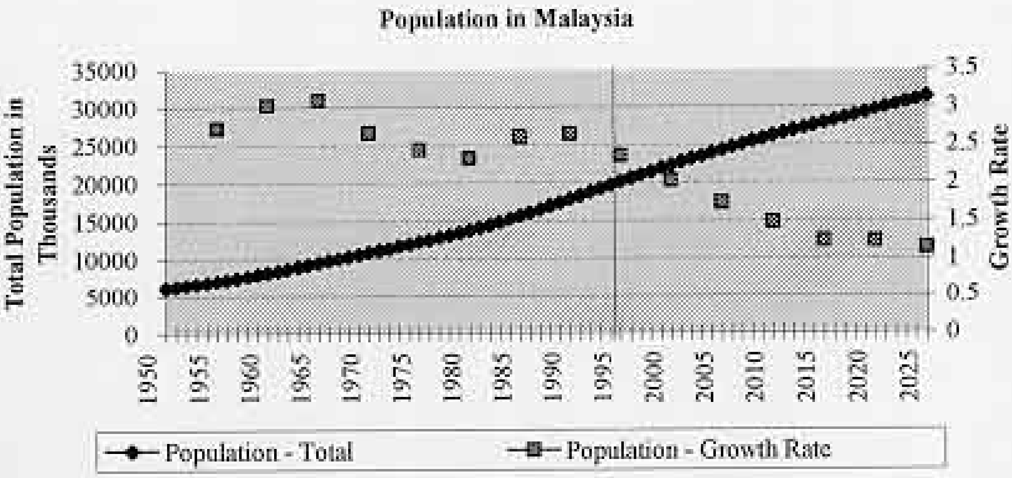
Source: World Resources Database (1994-95).

GRAPH #5



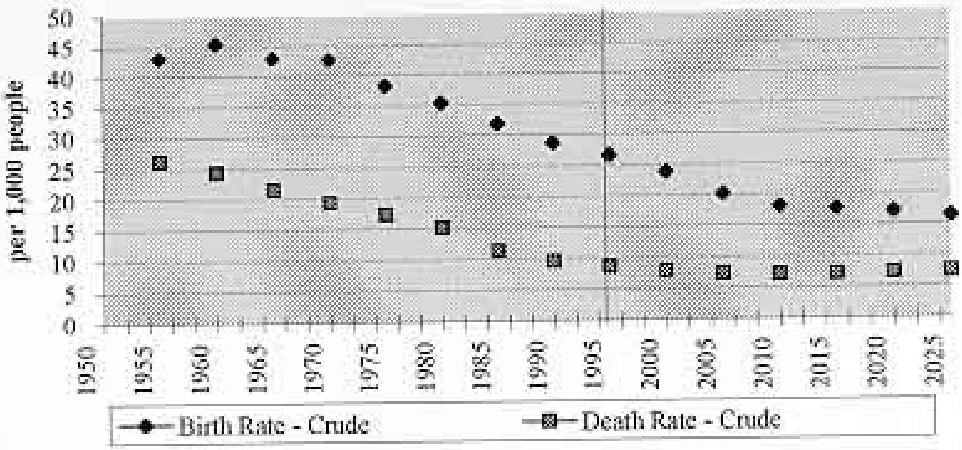
Source: World Resources Database (1994-95).

GRAPH #6



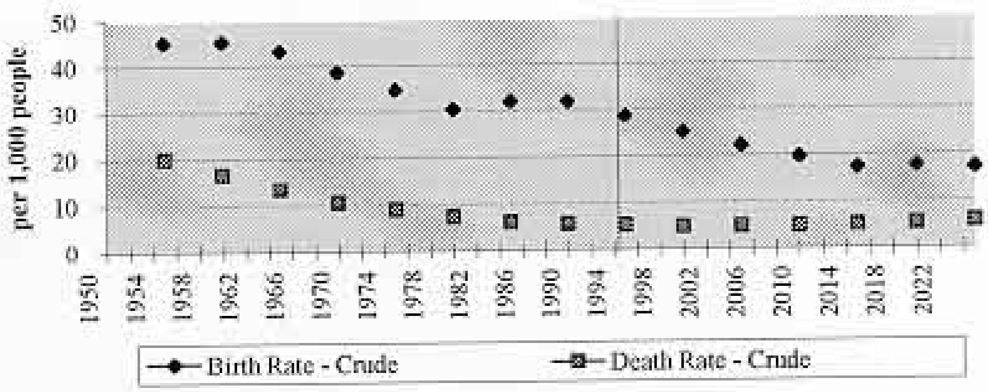
Source: World Resources Database (1994-95).

Population Transition in Indonesia



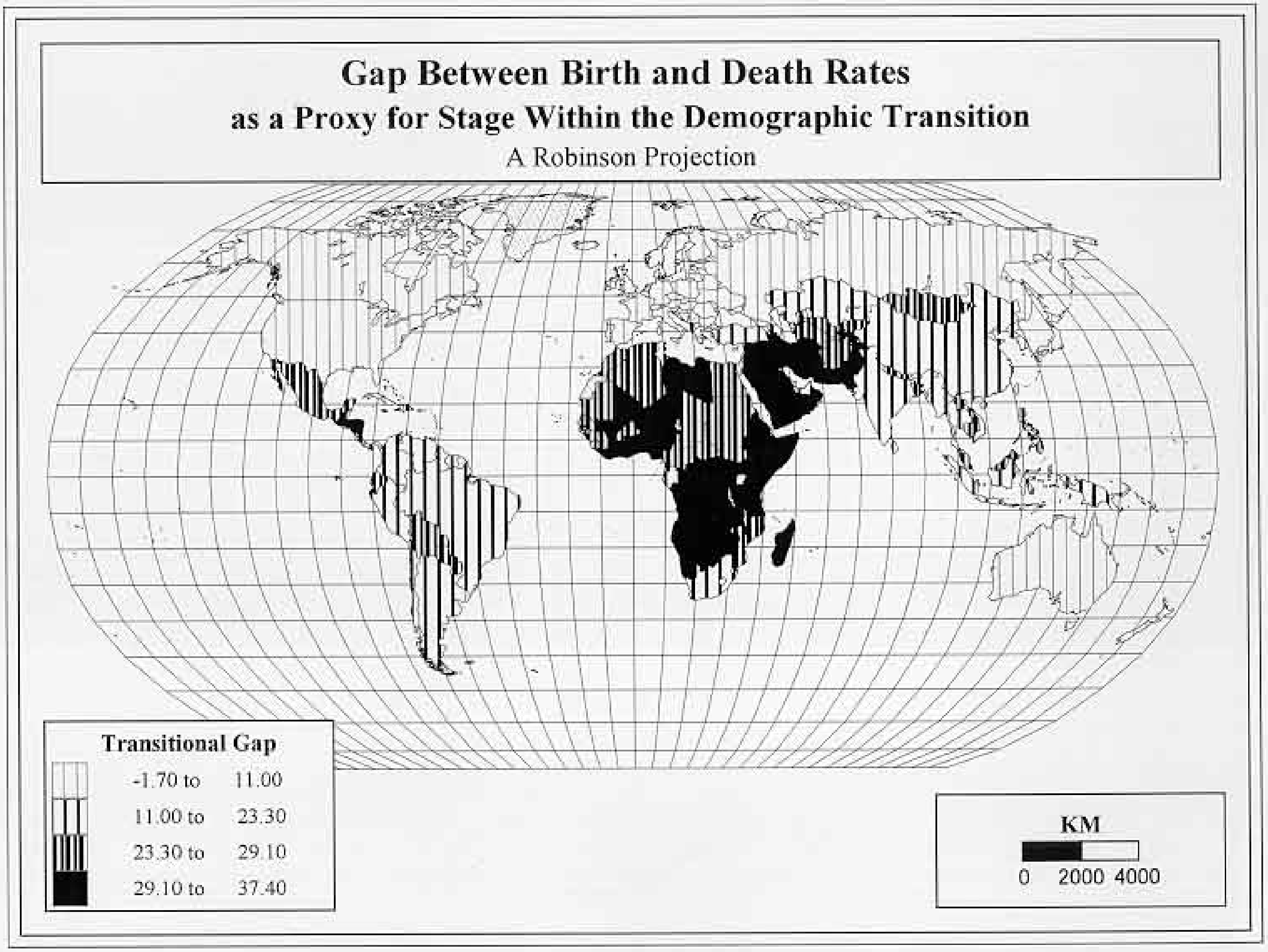
Source: World Resources Database (1994-95).

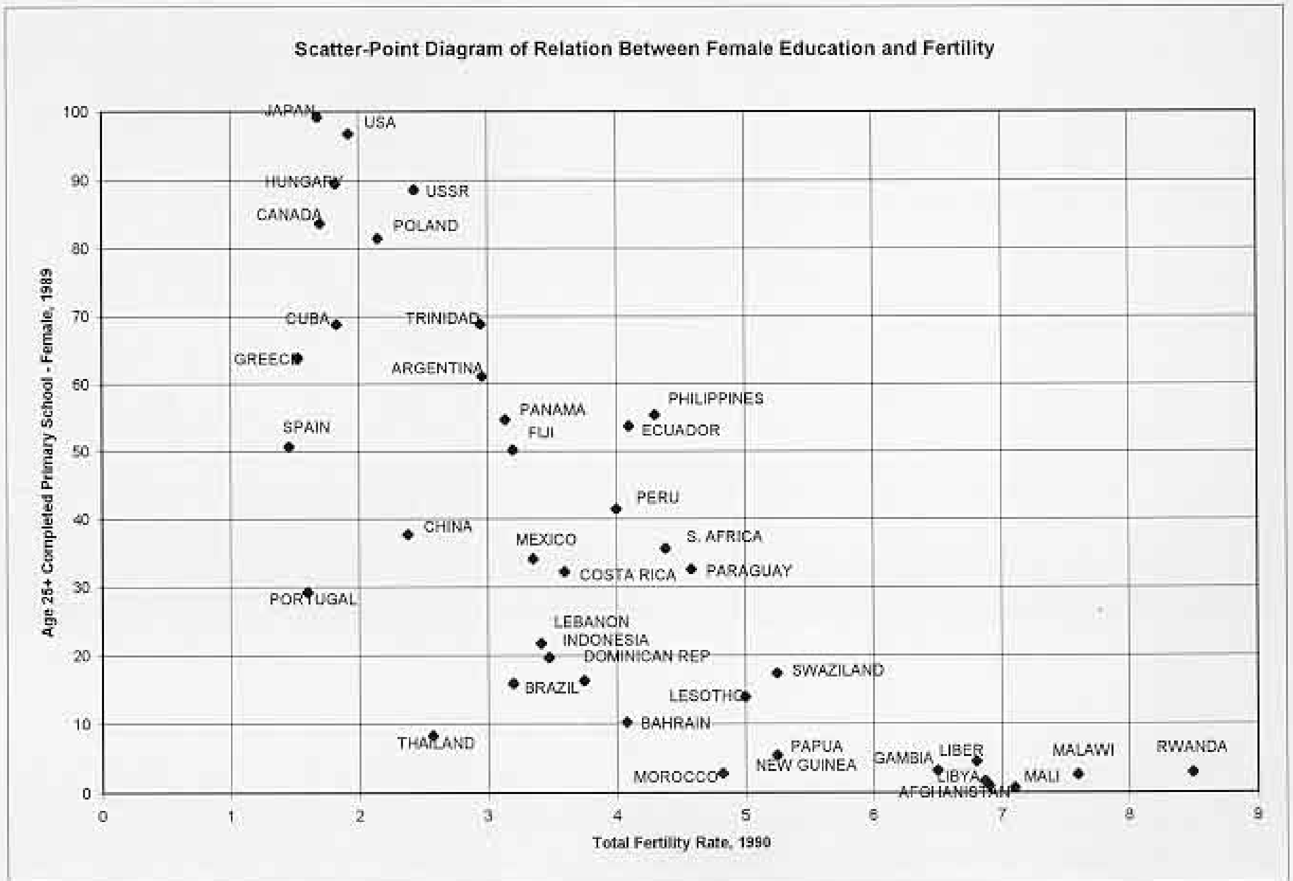
Population Transition in Malaysia

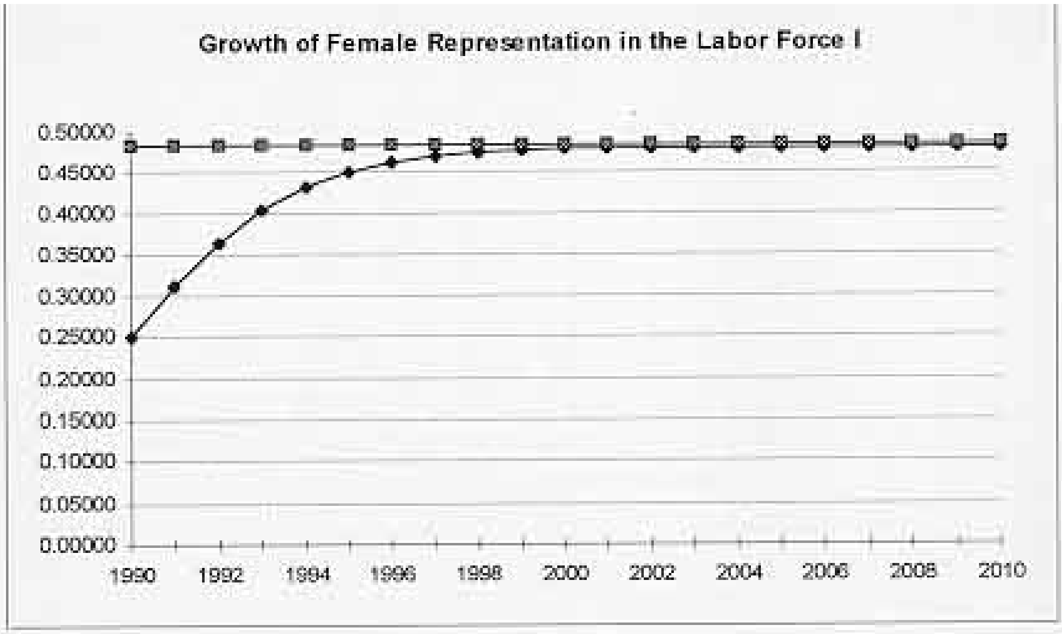


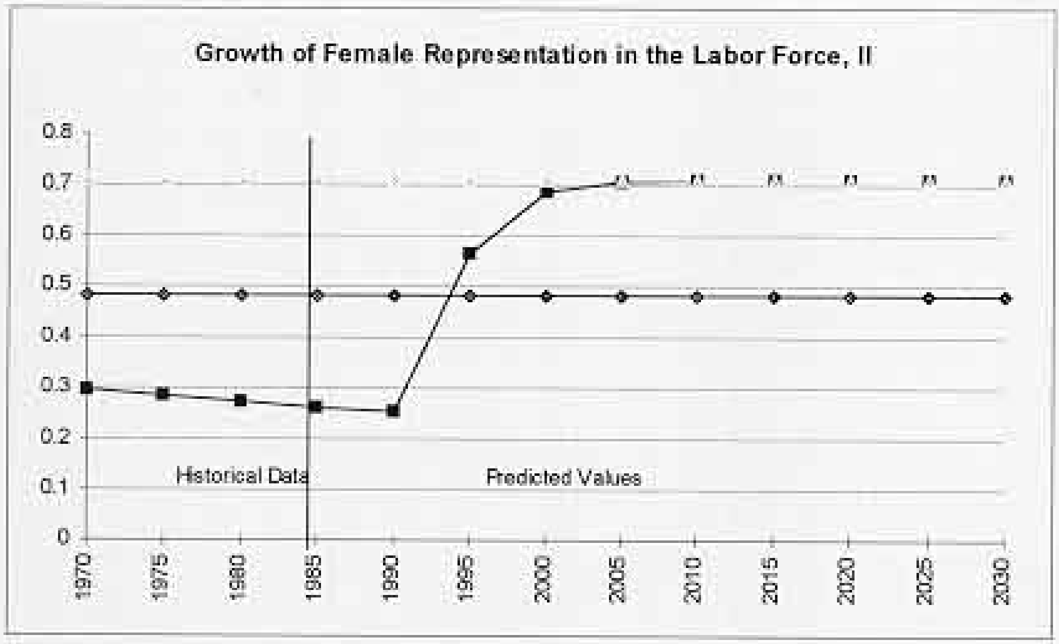
Source: World Resources Database (1994-95).

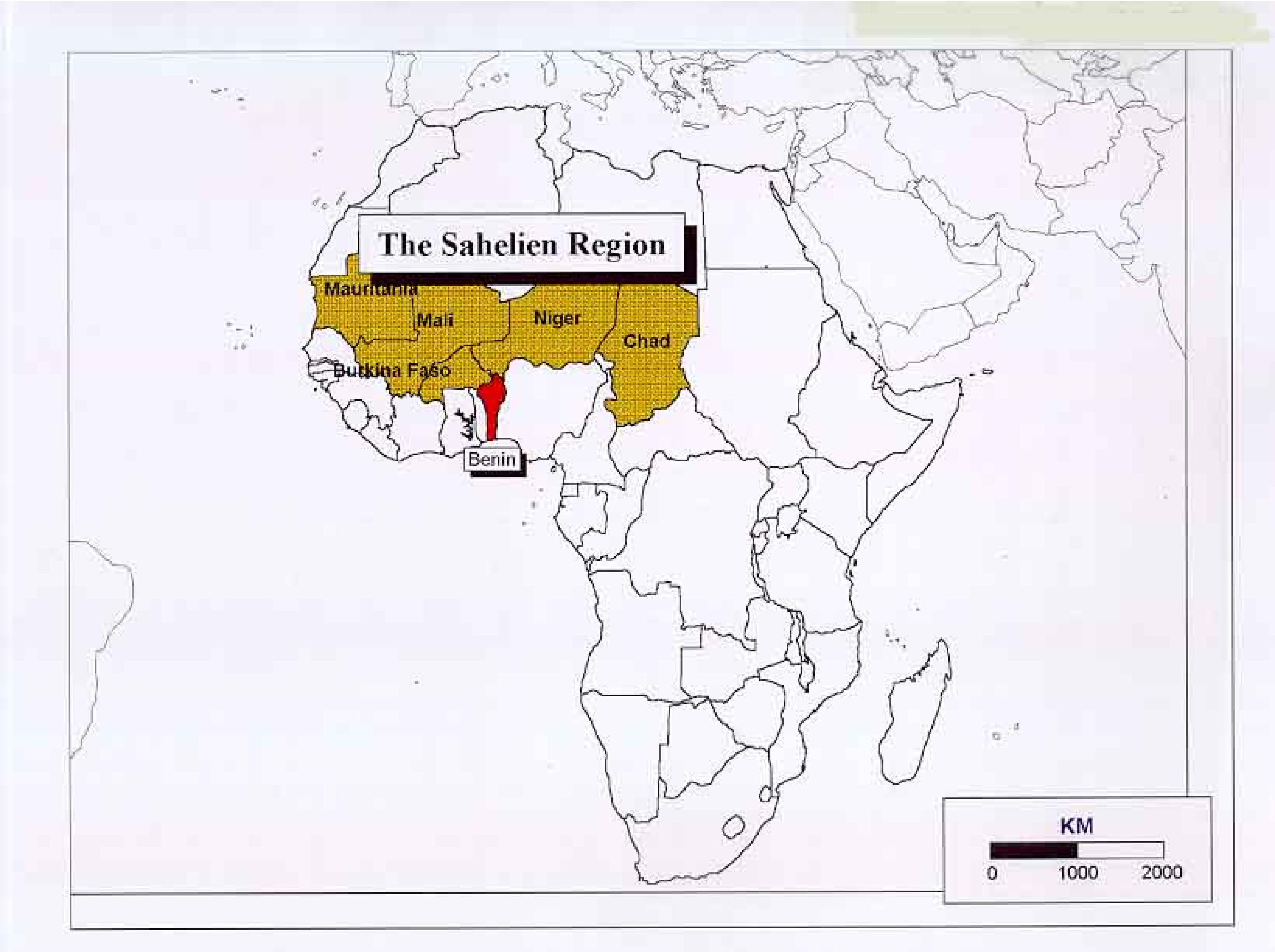
Thus, the population transition is not yet over and is expected to continue into the 21st century. Modernization provides an indirect link between population changes and increased timber exports. As


Gap Between Birth and Death Rates
as a Proxy for Stage Within the Demographic Transition
A Robinson Projection
Transitional Gap
-1.70 to 11.00
11.00 to 23.30
23.30 to 29.10
29.10 to 37.40
KM
0 2000 4000


Scatter-Point Diagram of Relation Between Female Education and Fertility
Age 25+ Completed Primary School - Female, 1989
Total Fertility Rate, 1990
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
8
9
JAPAN
USA
HUNGARY
USSR
CANADA
POLAND
CUBA
TRINIDAD
GREECE
ARGENTINA
PHILIPPINES
PANAMA
SPAIN
FIJI
ECUADOR
PERU
CHINA
MEXICO
S. AFRICA
COSTA RICA
PARAGUAY
PORTUGAL
LEBANON
INDONESIA
DOMINICAN REP
SWAZILAND
BRAZIL
LESOTHO
BAHRAIN
THAILAND
PAPUA
NEW GUINEA
GAMBIA
LIBER
MALAWI
RWANDA
MOROCCO
LIBYA
MALI
AFGHANISTAN


Growth of Female Representation in the Labor Force I
0.50000
0.45000
0.40000
0.35000
0.30000
0.25000
0.20000
0.15000
0.10000
0.05000
0.00000
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

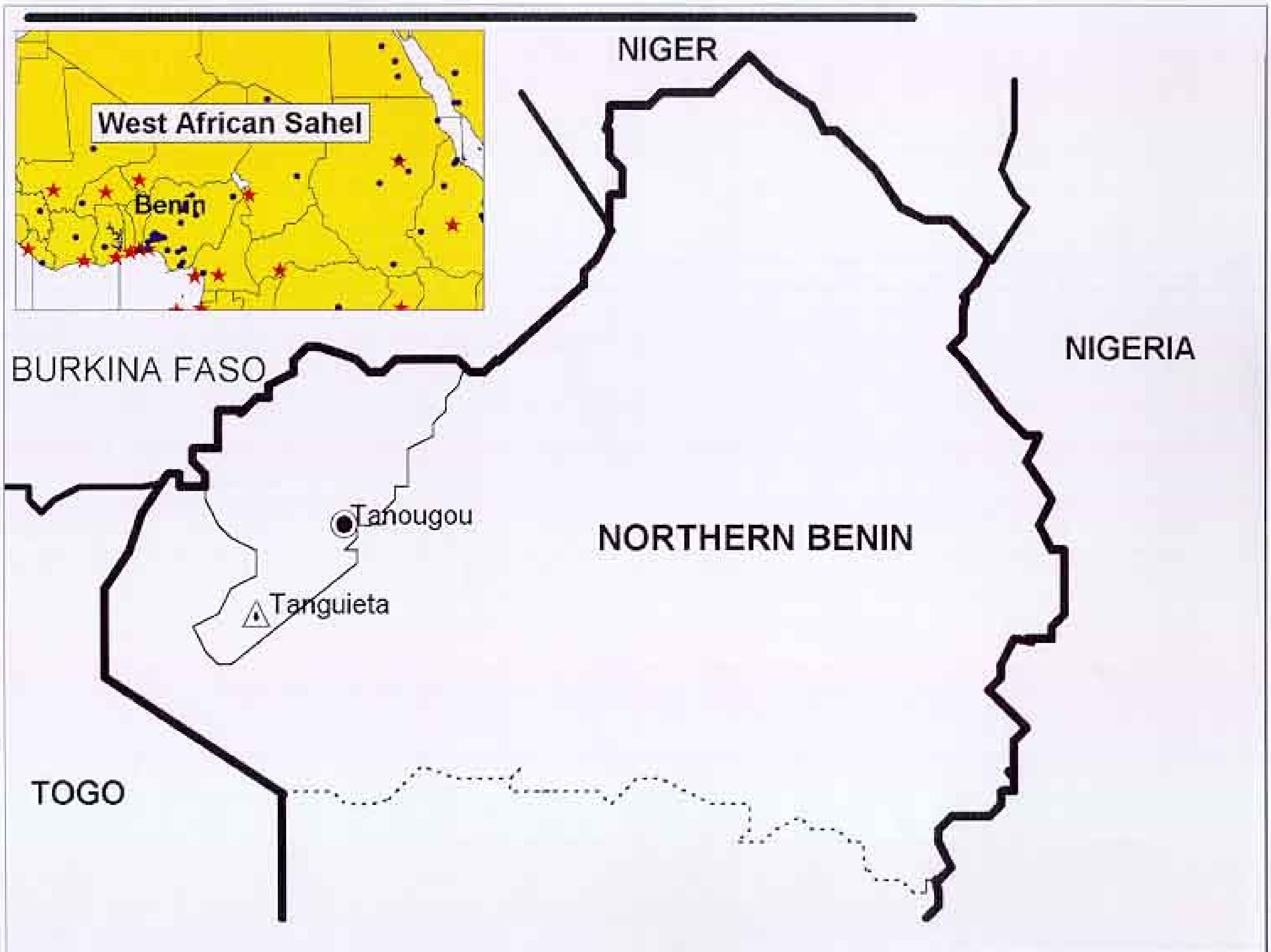

Growth of Female Representation in the Labor Force, II
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Historical Data
Predicted Values
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030



The Sahelien Region
Mauritania
Mali
Niger
Chad
Burkina Faso
Benin
KM
0
1000
2000

THE EFFECTS OF GLOBAL WARMING IN THE SOUTH SAHEL

91



West African Sahel
Benin
NIGER
NIGERIA
BURKINA FASO
Tanougou
NORTHERN BENIN
Tanguieta
TOGO

Figure 1

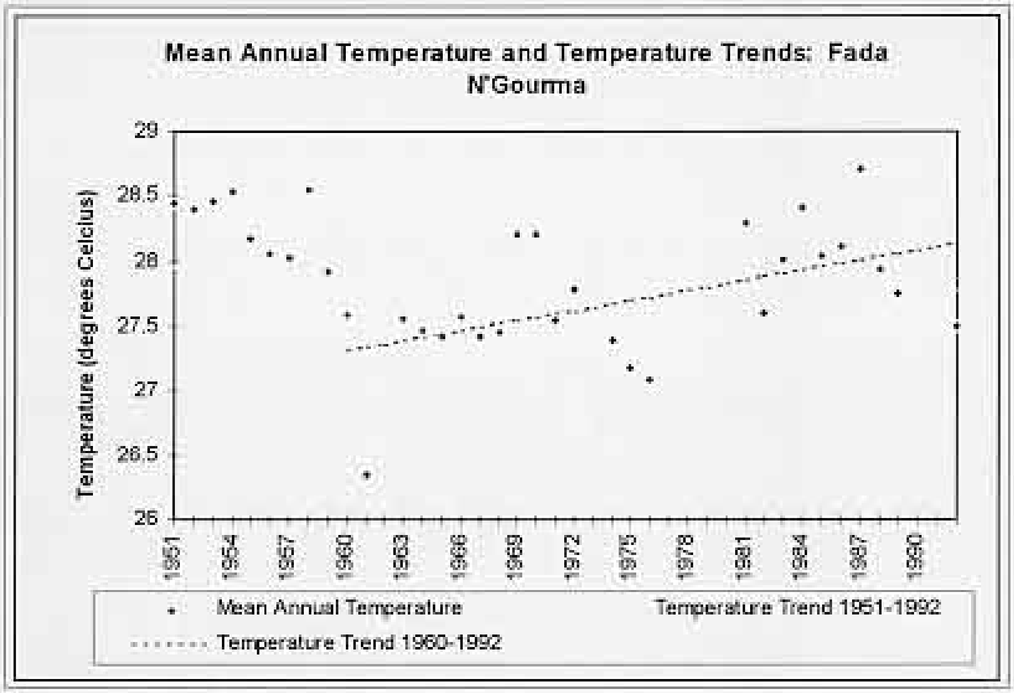

Mean Annual Temperature and Temperature Trends: Fada N'Gourma
Temperature (degrees Celcius)
29
28.5
28
27.5
27
26.5
26
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
Mean Annual Temperature
Temperature Trend 1951-1992
Temperature Trend 1960-1992

Figure 2

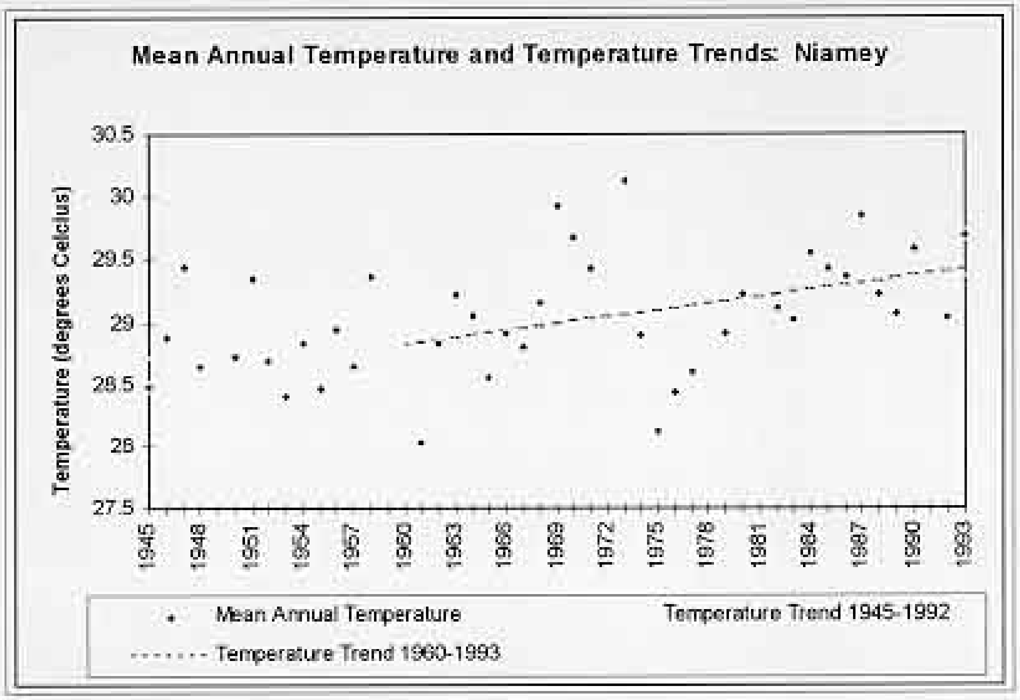
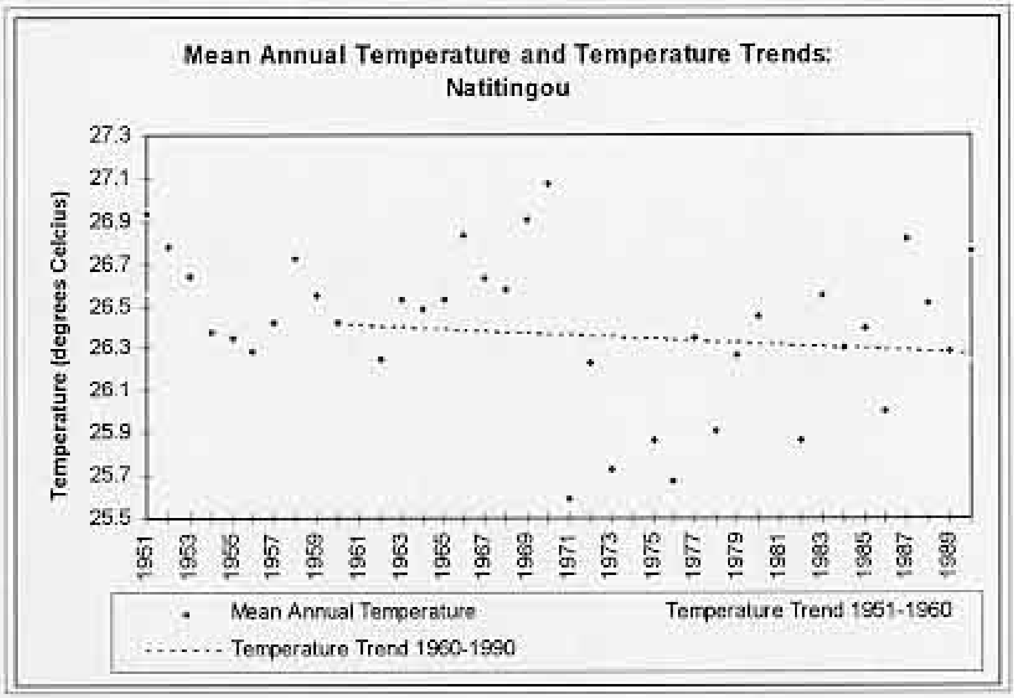

Mean Annual Temperature and Temperature Trends: Niamey
Temperature (degrees Celsius)
30.5
30
29.5
29
28.5
28
27.5
1945
1948
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
Mean Annual Temperature
Temperature Trend 1945-1992
Temperature Trend 1960-1993

Figure 3



Mean Annual Temperature and Temperature Trends: Natitingou
Temperature (degrees Celcius)
27.3
27.1
26.9
26.7
26.5
26.3
26.1
25.9
25.7
25.5
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
Mean Annual Temperature
Temperature Trend 1951-1960
Temperature Trend 1960-1990

Figure 4

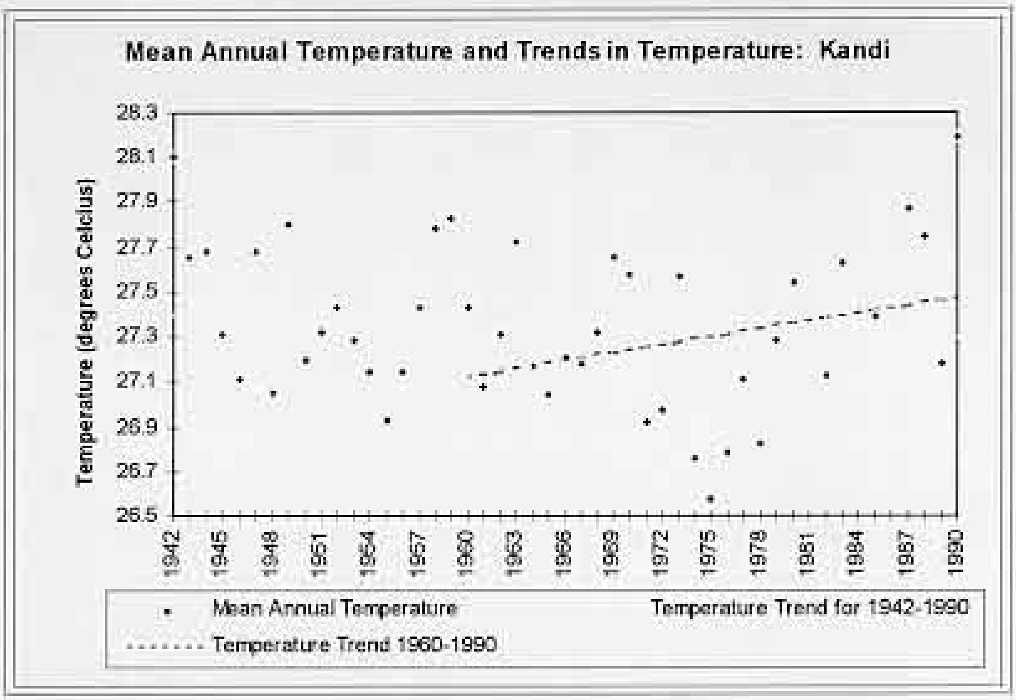
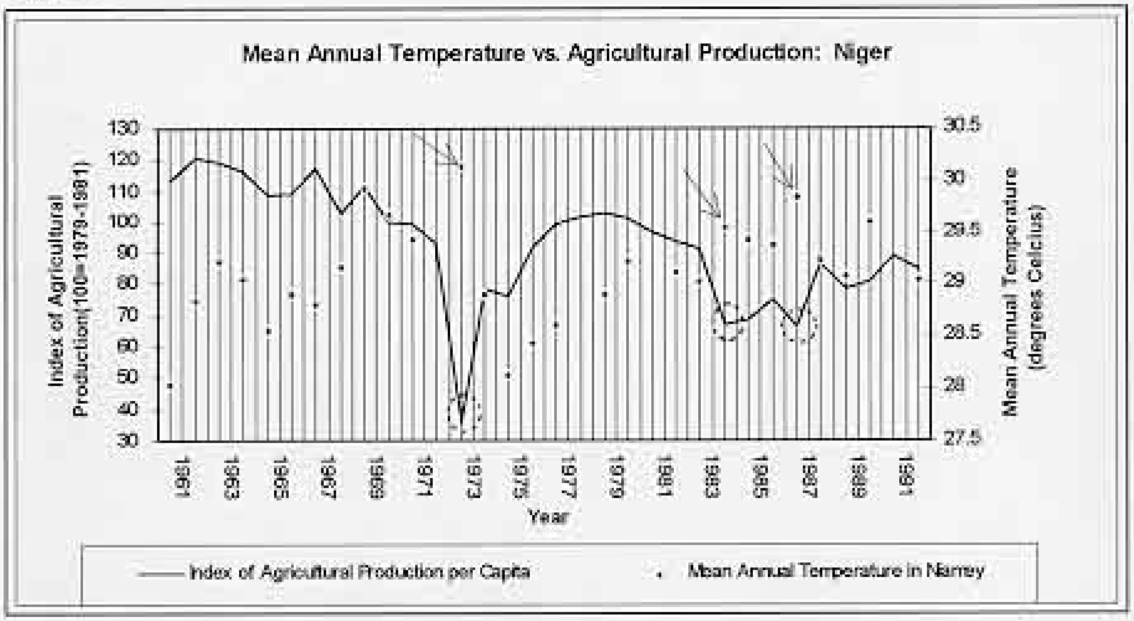

Mean Annual Temperature and Trends in Temperature: Kandi
Temperature (degrees Celcius)
28.3
28.1
27.9
27.7
27.5
27.3
27.1
26.9
26.7
26.5
1942
1945
1948
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
Mean Annual Temperature
Temperature Trend for 1942-1990
Temperature Trend 1960-1990

Figure 5



Mean Annual Temperature vs. Agricultural Production: Niger
Index of Agricultural Production(100=1979-1981)
Mean Annual Temperature (degrees Celcius)
130
120
110
100
90
80
70
60
50
40
30
30.5
30
29.5
29
28.5
28
27.5
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
Year
Index of Agricultural Production per Capita
Mean Annual Temperature in Niamey

Figure 6

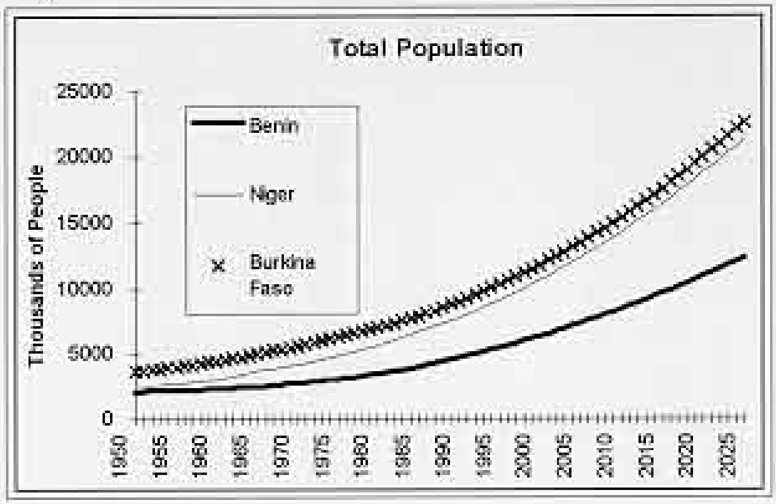

Total Population
25000
20000
15000
10000
5000
0
Thousands of People
Benin
Niger
Burkina Faso
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025

Figure 7

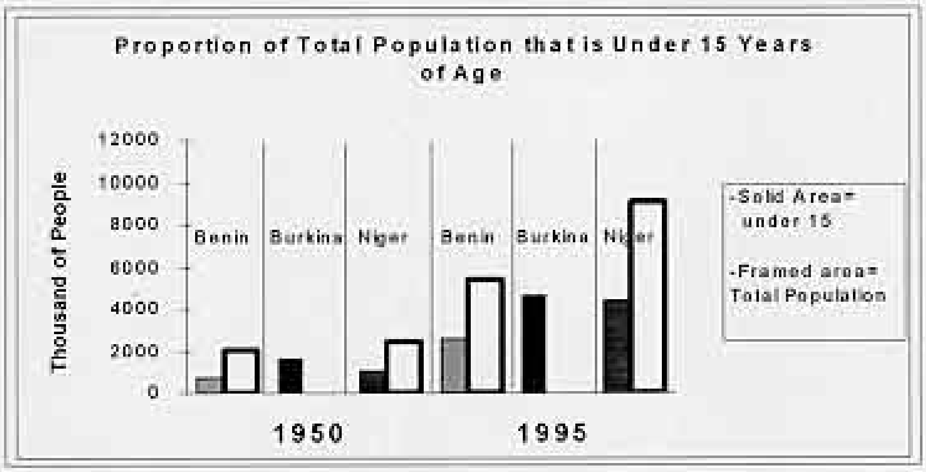
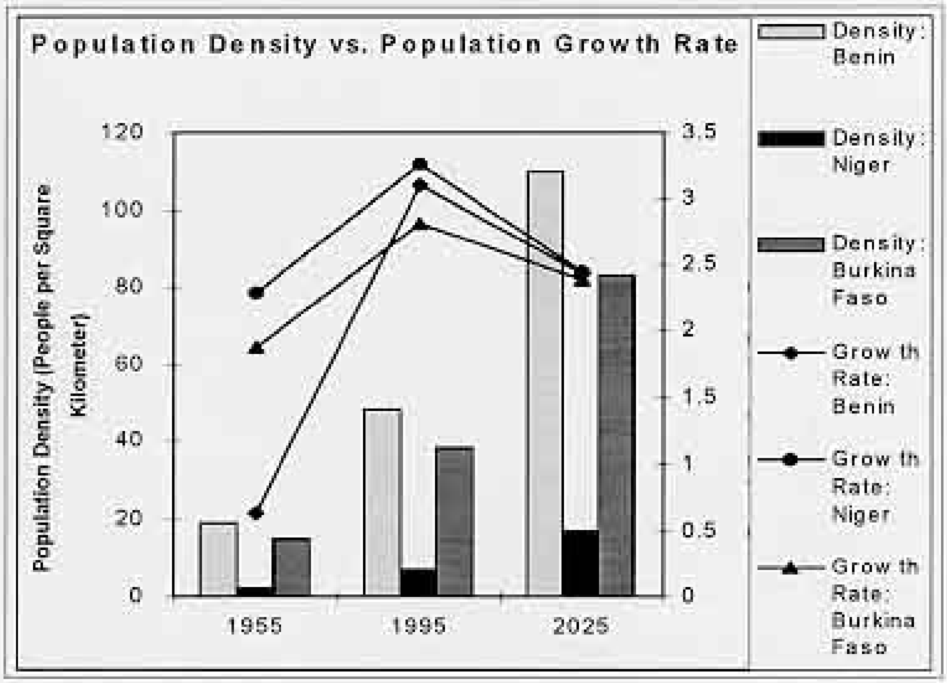

Proportion of Total Population that is Under 15 Years of Age
Thousand of People
12000
10000
8000
6000
4000
2000
0
Benin
Burkina
Niger
Benin
Burkina
Niger
1950
1995
-Solid Area= under 15
-Framed area= Total Population

Figure 8



Population Density vs. Population Growth Rate
Population Density (People per Square Kilometer)
120
100
80
60
40
20
0
3.5
3
2.5
2
1.5
1
0.5
0
1955
1995
2025
Density: Benin
Density: Niger
Density: Burkina Faso
Grow th Rate: Benin
Grow th Rate: Niger
Grow th Rate: Burkina Faso

Figure 9

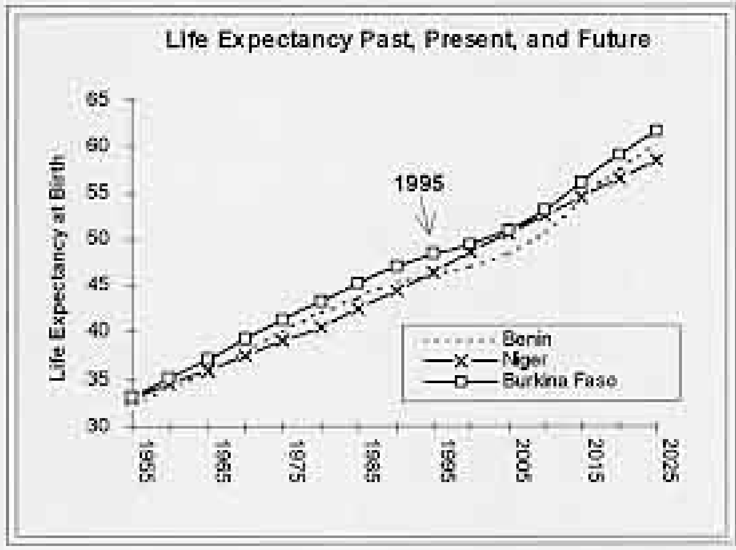

Life Expectancy Past, Present, and Future
Life Expectancy at Birth
65
60
55
50
45
40
35
30
1955
1965
1975
1985
1995
2005
2015
2025
1995
Benin
Niger
Burkina Faso

Figure 10

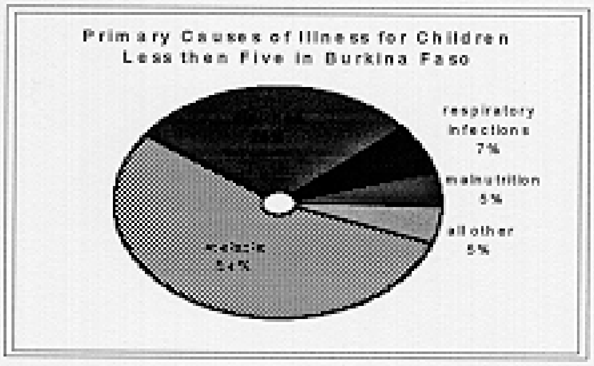
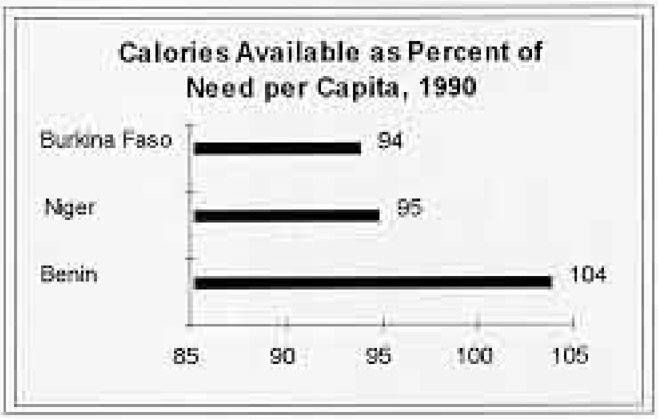

Primary Causes of Illness for Children
Less then Five in Burkina Faso
respiratory
infections
7%
malnutrition
5%
all other
5%
54%

Figure 11


Calories Available as Percent of
Need per Capita, 1990
Burkina Faso
94
Niger
95
Benin
104
85
90
95
100
105

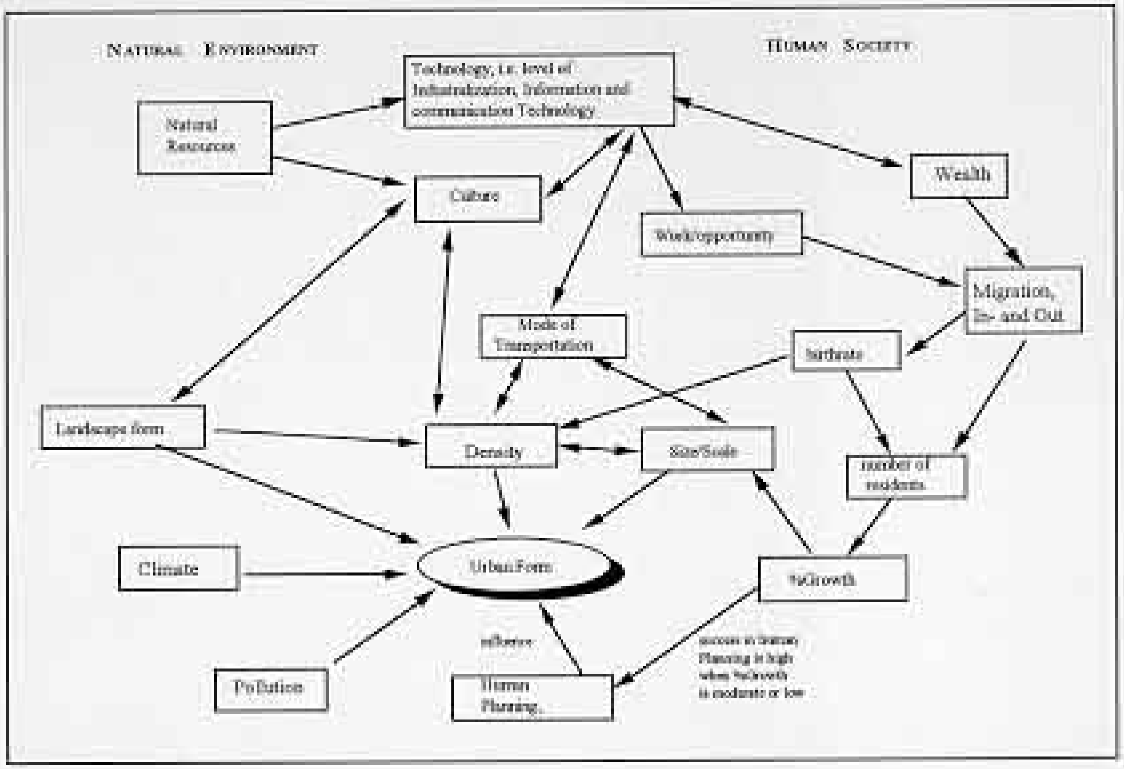
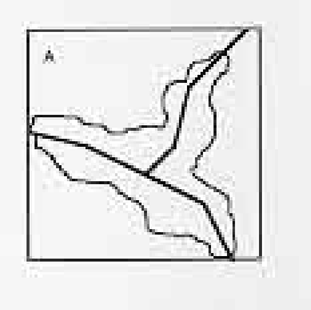
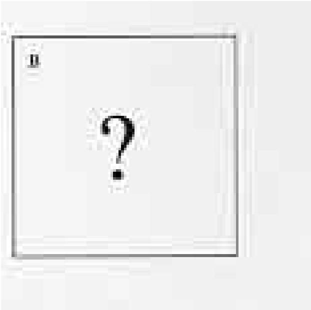
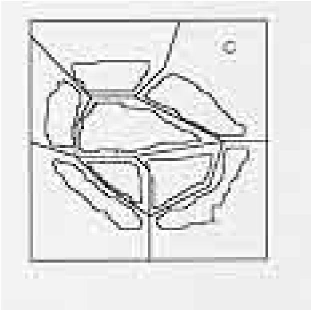


Figure 1 - Influences on Urban form


A




C

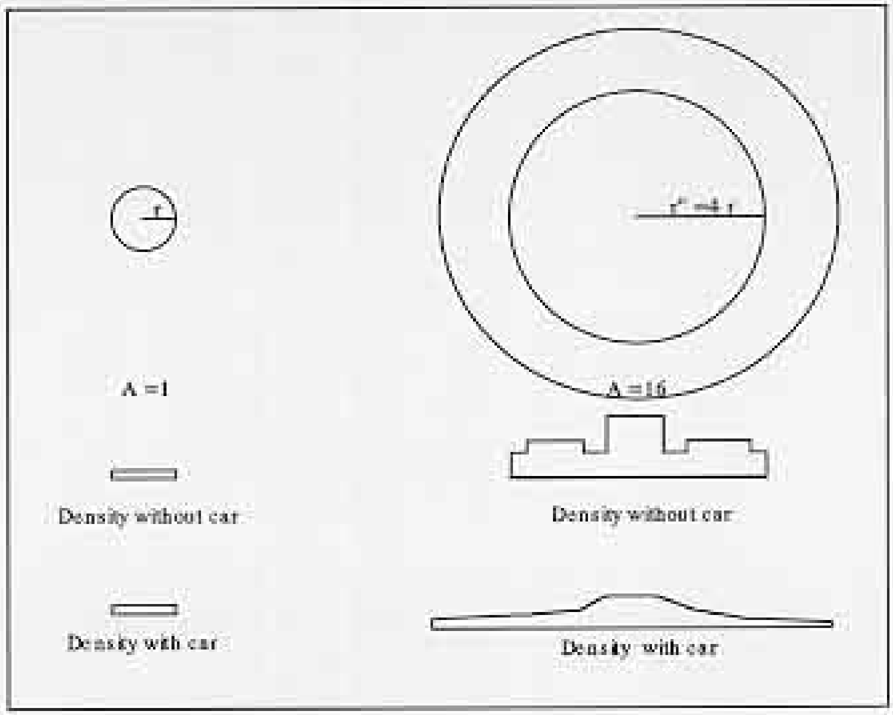


Figure 2 - Morphologies

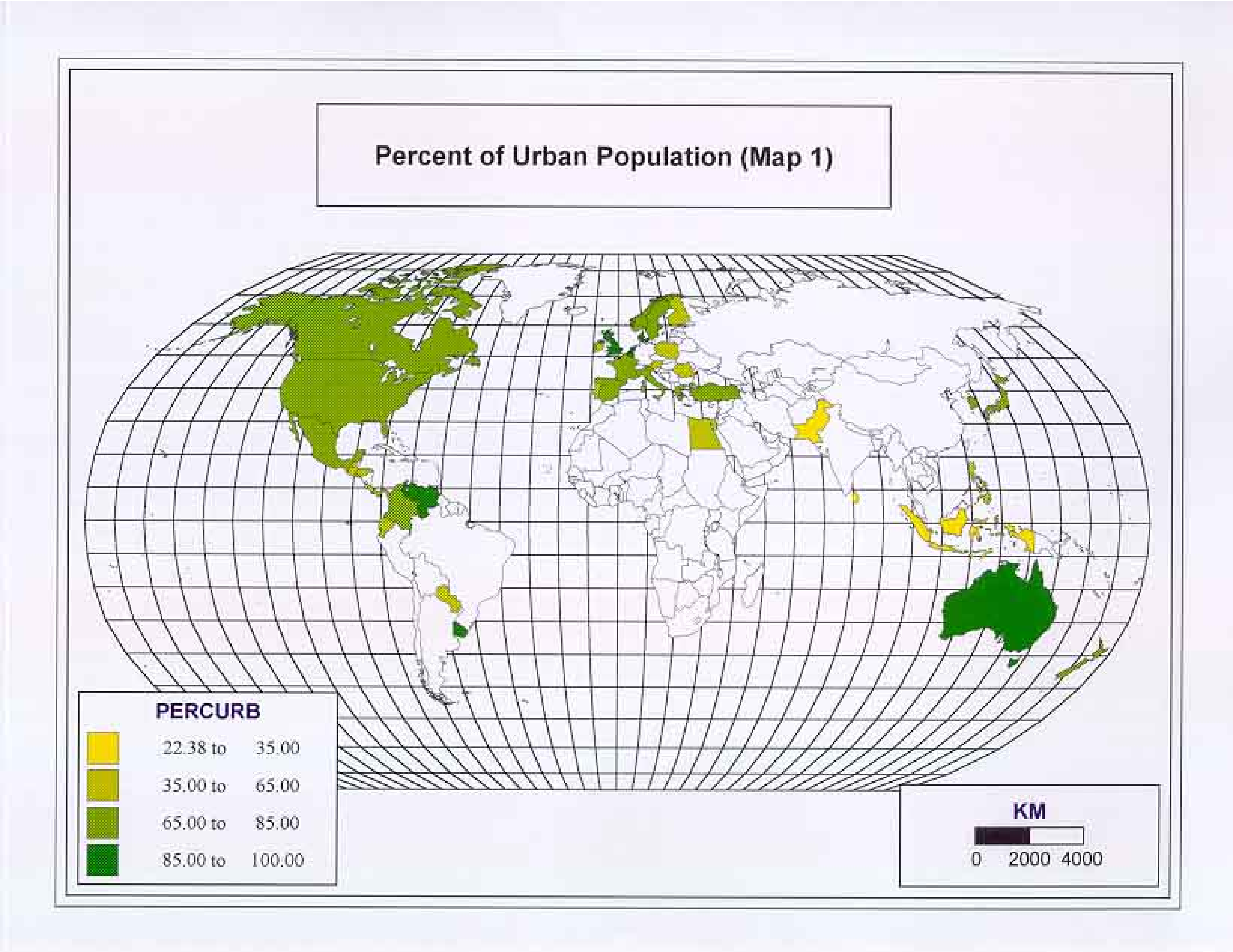

Percent of Urban Population (Map 1)
PERCURB
22.38 to 35.00
35.00 to 65.00
65.00 to 85.00
85.00 to 100.00
KM
0 2000 4000

Figure 3a - Pattern A

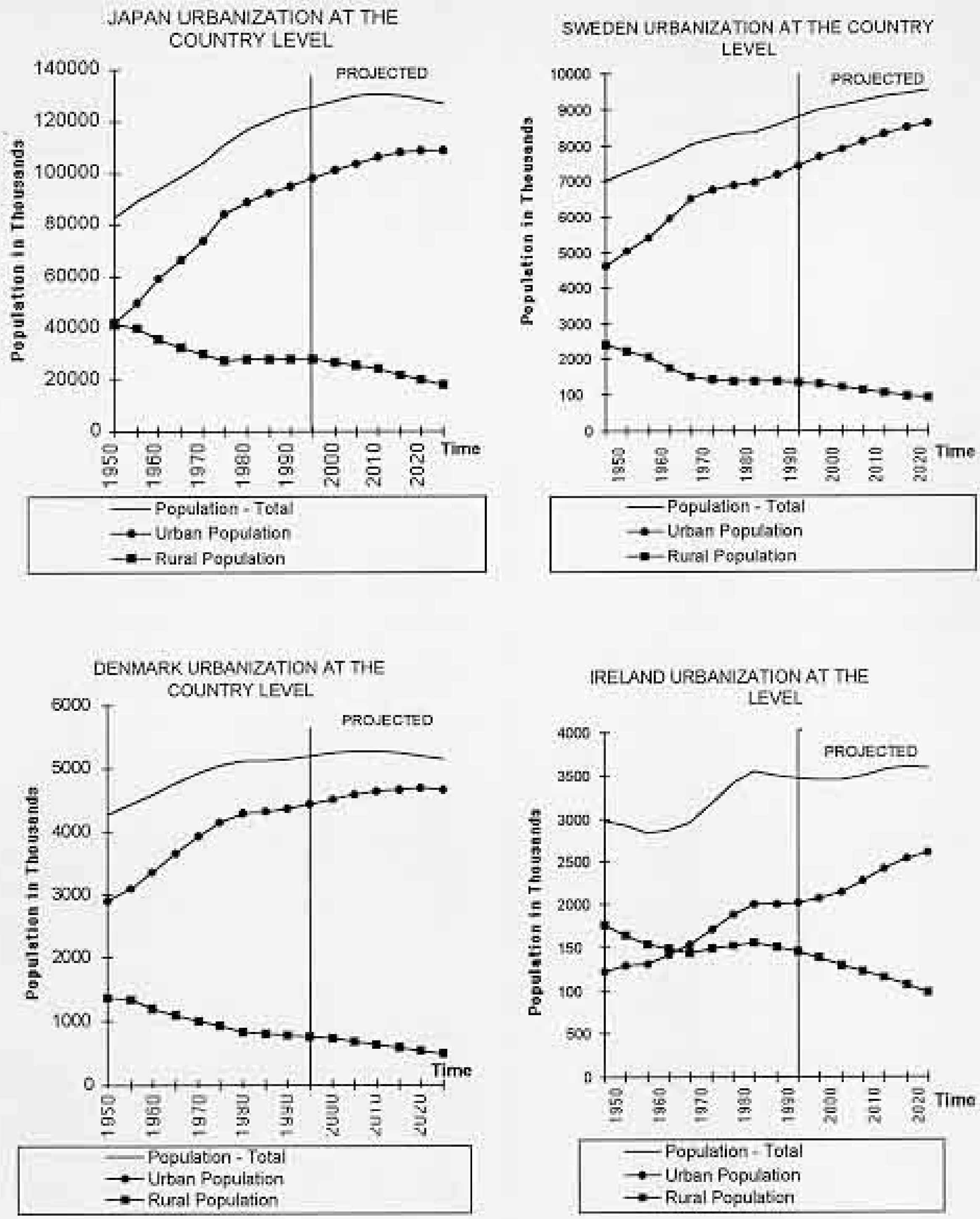


Figure 3b - Pattern B

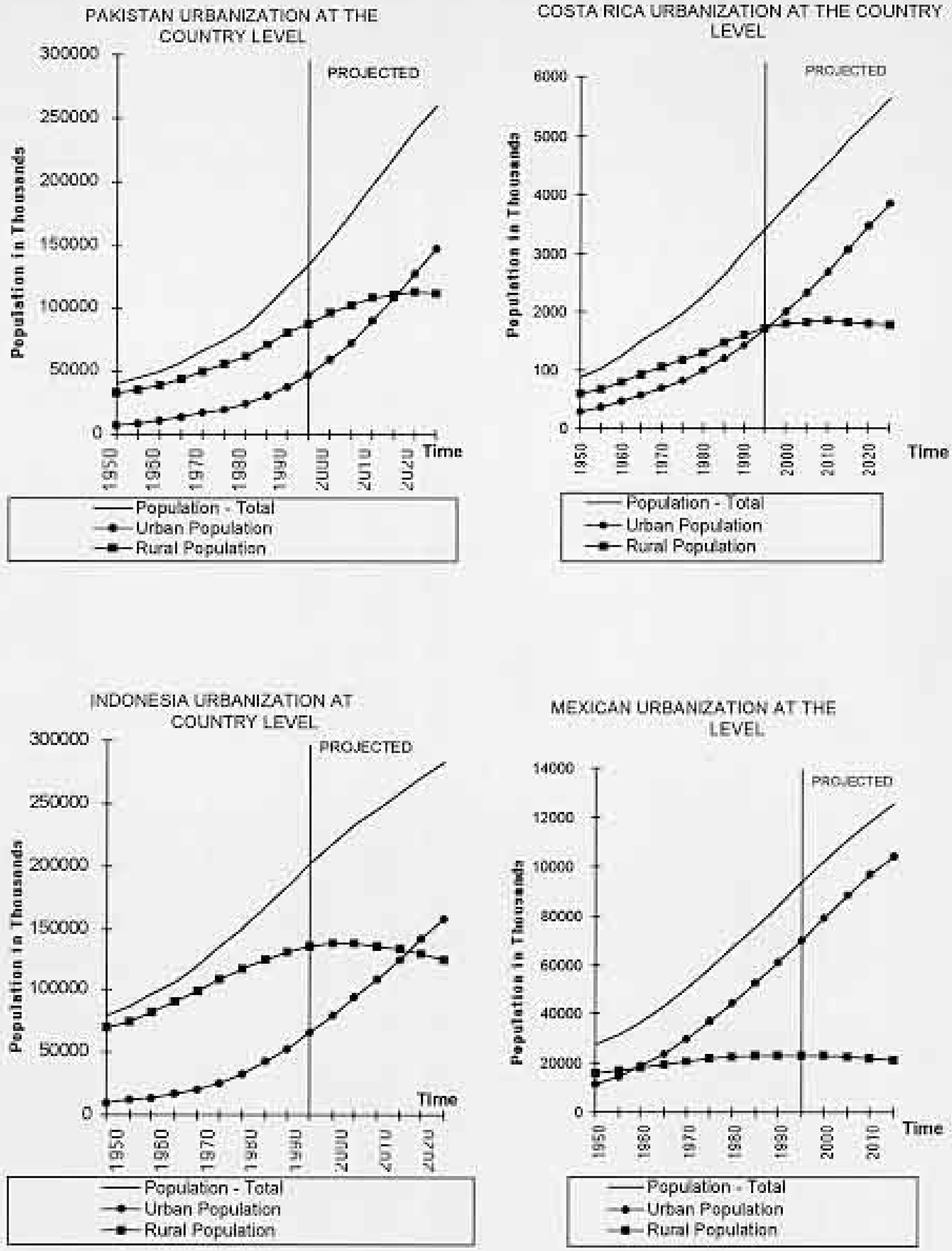
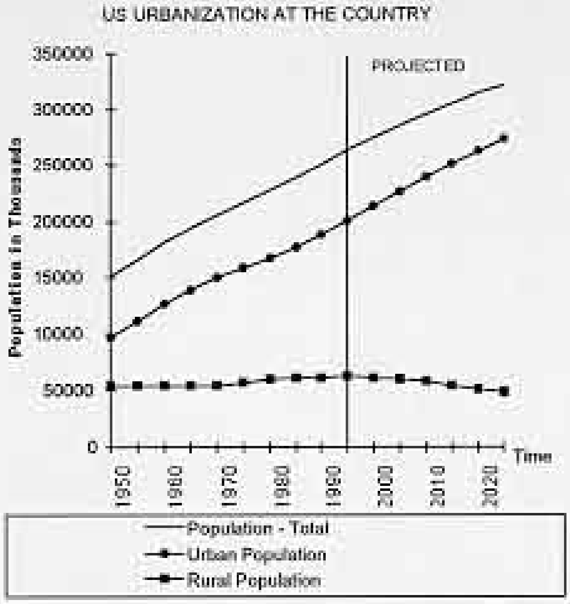
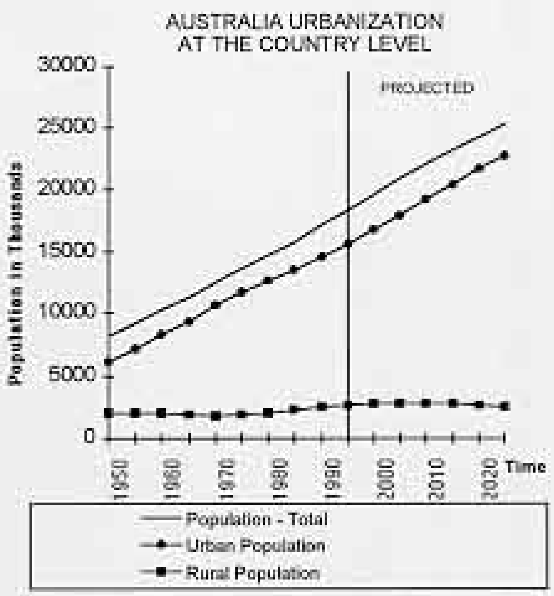
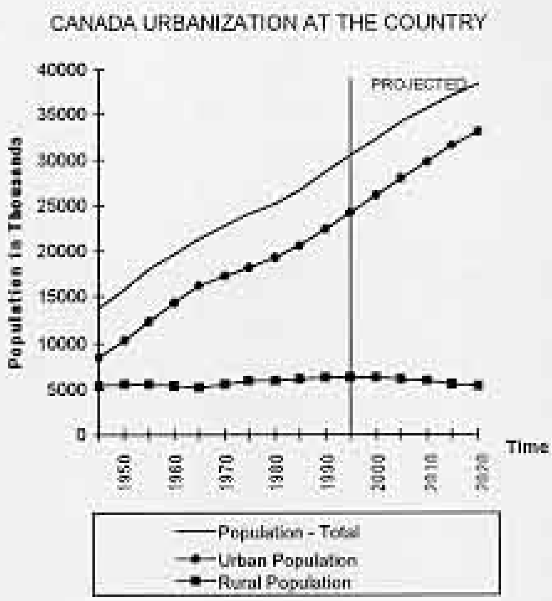
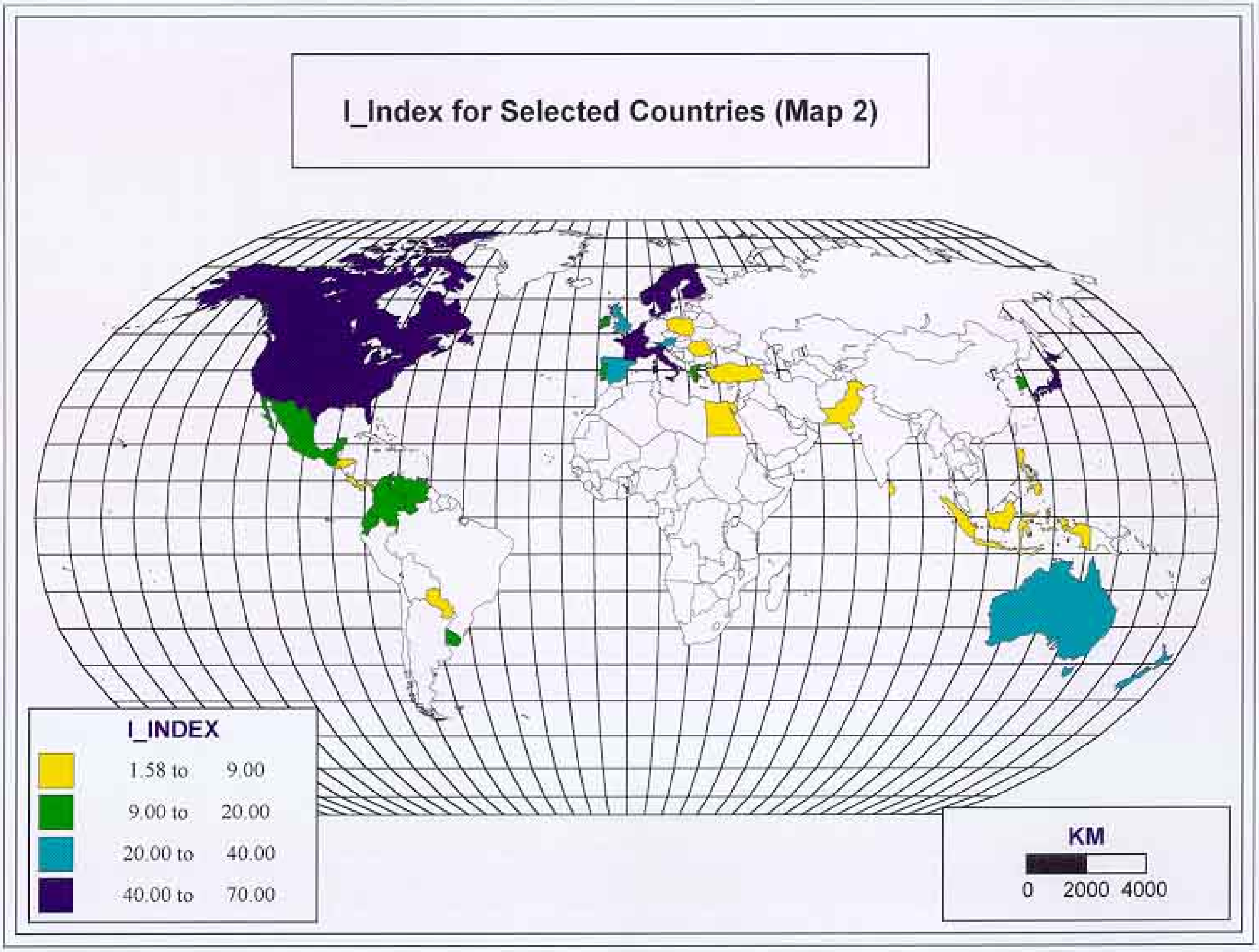


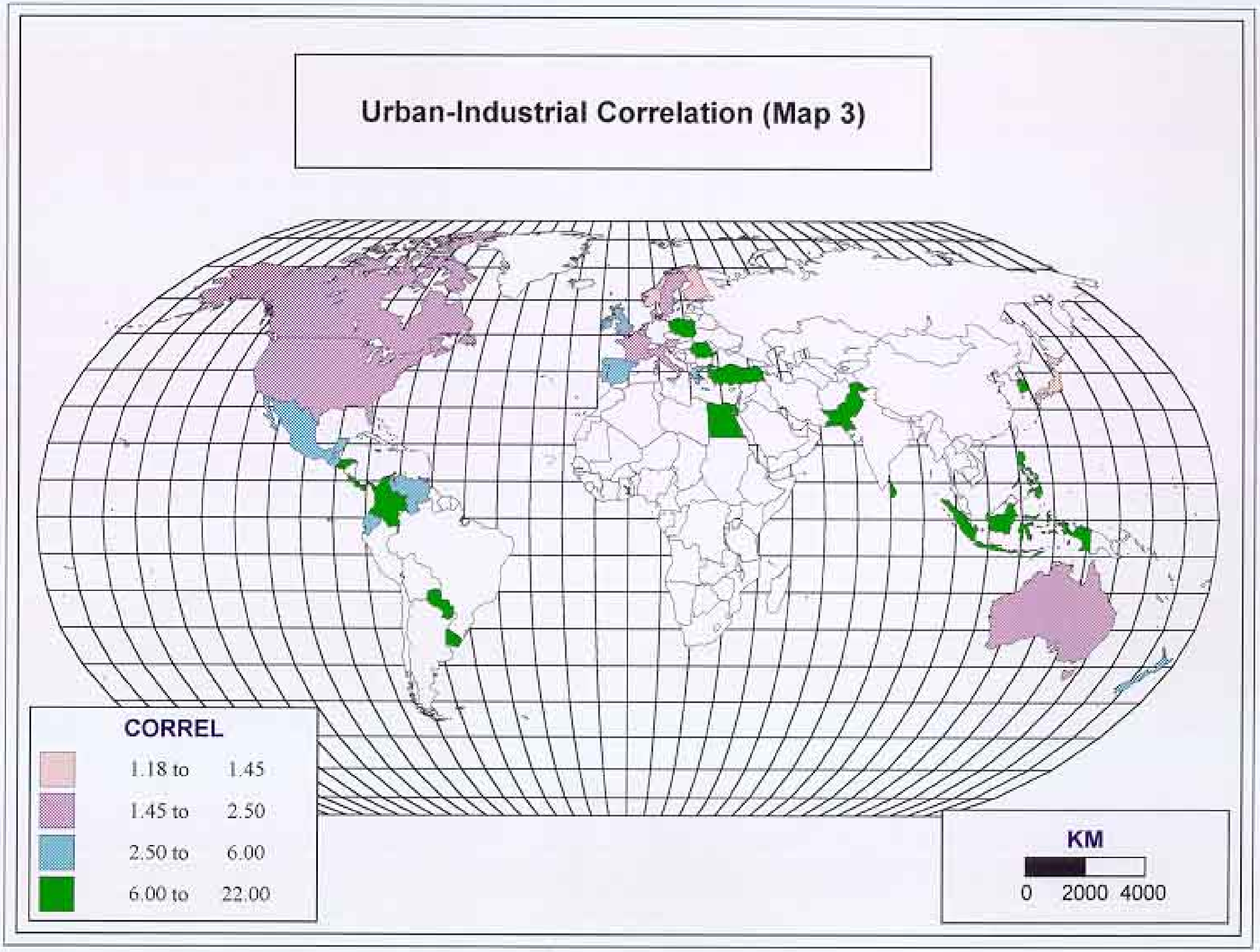
Figure 3c - Pattern C








I_Index for Selected Countries (Map 2)
I_INDEX
1.58 to 9.00
9.00 to 20.00
20.00 to 40.00
40.00 to 70.00
KM
0 2000 4000



Urban-Industrial Correlation (Map 3)
CORREL
1.18 to 1.45
1.45 to 2.50
2.50 to 6.00
6.00 to 22.00
KM
0 2000 4000

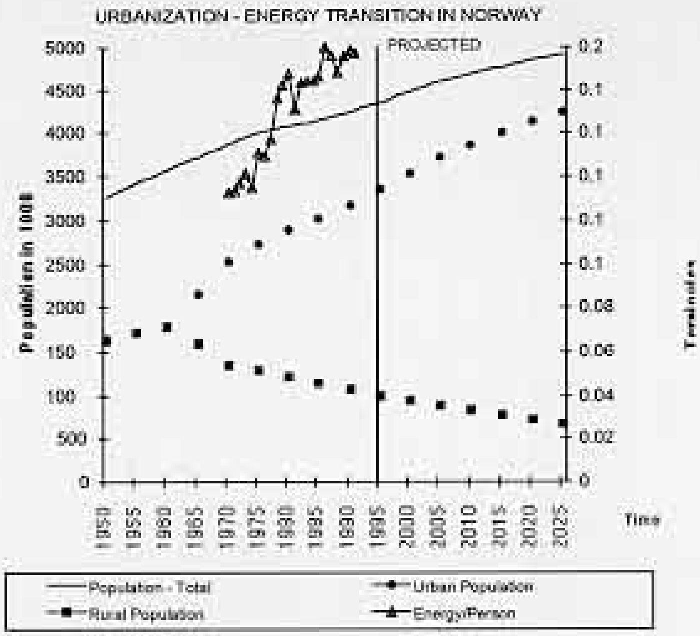


Figure 4 a - Urbanization and Energy Consumption Trend in Norway

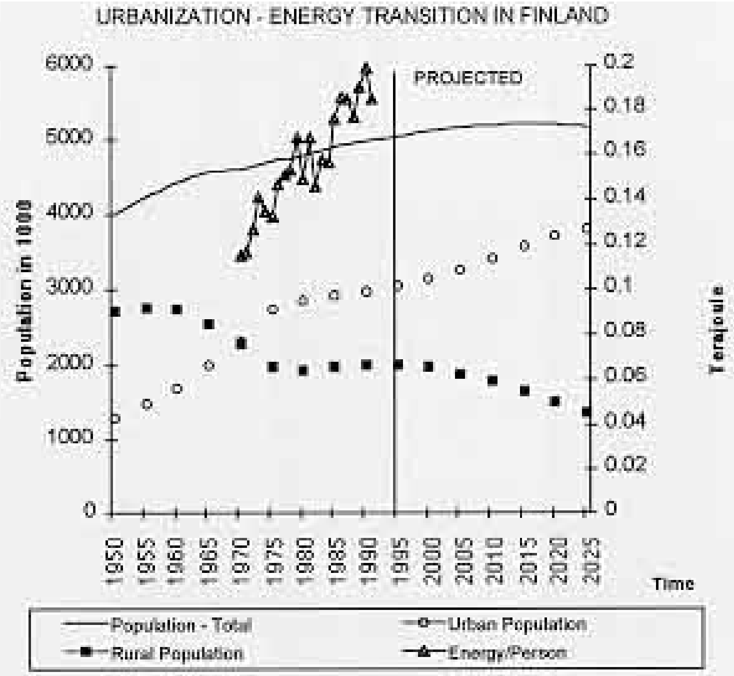


Figure 4 b - Urbanization and Energy Consumption Trend in Finland

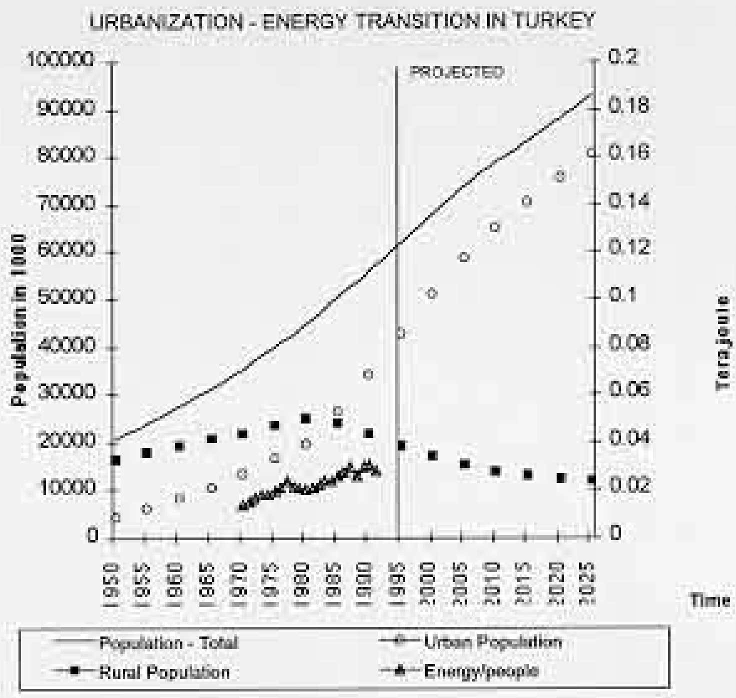


Figure 5 a - "Low Energy" Urbanization in Turkey

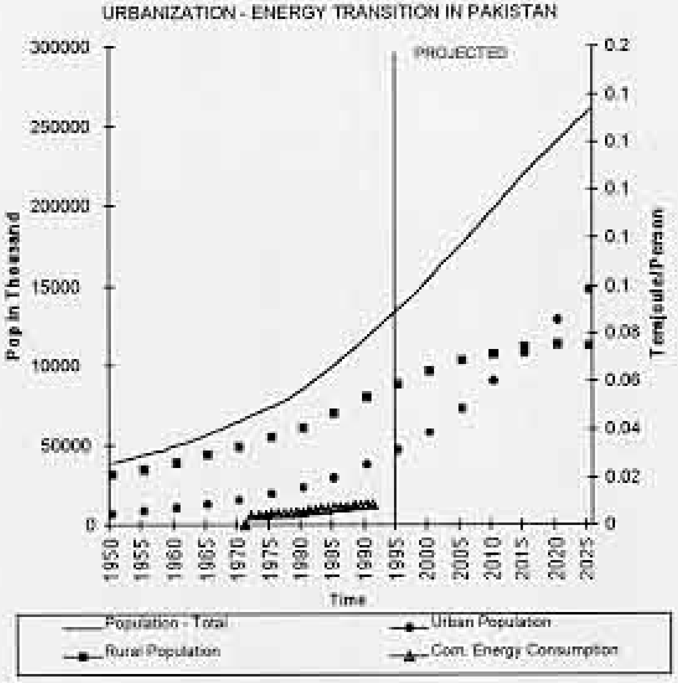


Figure 5 b - "Low Energy" Urbanization in Pakistan

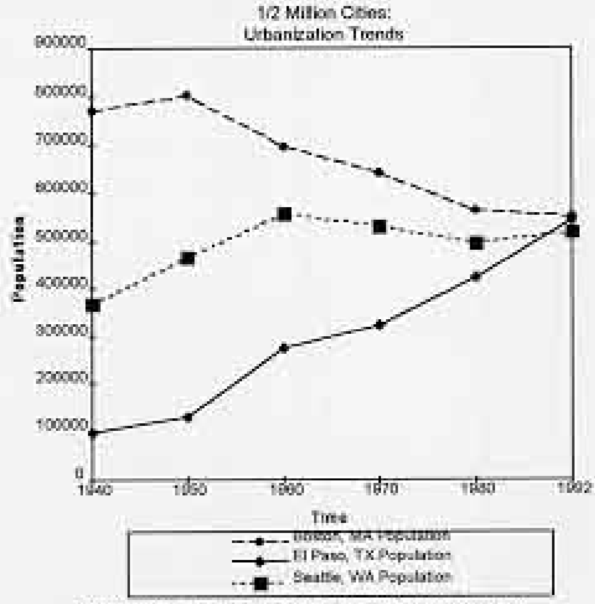


Figure 6a - Urban population development

Figure 6b - Urban population development

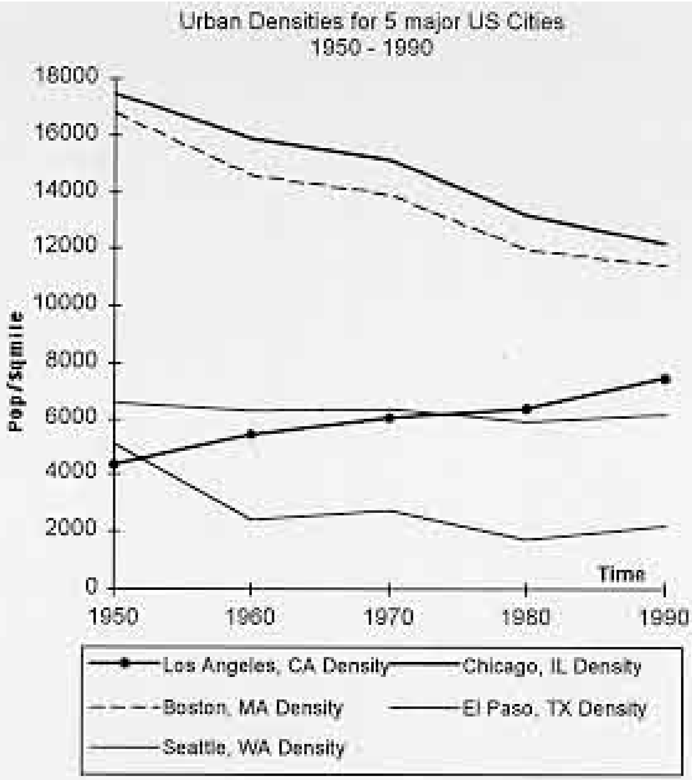


Figure 7 - Population Density Development

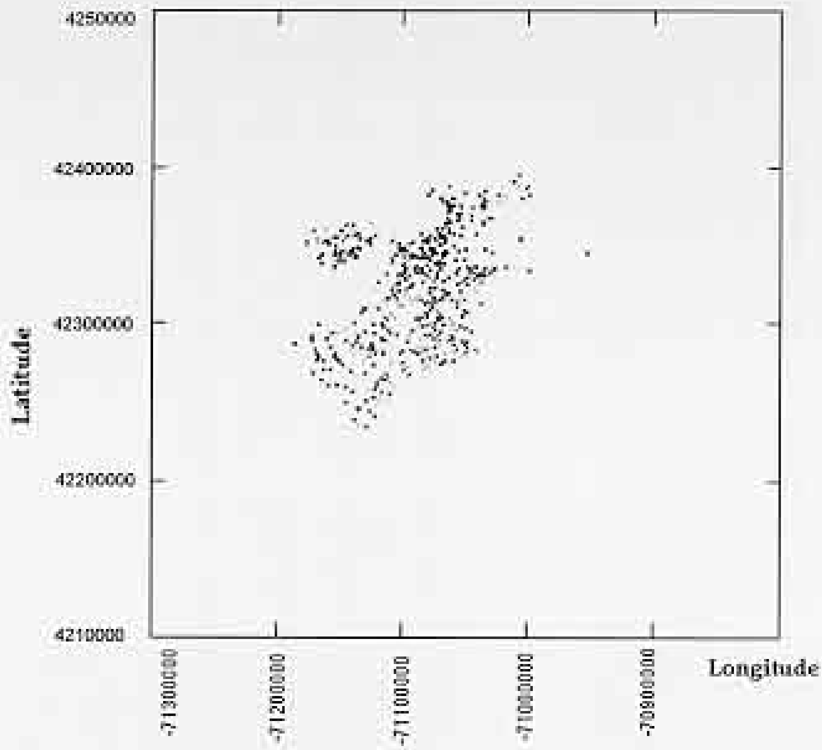


Figure 8a - City of Boston Shape in 1990 (Density by Color)

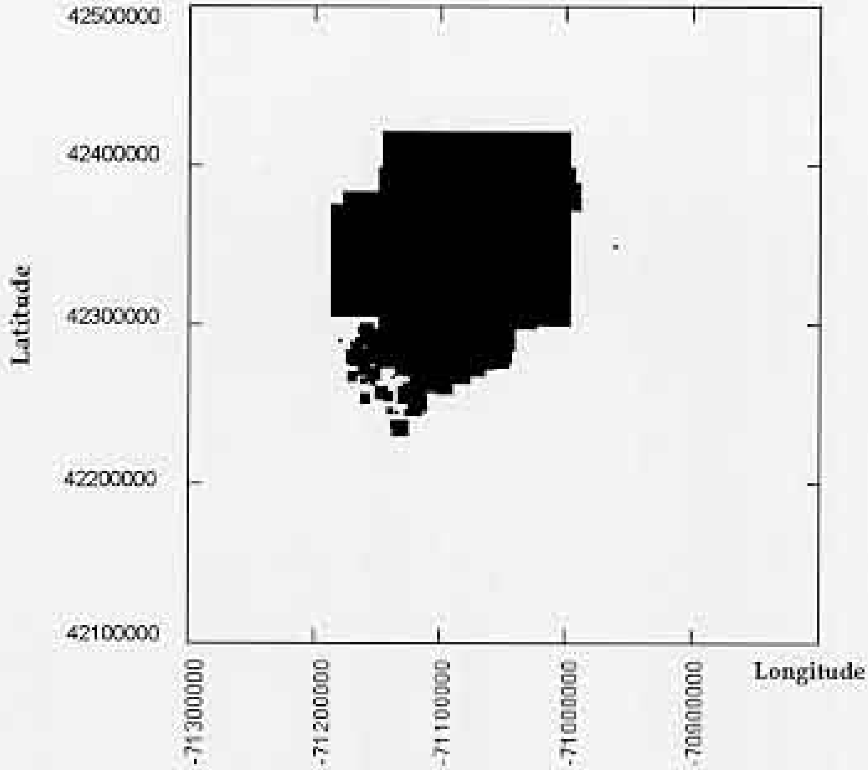


Figure 8b - City of Boston Shape in 1990 (Density by size of symbol)

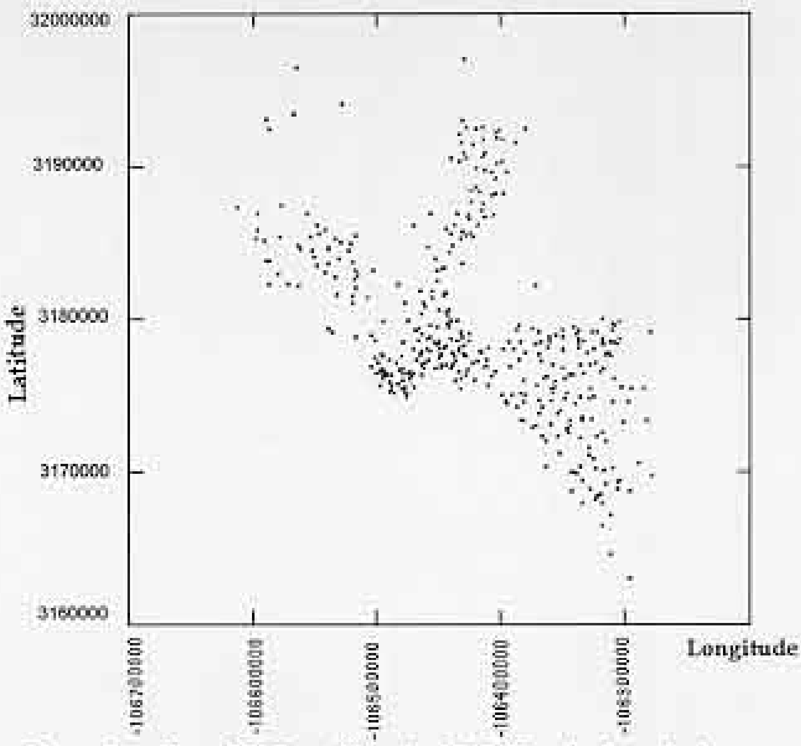


Figure 9a - City of El Paso Shape in 1990 (Density by color)

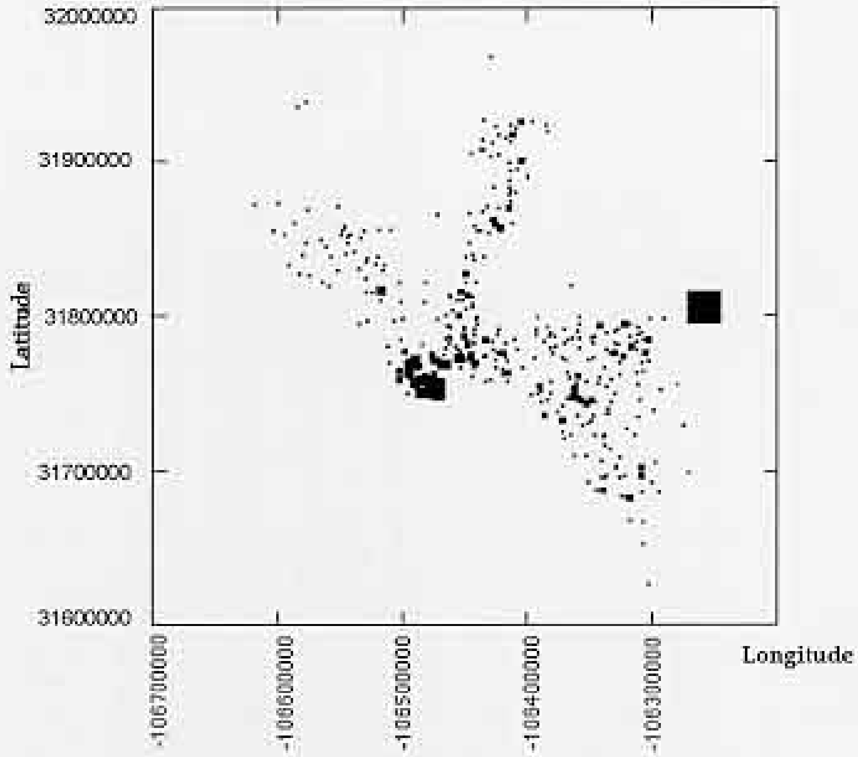
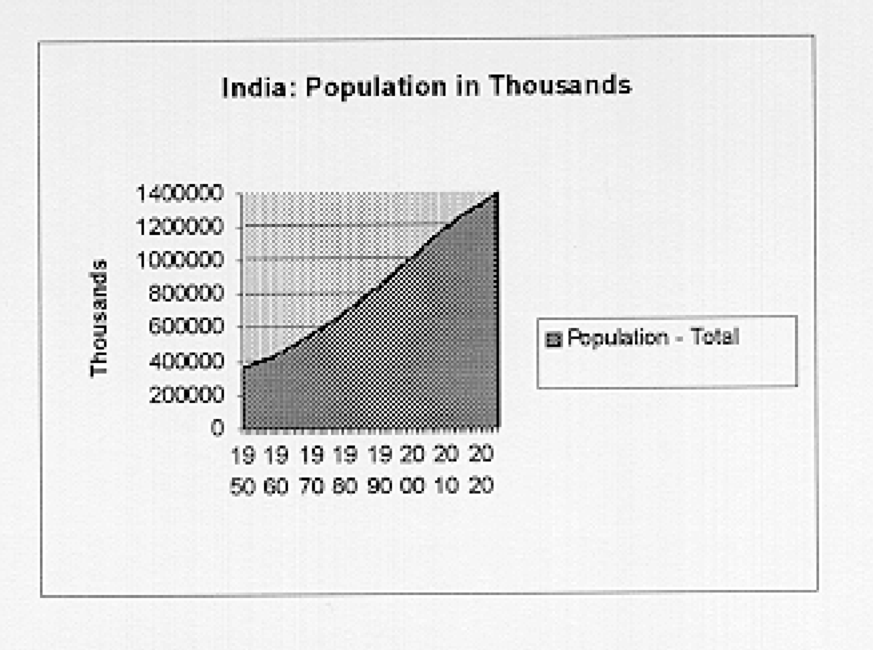
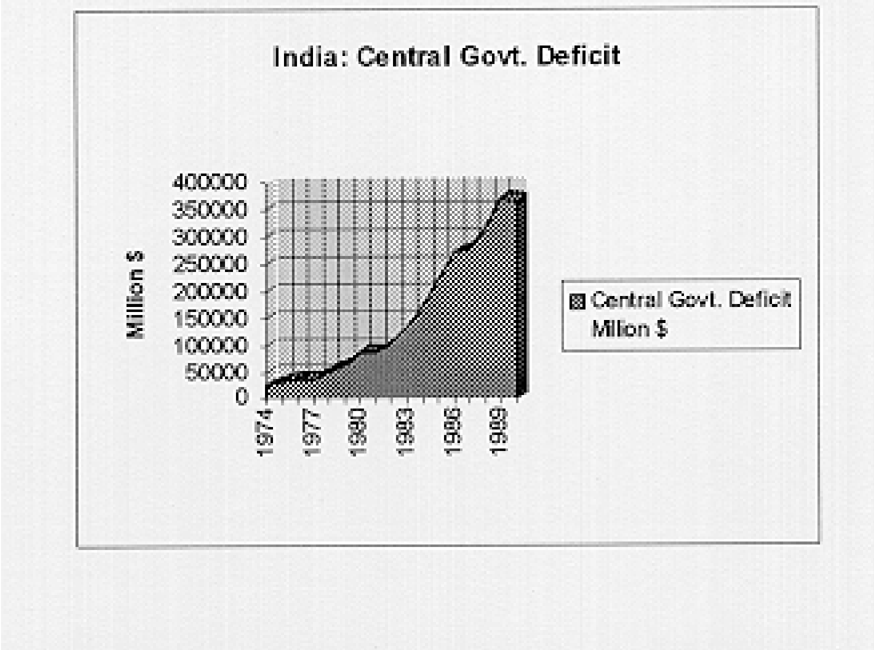
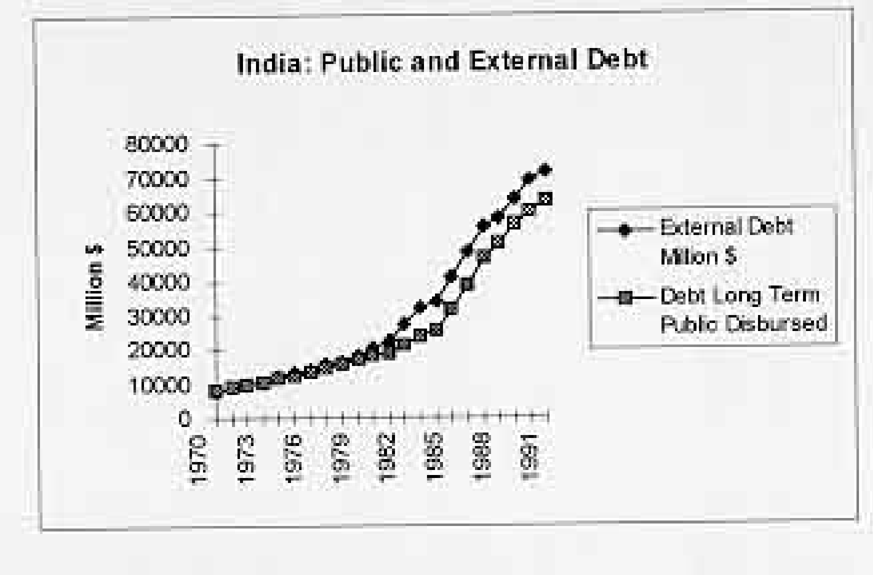
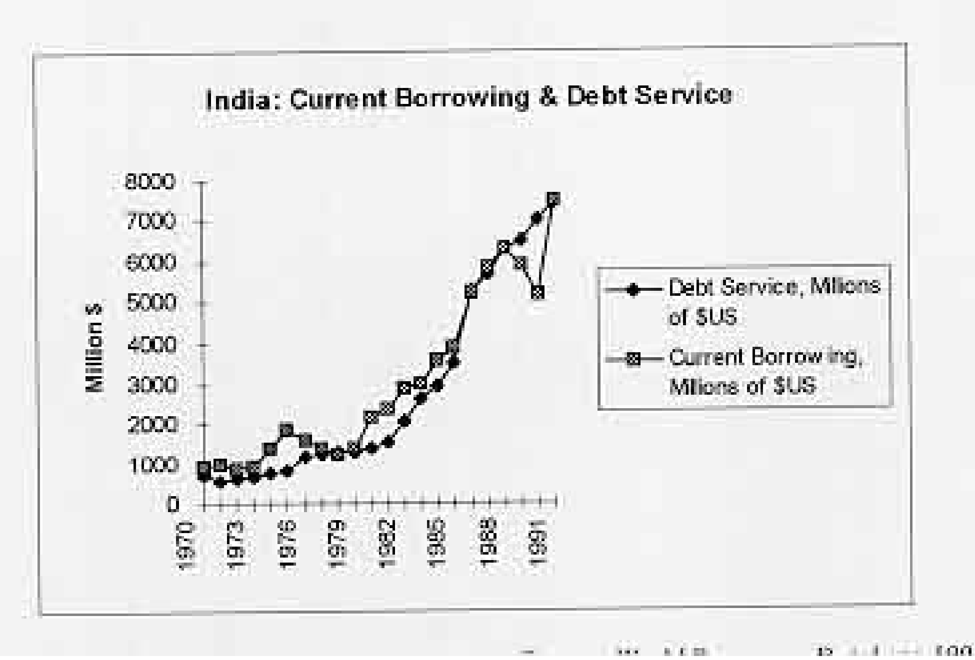


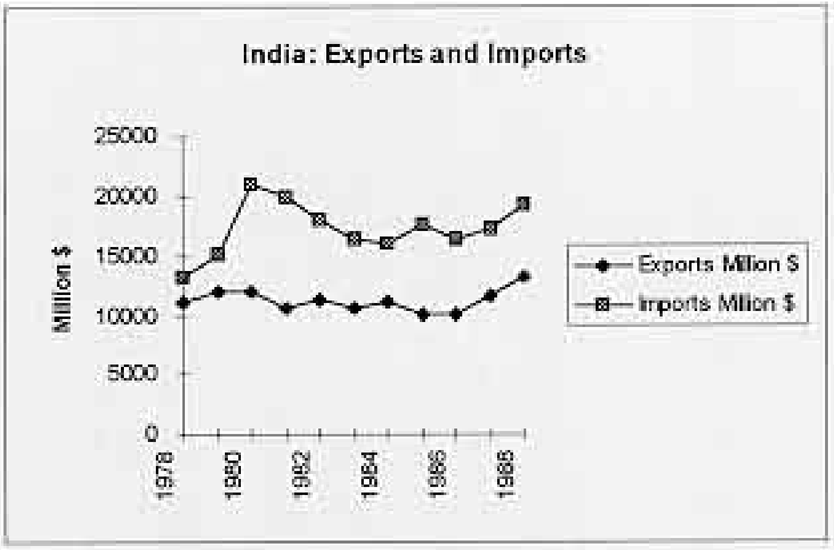
Figure 9b - City of El Paso Shape in 1990 (Density by size of symbol)

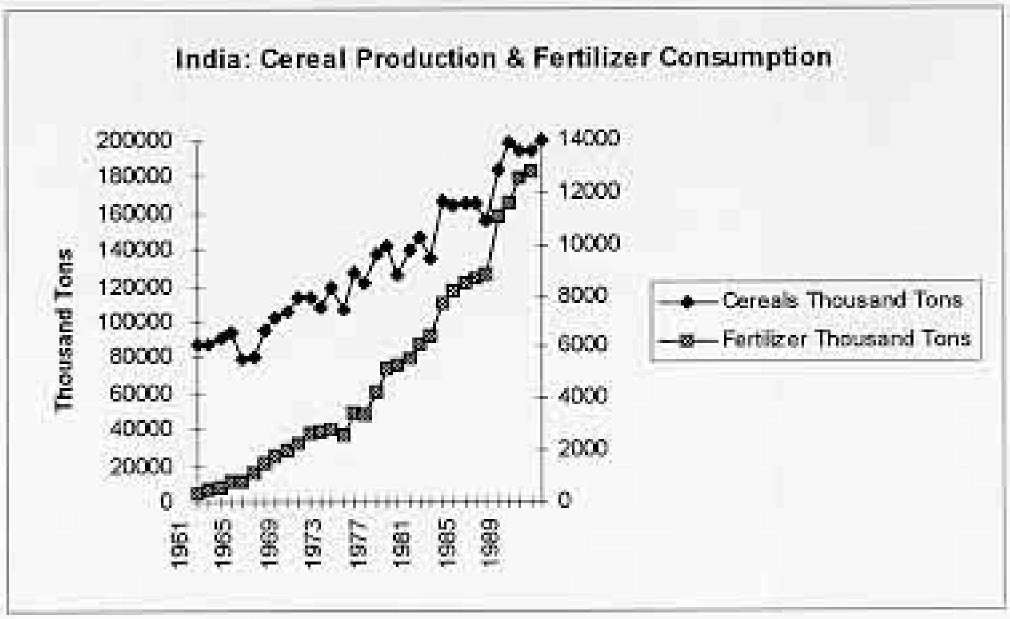

India: Population in Thousands
Thousands
1400000
1200000
1000000
800000
600000
400000
200000
0
19 19 19 19 19 20 20 20
50 60 70 80 90 00 10 20
Population - Total

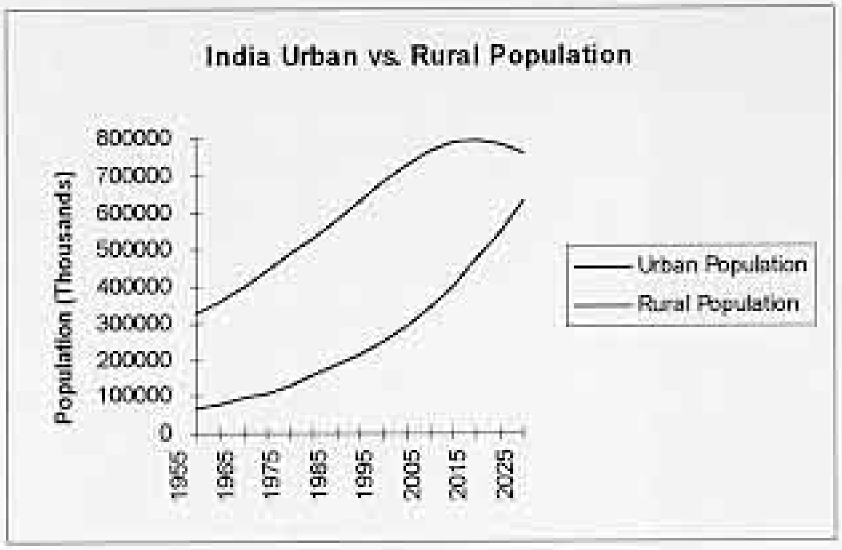

India: Central Govt. Deficit
Million $
400000
350000
300000
250000
200000
150000
100000
50000
0
1974
1977
1980
1983
1986
1989
Central Govt. Deficit
Milion $

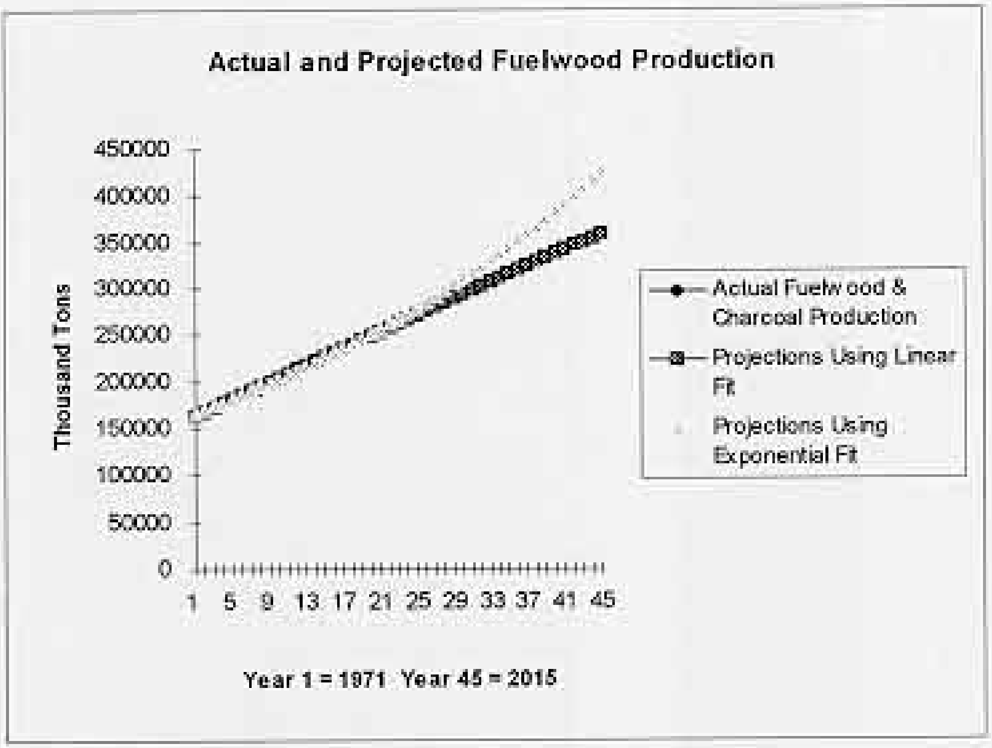

India: Public and External Debt
Million $
80000
70000
60000
50000
40000
30000
20000
10000
0
1970
1973
1976
1979
1982
1985
1988
1991
External Debt Milion $
Debt Long Term Public Disbursed


India: Current Borrowing & Debt Service
8000
7000
6000
5000
4000
3000
2000
1000
0
Million $
1970
1973
1976
1979
1982
1985
1988
1991
Debt Service, Milions of $US
Current Borrow ing, Milions of $US

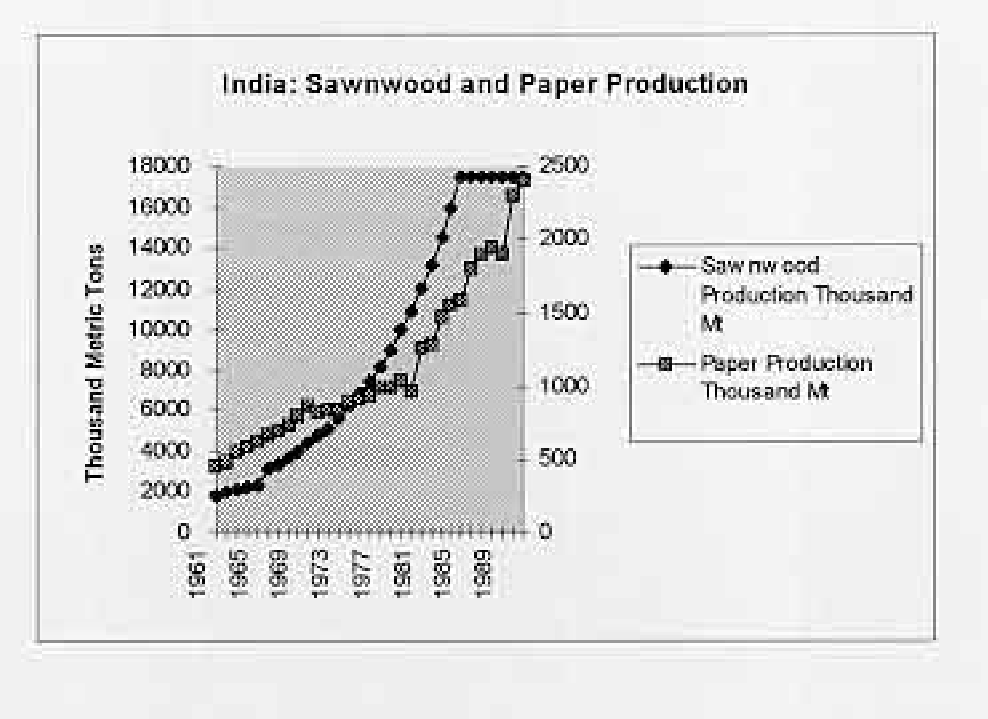

India: Exports and Imports
25000
20000
15000
10000
5000
0
Million $
1978
1980
1982
1984
1986
1988
Exports Milion $
Imports Milion $

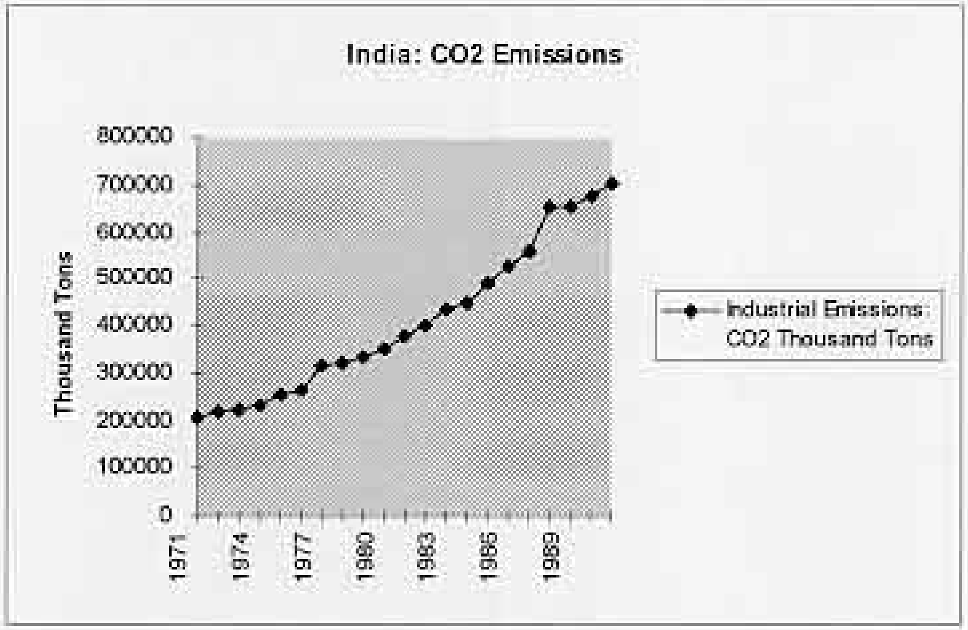

India: Cereal Production & Fertilizer Consumption
Thousand Tons
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
14000
12000
10000
8000
6000
4000
2000
0
1961
1965
1969
1973
1977
1981
1985
1989
Cereals Thousand Tons
Fertilizer Thousand Tons

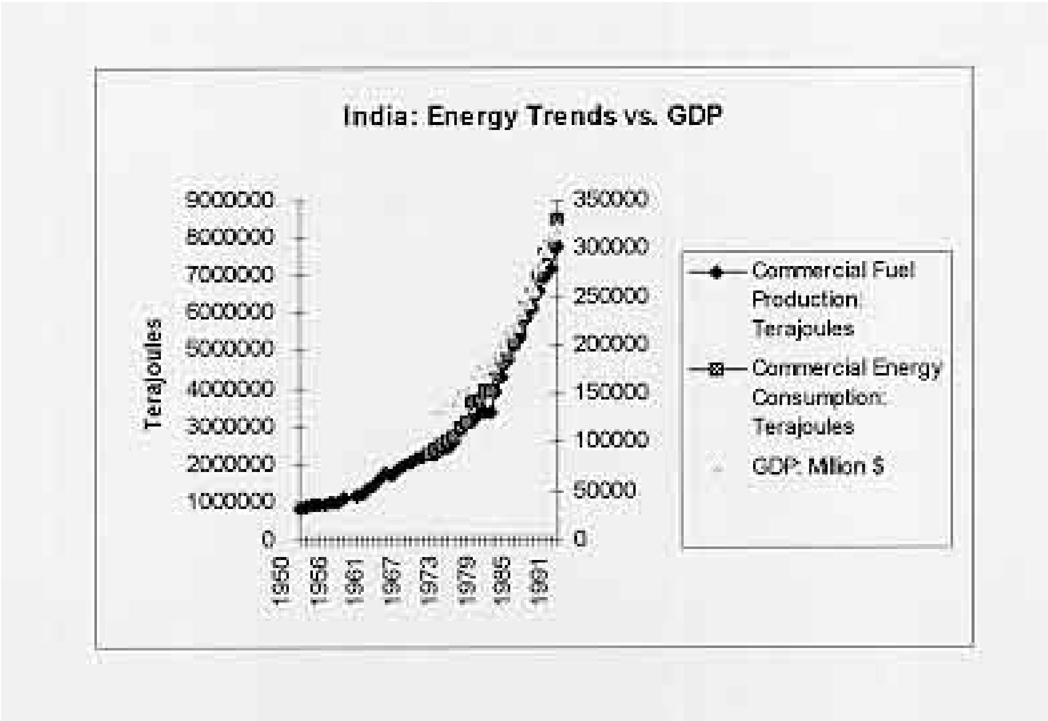

India Urban vs. Rural Population
Population (Thousands)
800000
700000
600000
500000
400000
300000
200000
100000
0
1955
1965
1975
1985
1995
2005
2015
2025
Urban Population
Rural Population


Actual and Projected Fuelwood Production
450000
400000
350000
300000
250000
200000
150000
100000
50000
0
Thousand Tons
1 5 9 13 17 21 25 29 33 37 41 45
Year 1 = 1971 Year 45 = 2015
Actual Fuelw ood & Charcoal Production
Projections Using Linear Fit
Projections Using Exponential Fit

171


India: Sawnwood and Paper Production
Thousand Metric Tons
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2500
2000
1500
1000
500
0
1961
1965
1969
1973
1977
1981
1985
1989
Saw nw ood Production Thousand Mt
Paper Production Thousand Mt


India: CO2 Emissions
Thousand Tons
800000
700000
600000
500000
400000
300000
200000
100000
0
1971
1974
1977
1980
1983
1986
1989
Industrial Emissions:
CO2 Thousand Tons


India: Energy Trends vs. GDP
Terajoules
9000000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
350000
300000
250000
200000
150000
100000
50000
0
1950
1956
1961
1967
1973
1979
1985
1991
Commercial Fuel Production: Terajoules
Commercial Energy Consumption: Terajoules
GDP: Milion $

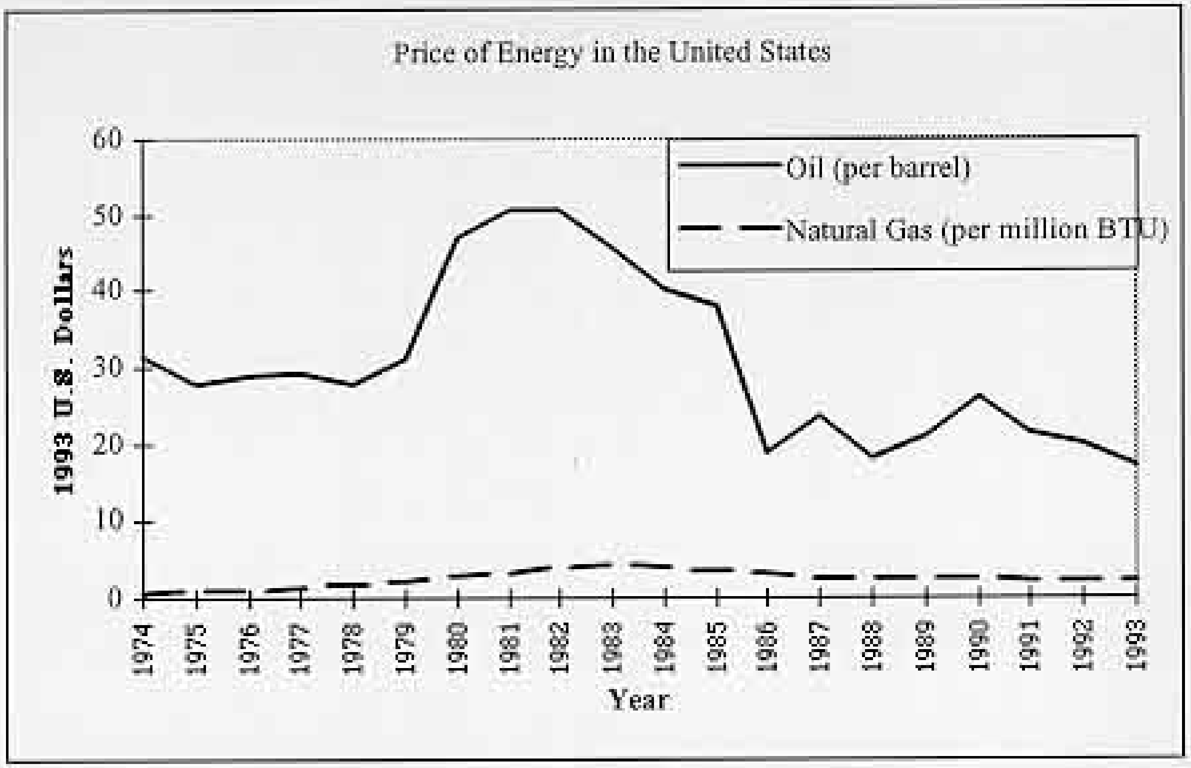


figure 1 (Source: World Resource Database, 1995)

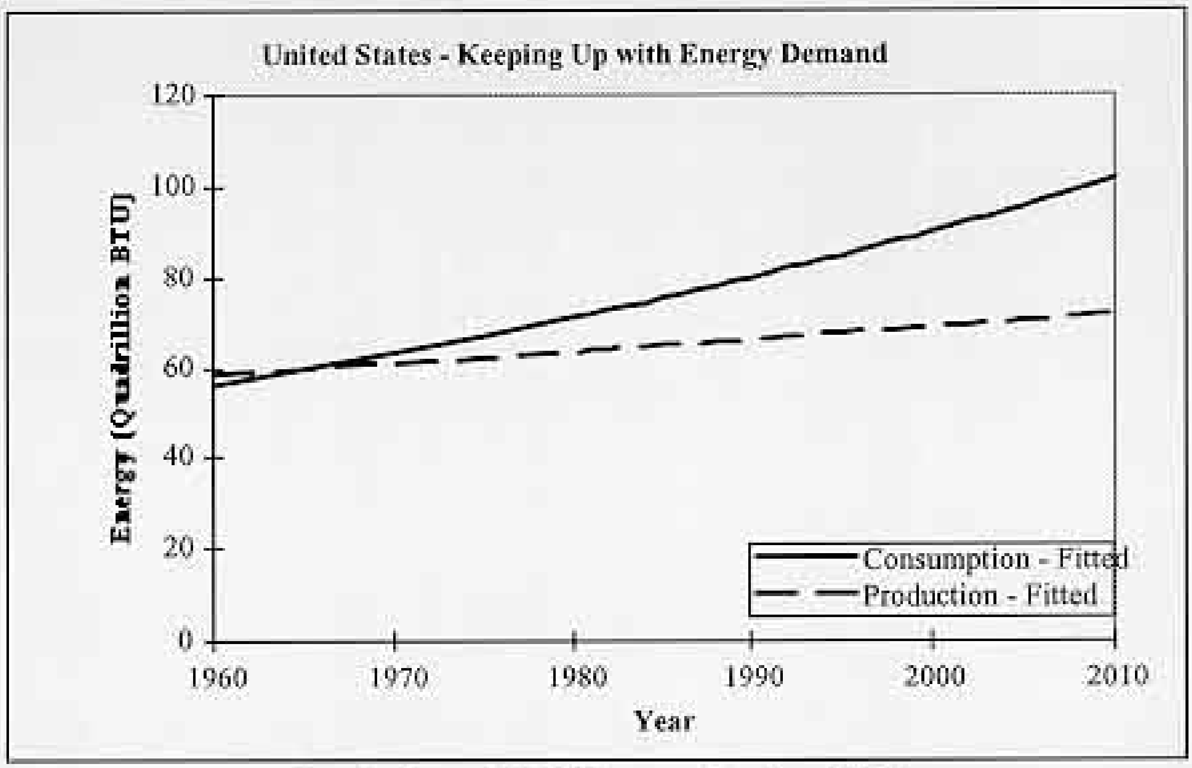


figure 2 (Source: World Resource Database, 1995)

exponential fit for all data

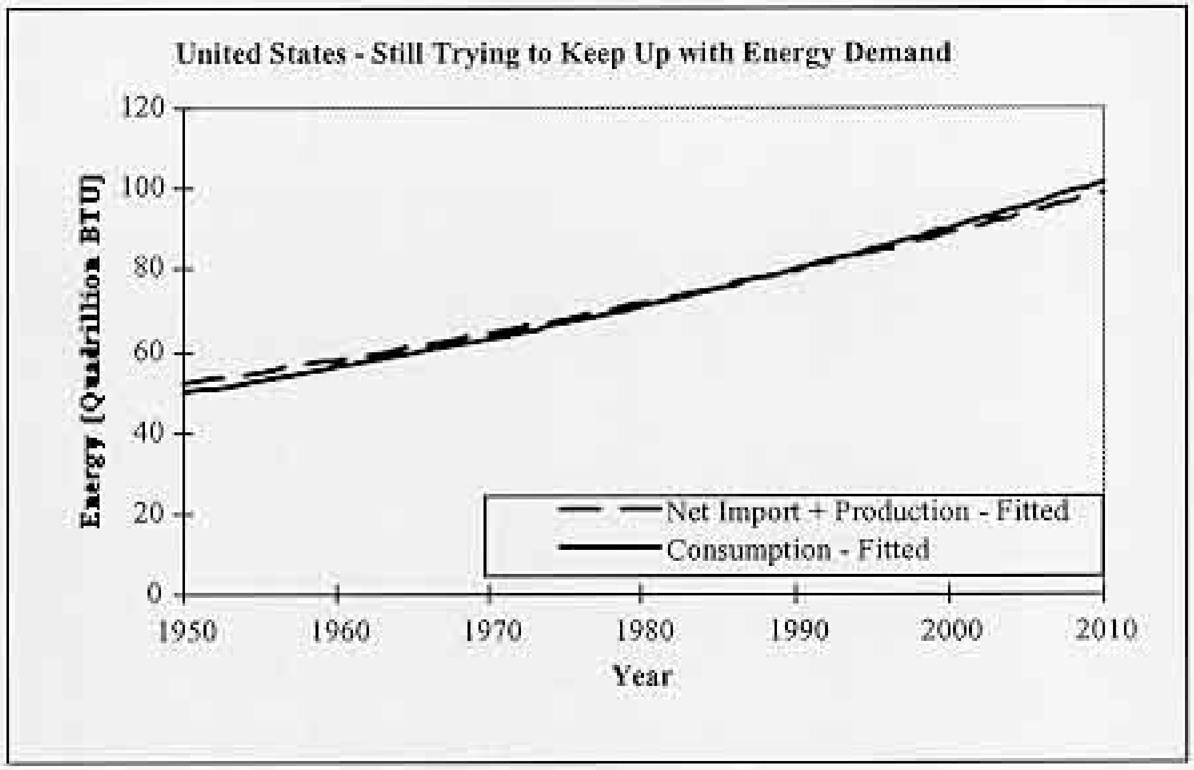


figure 3 (Source: World Resource Database, 1995) exponential fit for all data

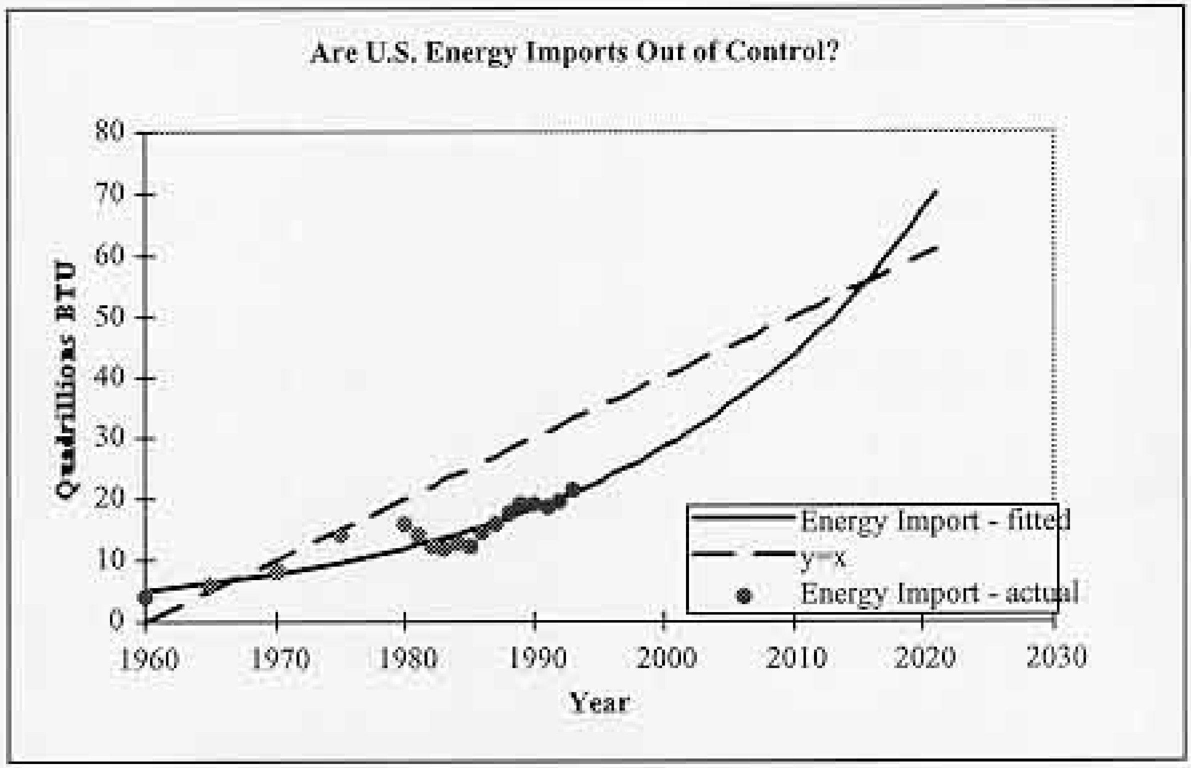


figure 4 (Source: World Resource Database, 1995)

exponential fit for energy import data

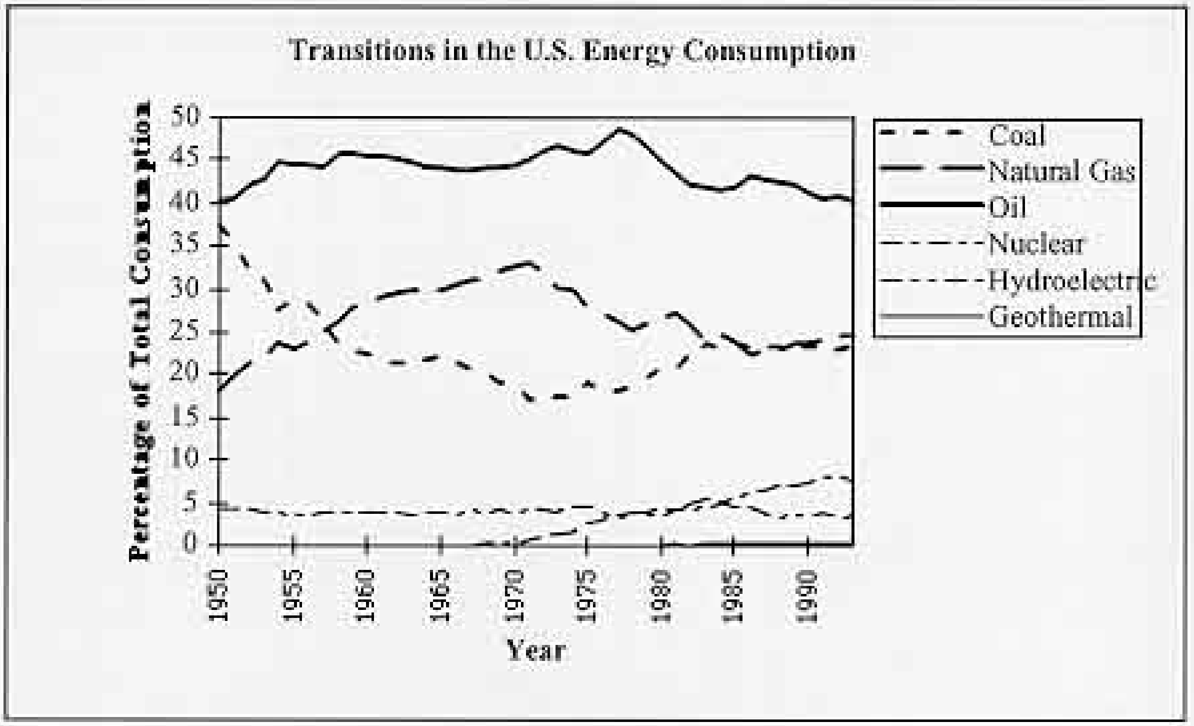


figure 5 (Source: Annual Energy Review, 1993)

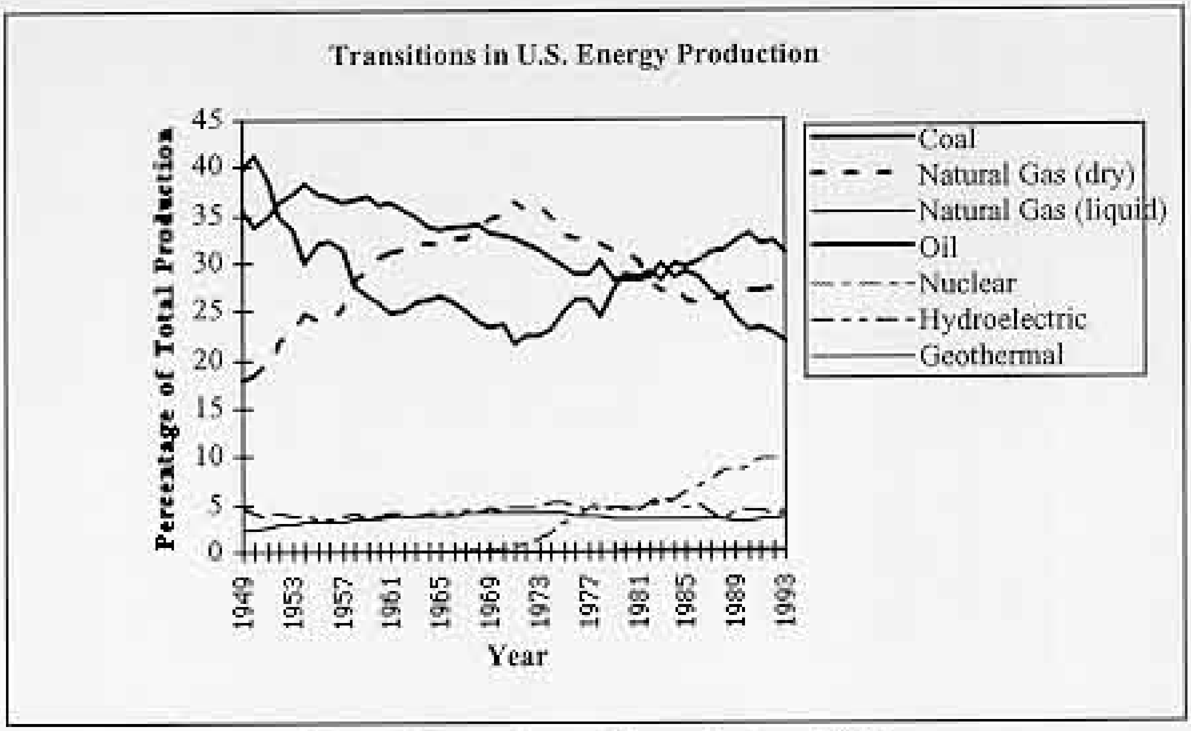


figure 6 (Source: Annual Energy Review, 1993)

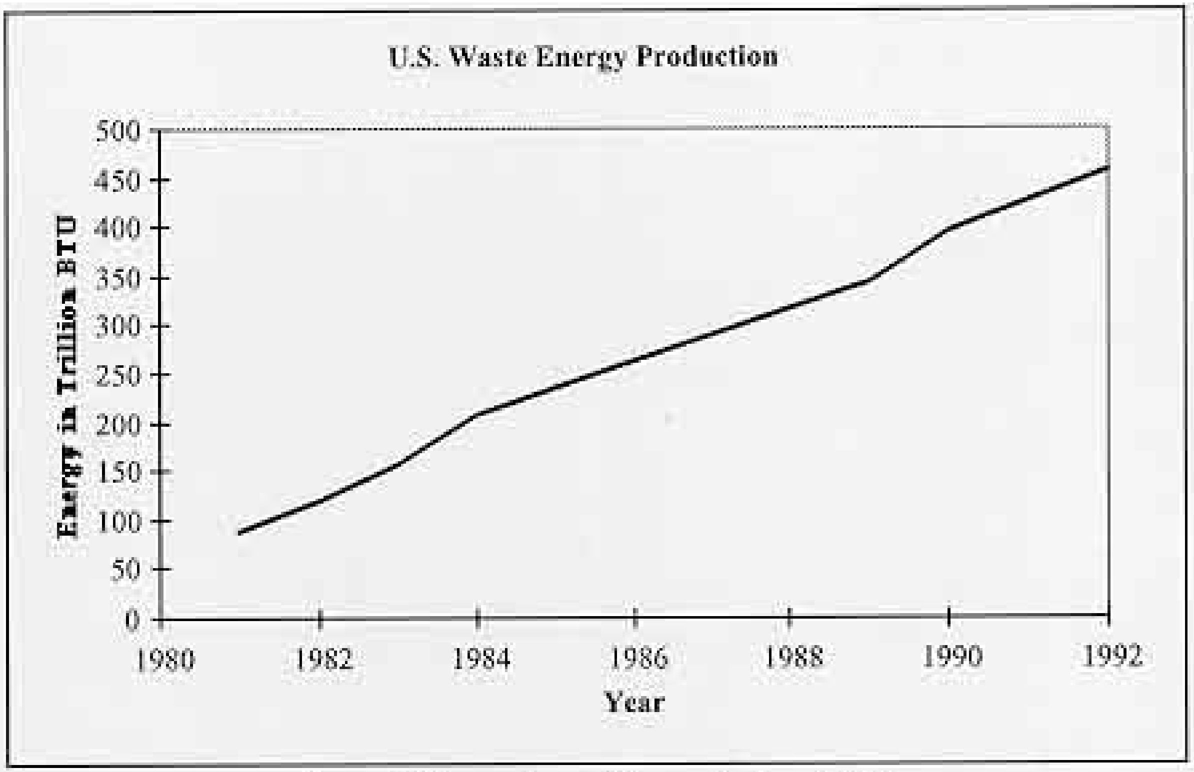


figure 7 (Source: Annual Energy Review, 1993)

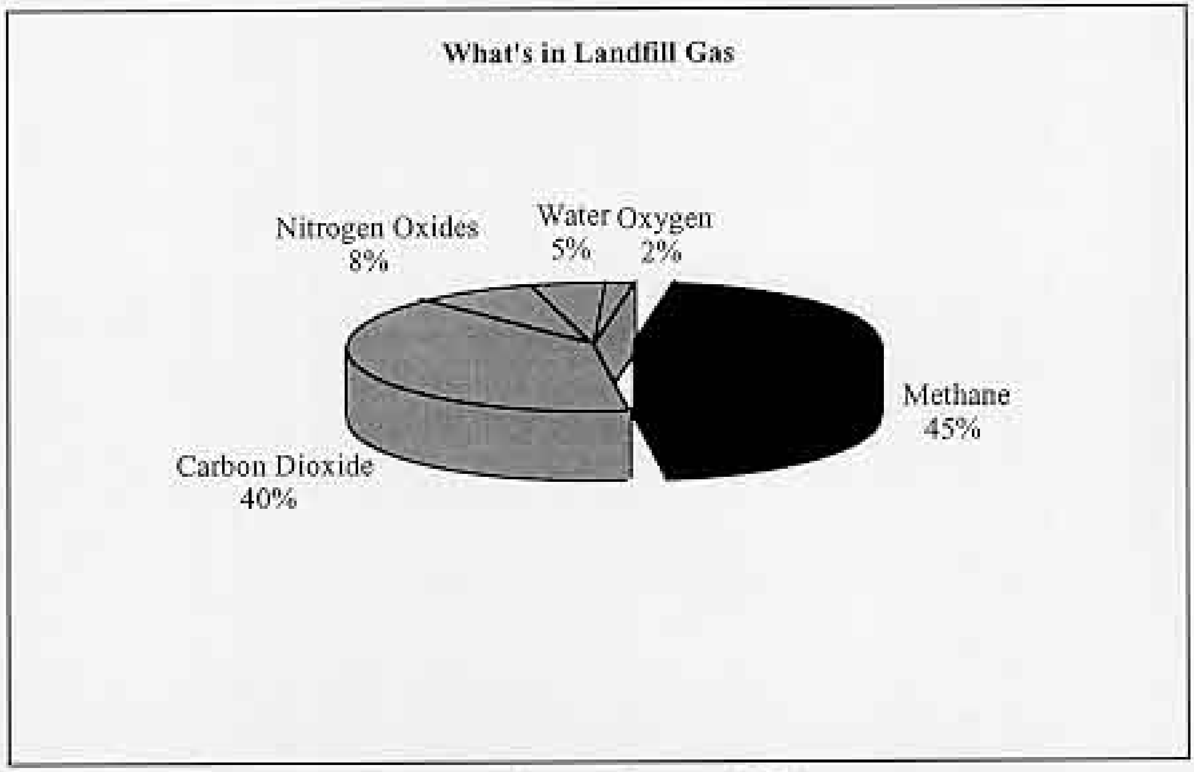


figure 8 (Source: Chestnut, 1991)

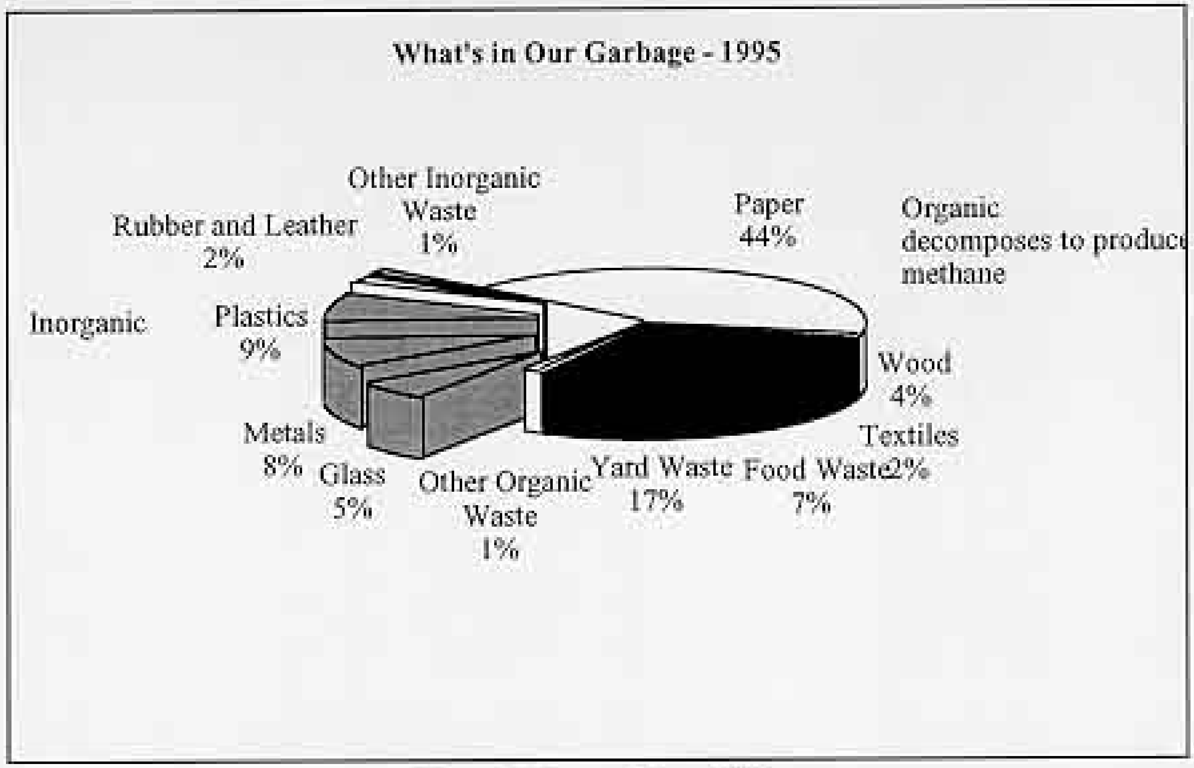


figure 9 (Source: Qian, 1995)

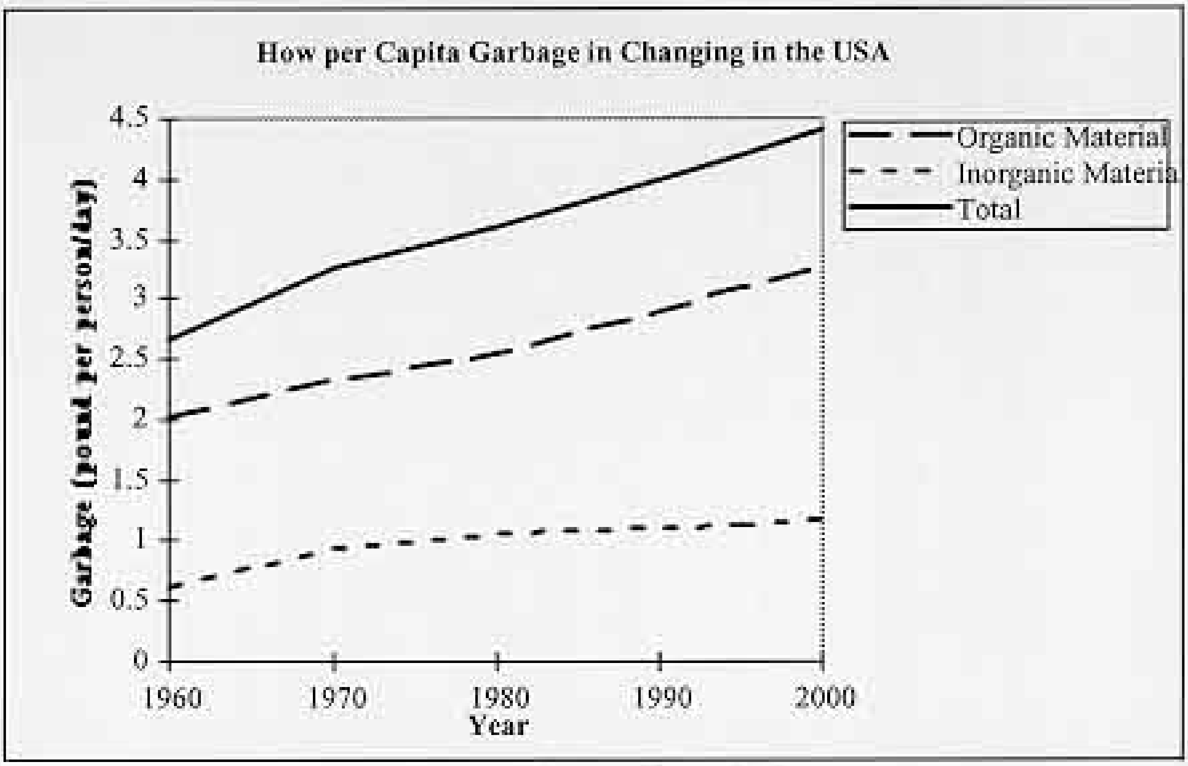


figure 10 (Source: Qian, 1995)

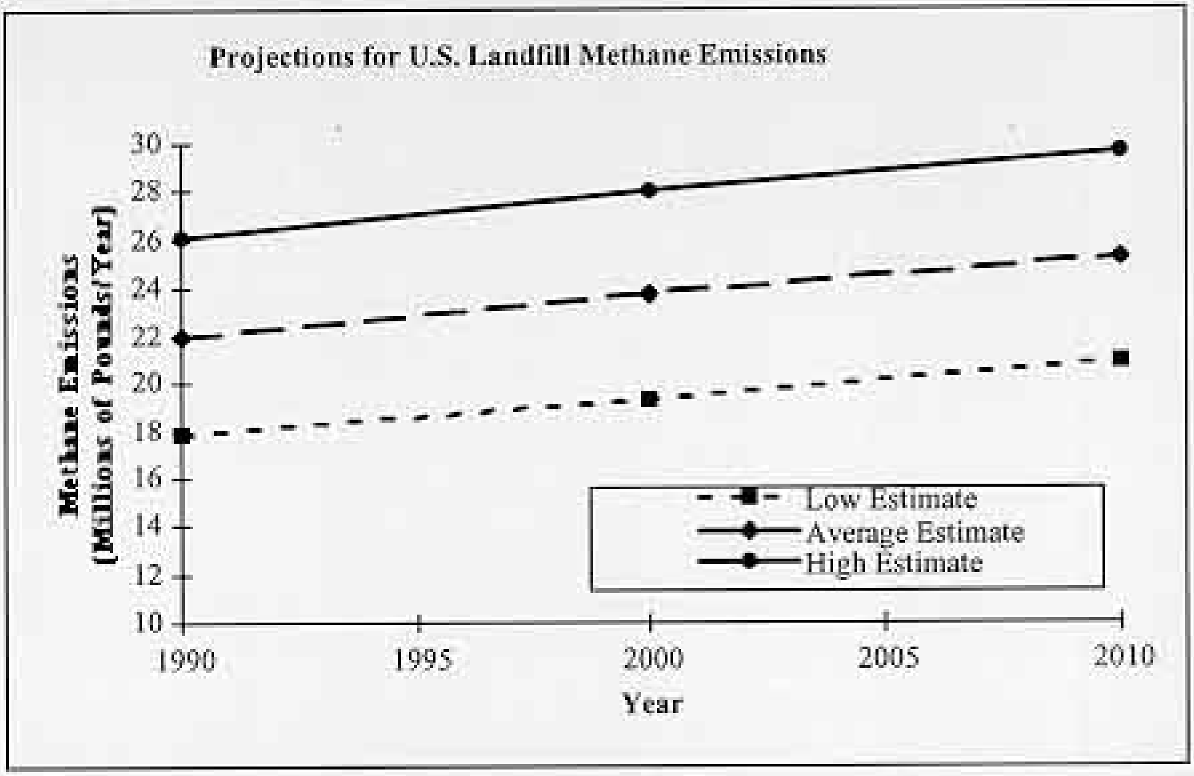


figure 11 (Source: Hogan, 1993)

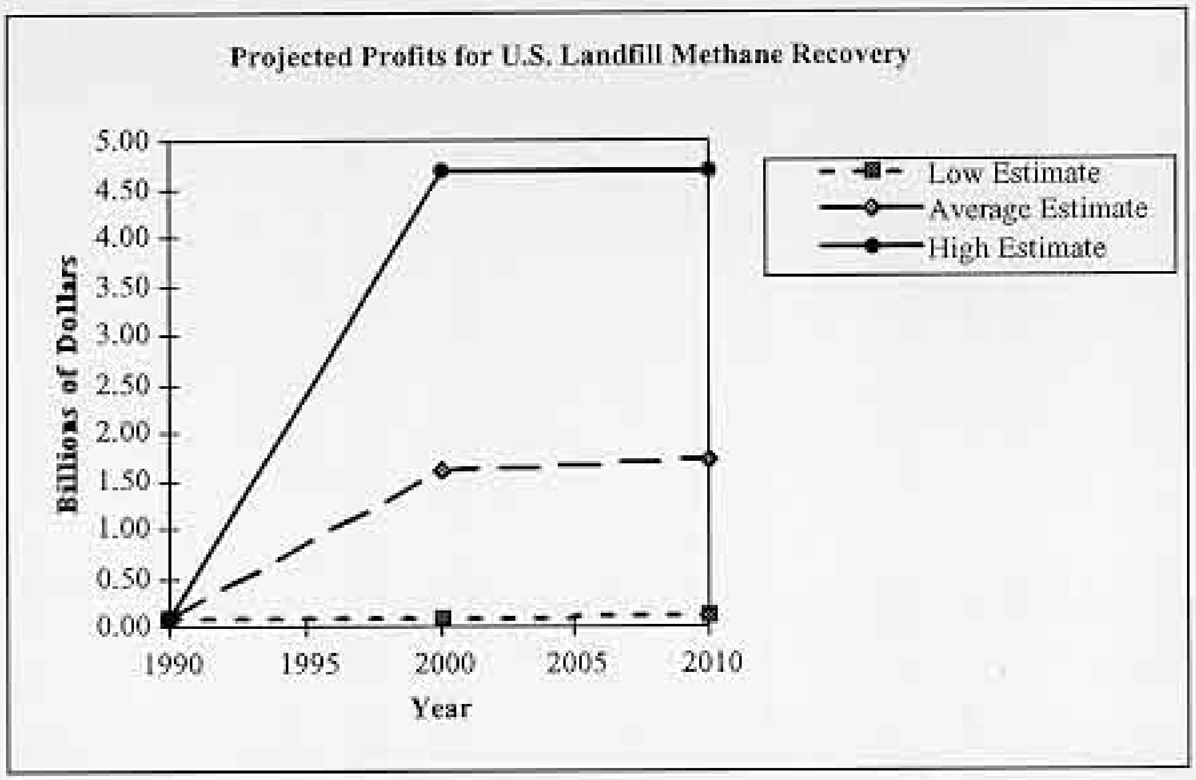


figure 12 (Source: Hogan, 1993)

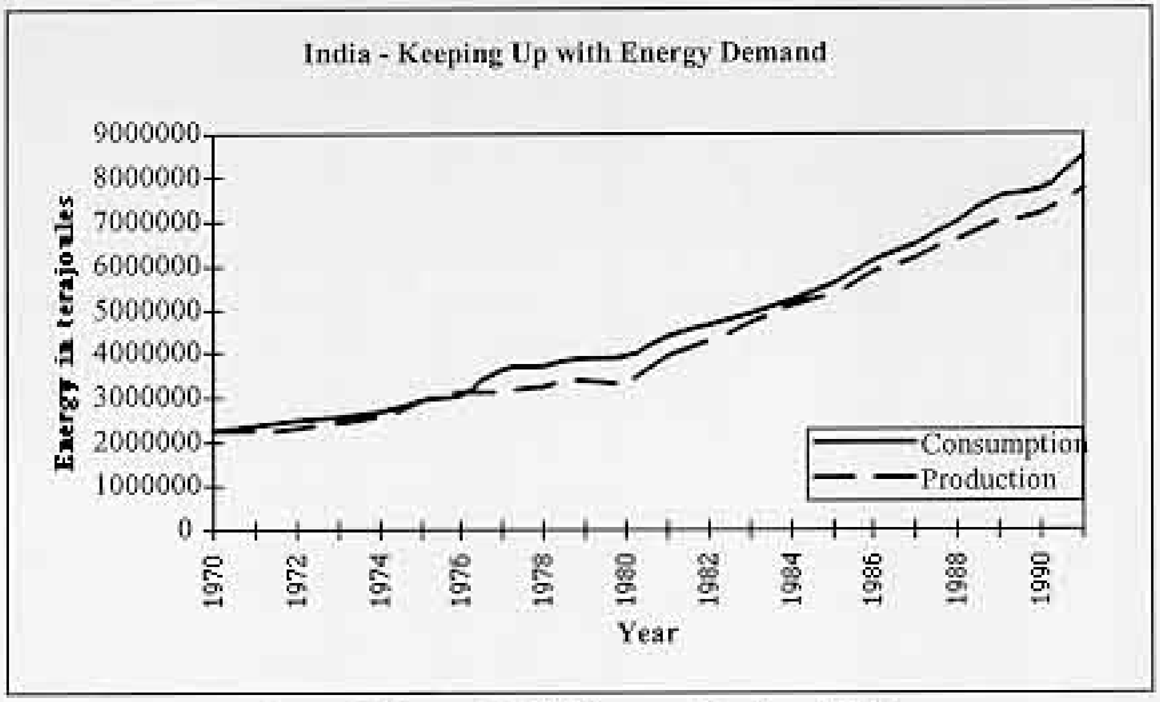


figure 13 (Source: World Resource Database, 1995)

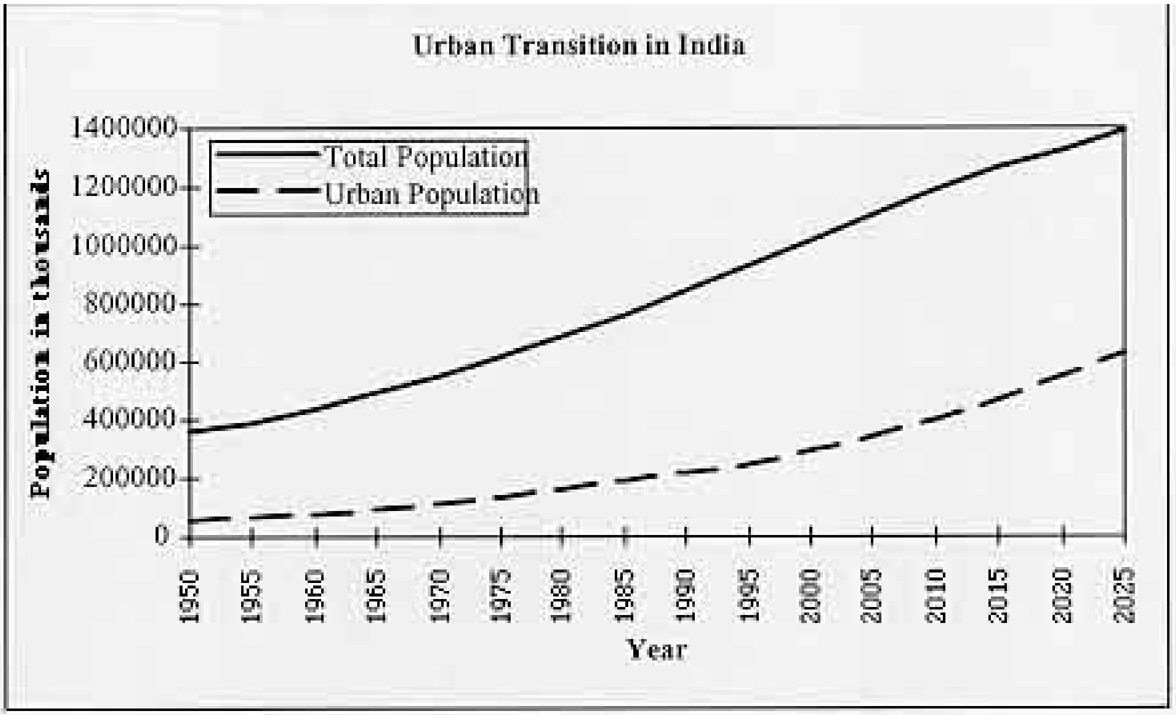


figure 14 (Source: World Resource Database, 1995)

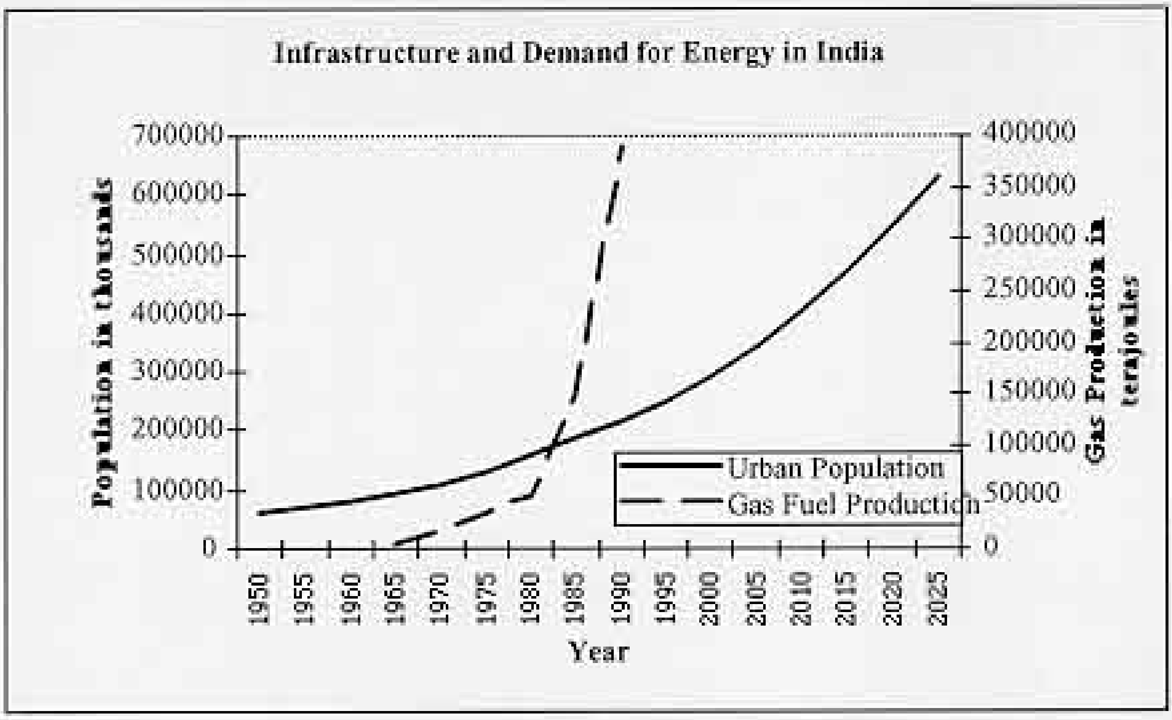


figure 15 (Source: World Resource Database, 1995)

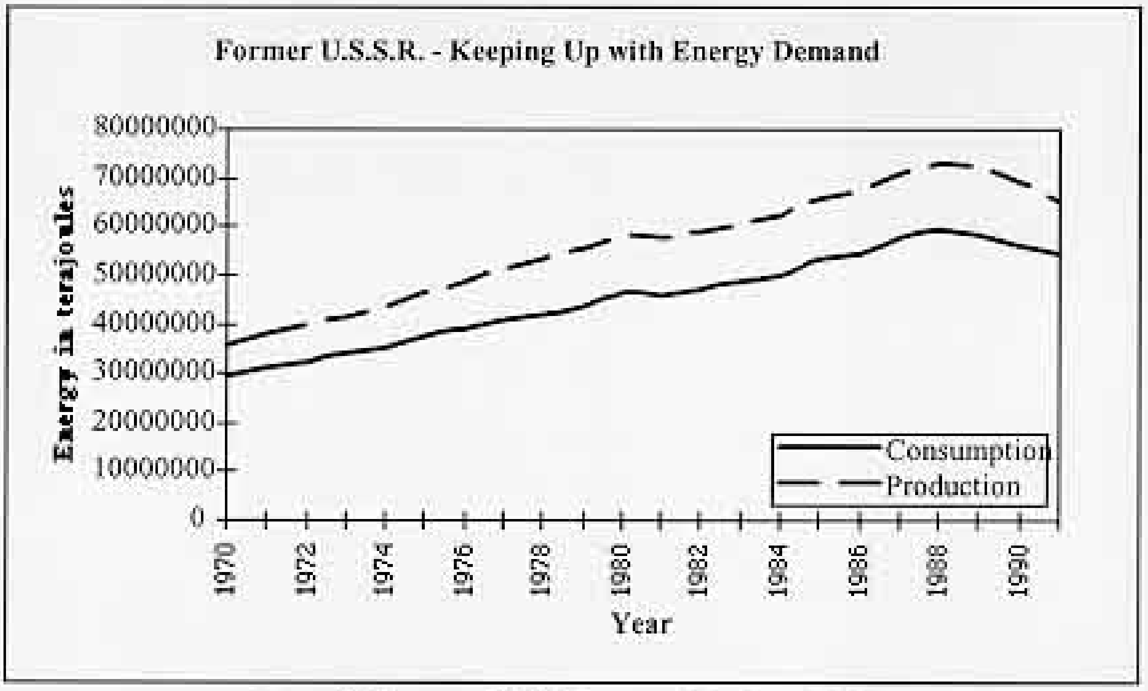


figure 16 (Source: World Resource Database, 1995)

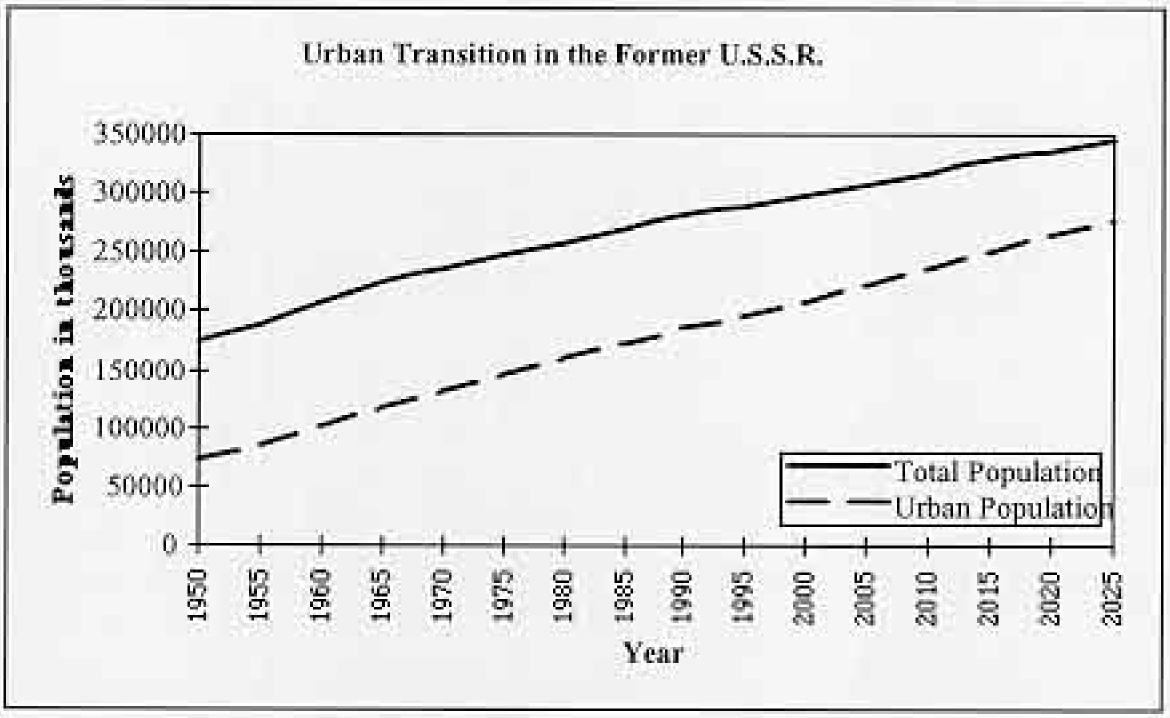


figure 17 (Source: World Resource Database, 1995)

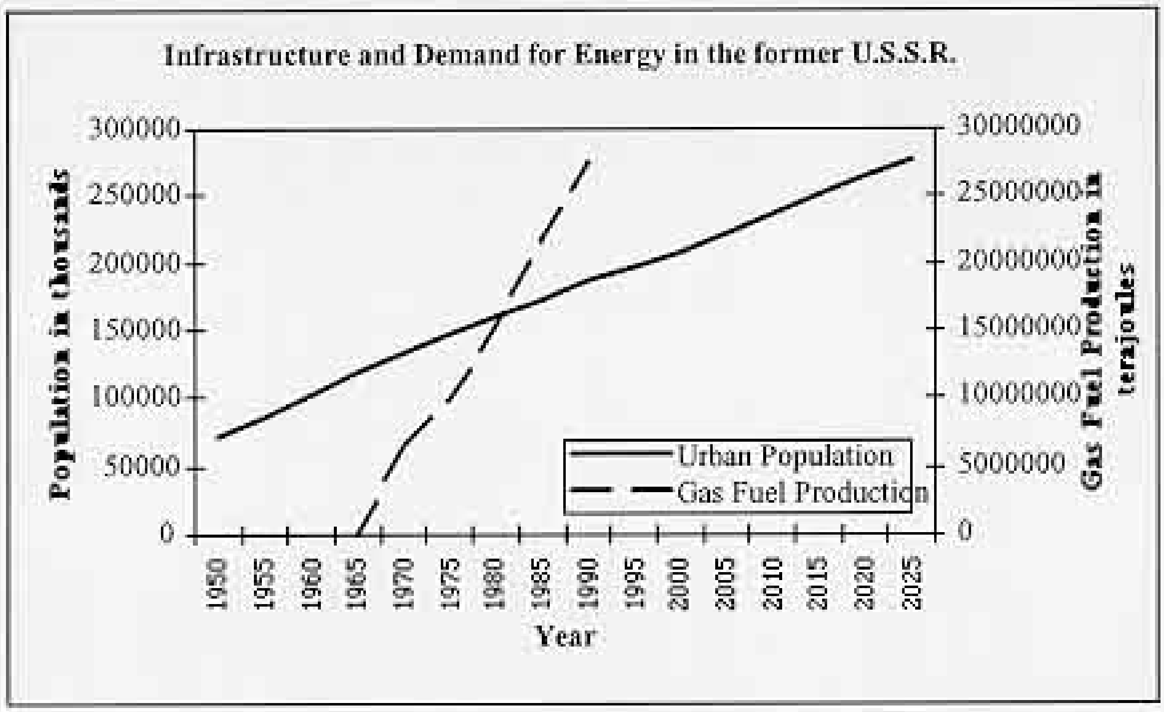


figure 18 (Source: World Resource Database, 1995)

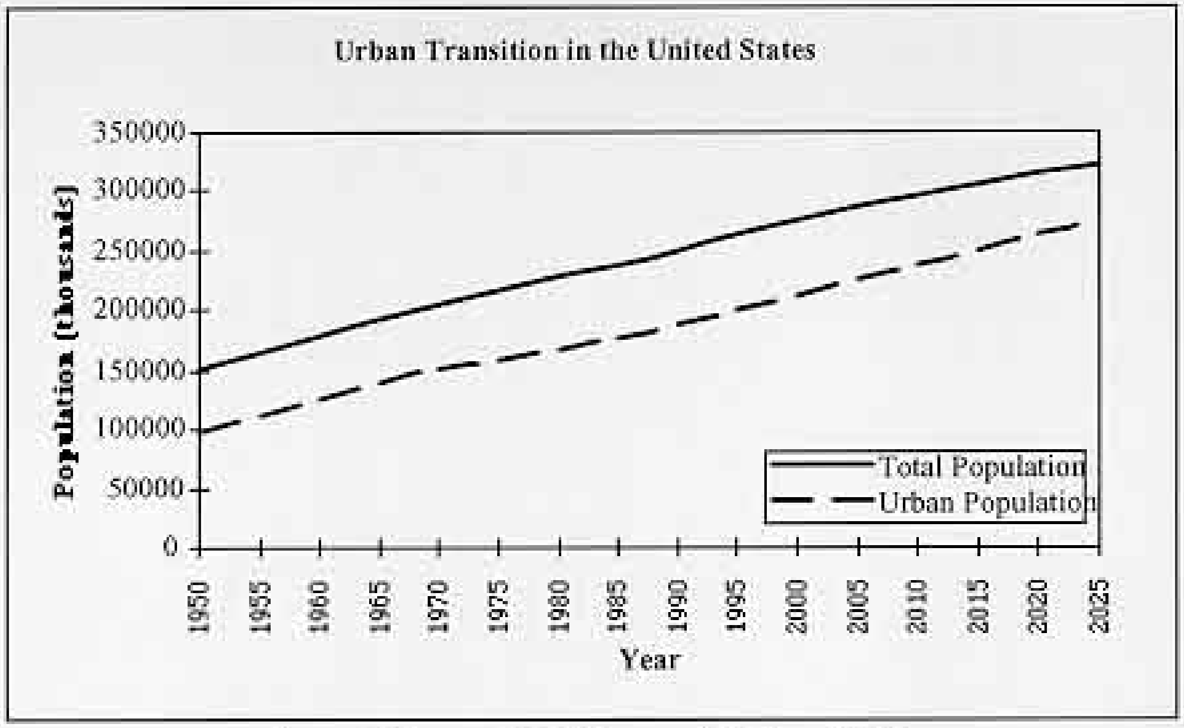


figure 19 (Source: World Resource Database, 1995)

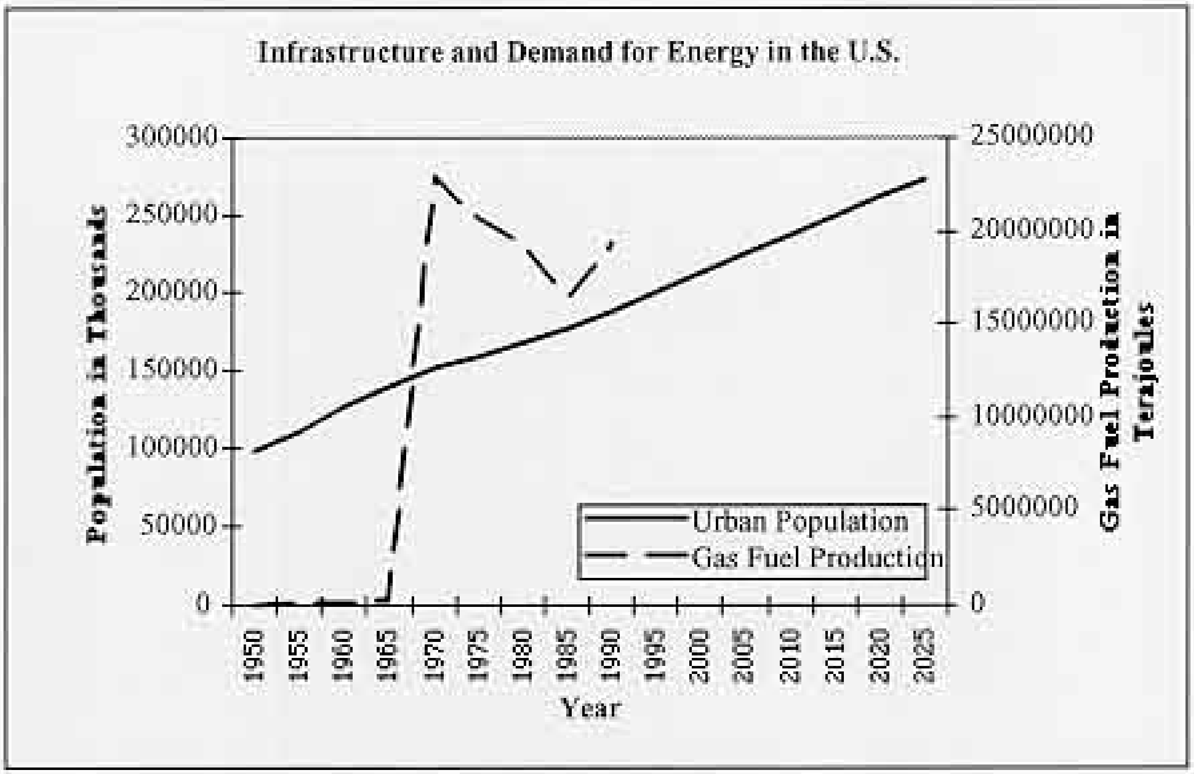


figure 20 (Source: World Resource Database, 1995)

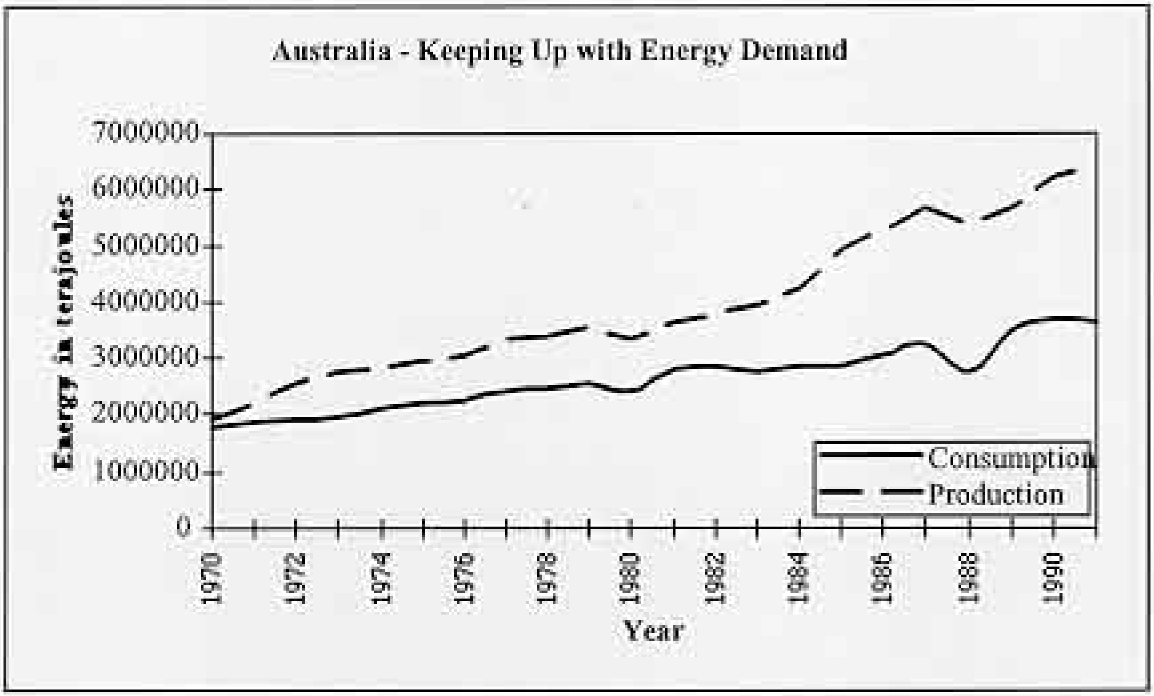


figure 21 (Source: World Resource Database, 1995)

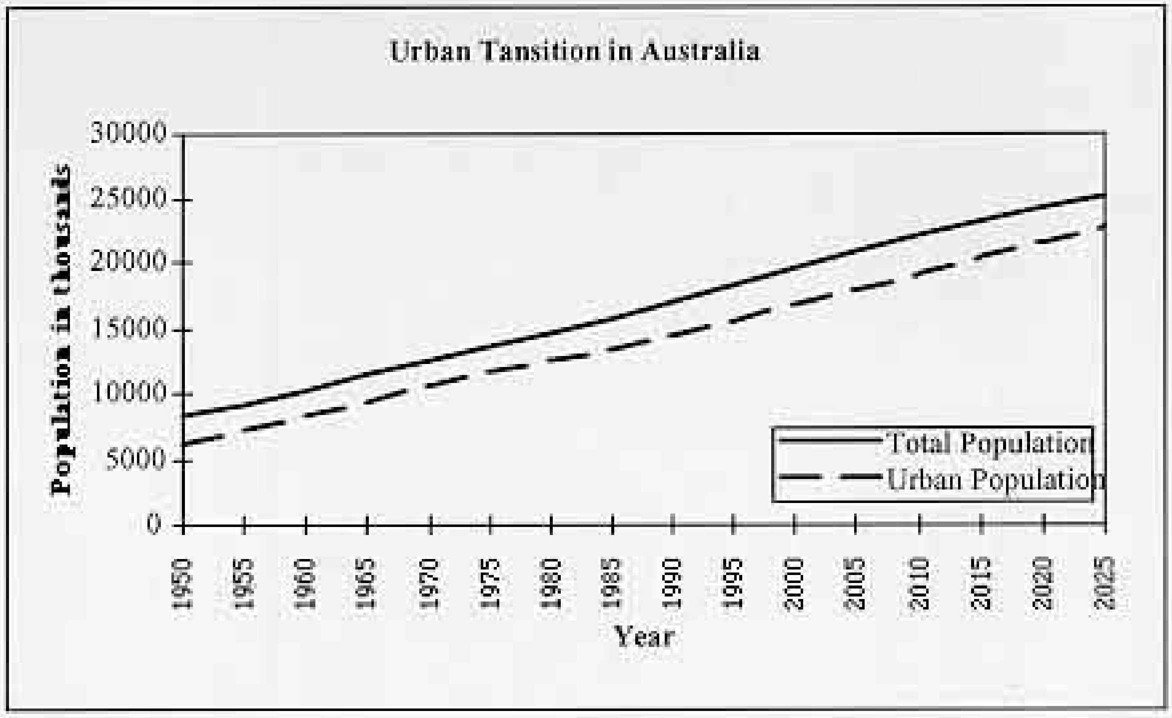


figure 22 (Source: World Resource Database, 1995)

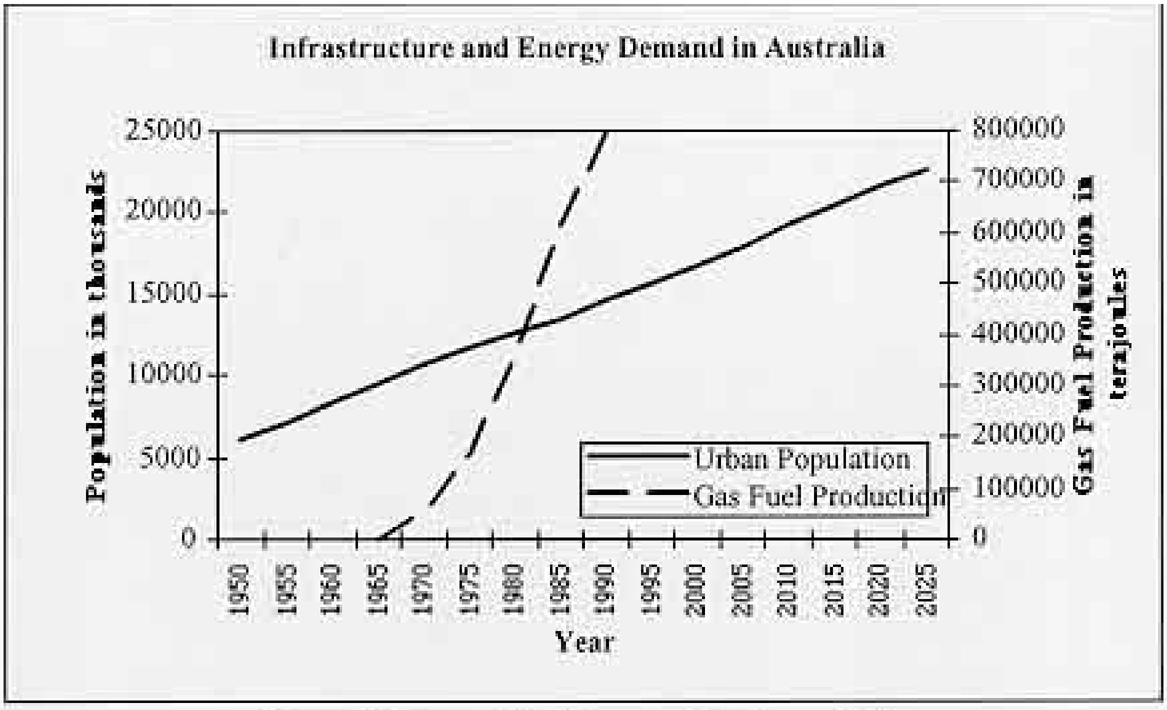


figure 23 (Source: World Resource Database, 1995)

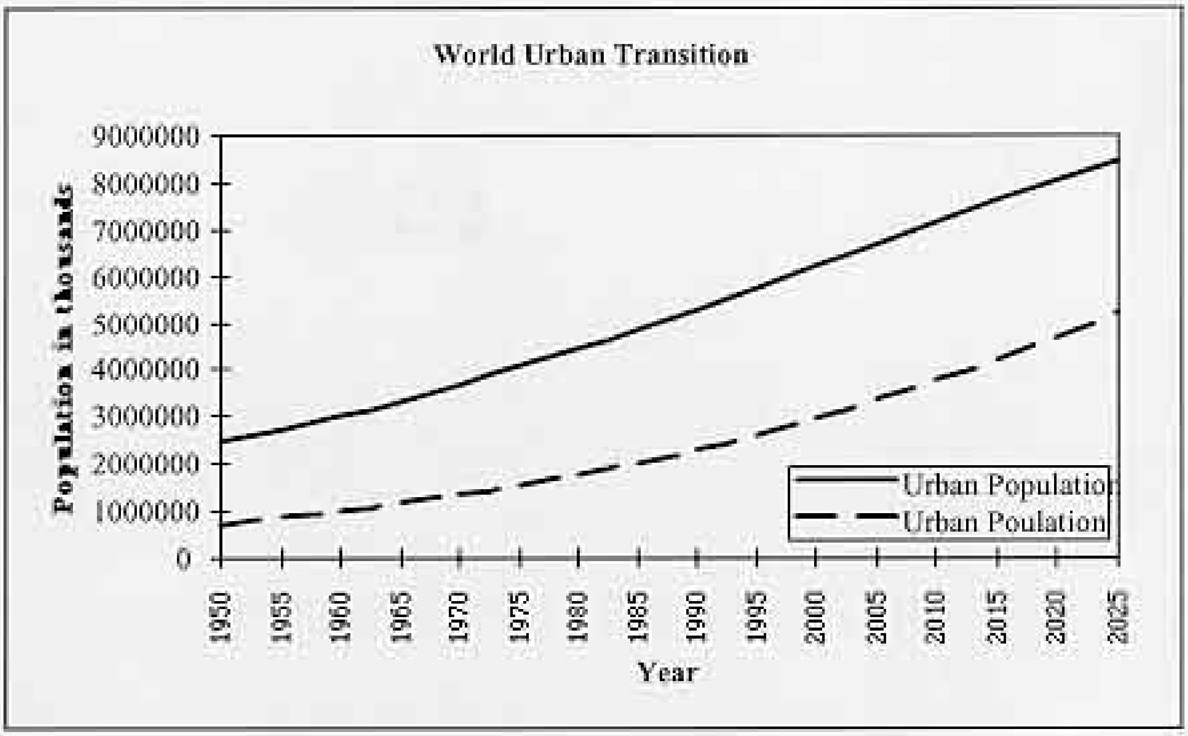


figure 24 (Source: World Resource Database, 1995)

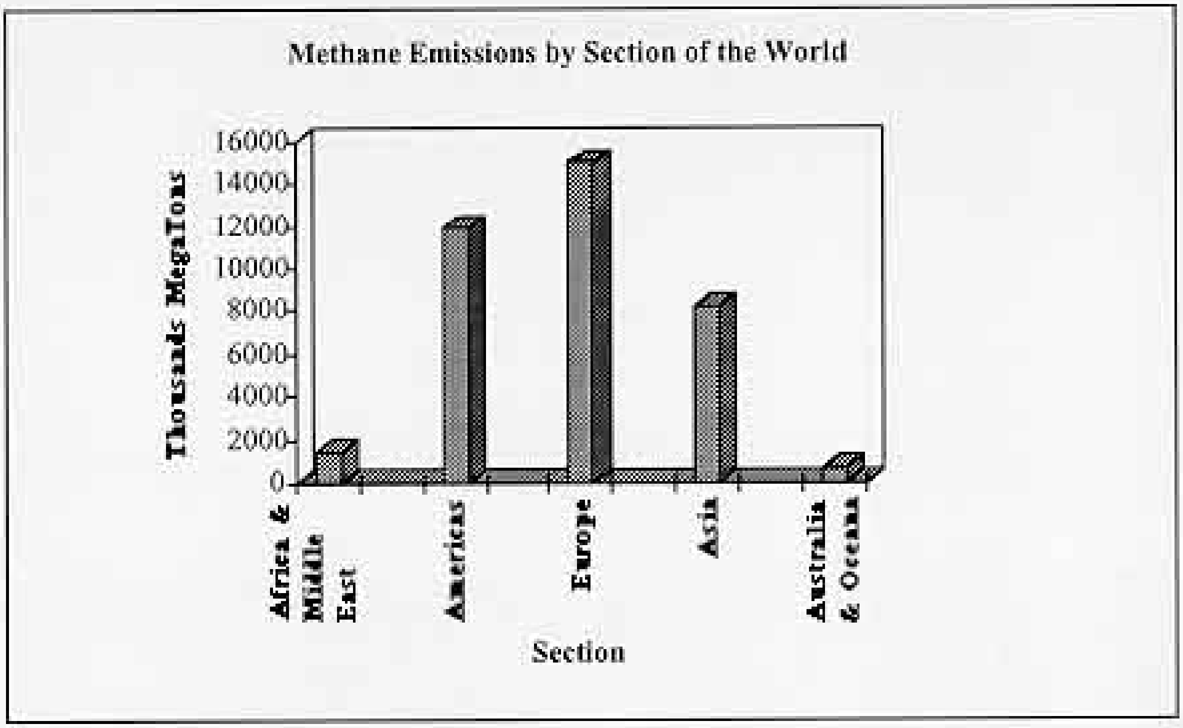


figure 25 (Source: World Resource Database, 1995)

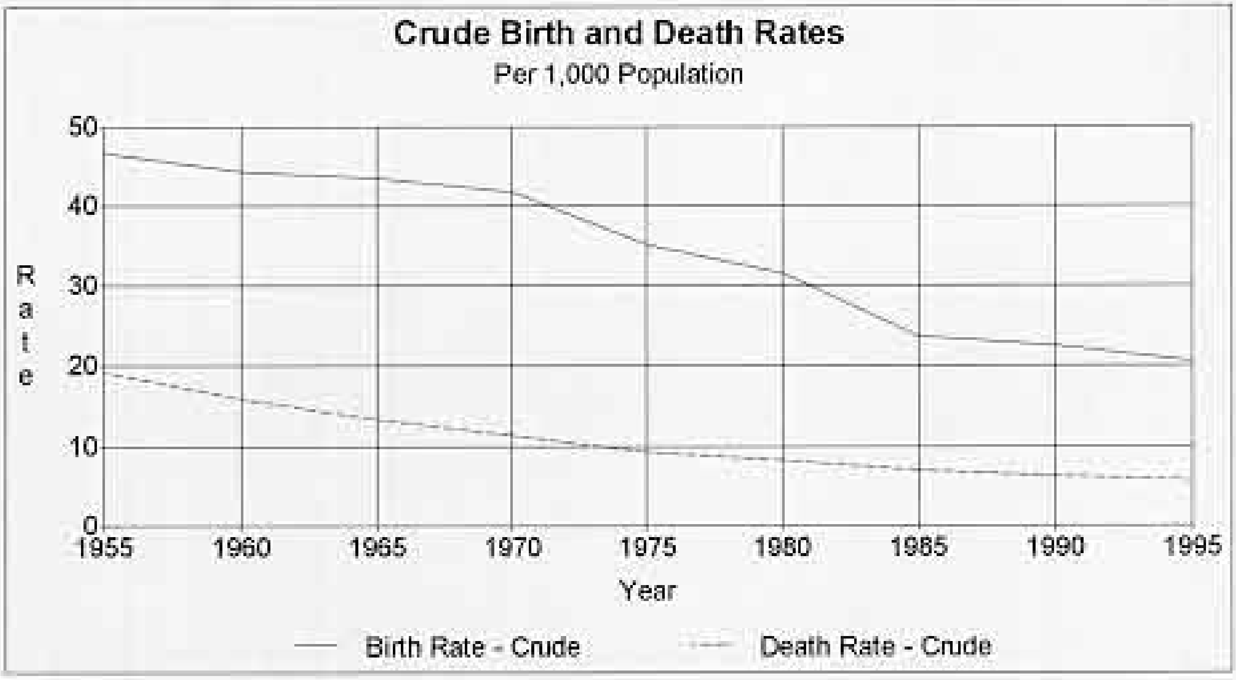


Fig. 1: Graph of the demographic transition of Thailand (Source: World Resources Database)

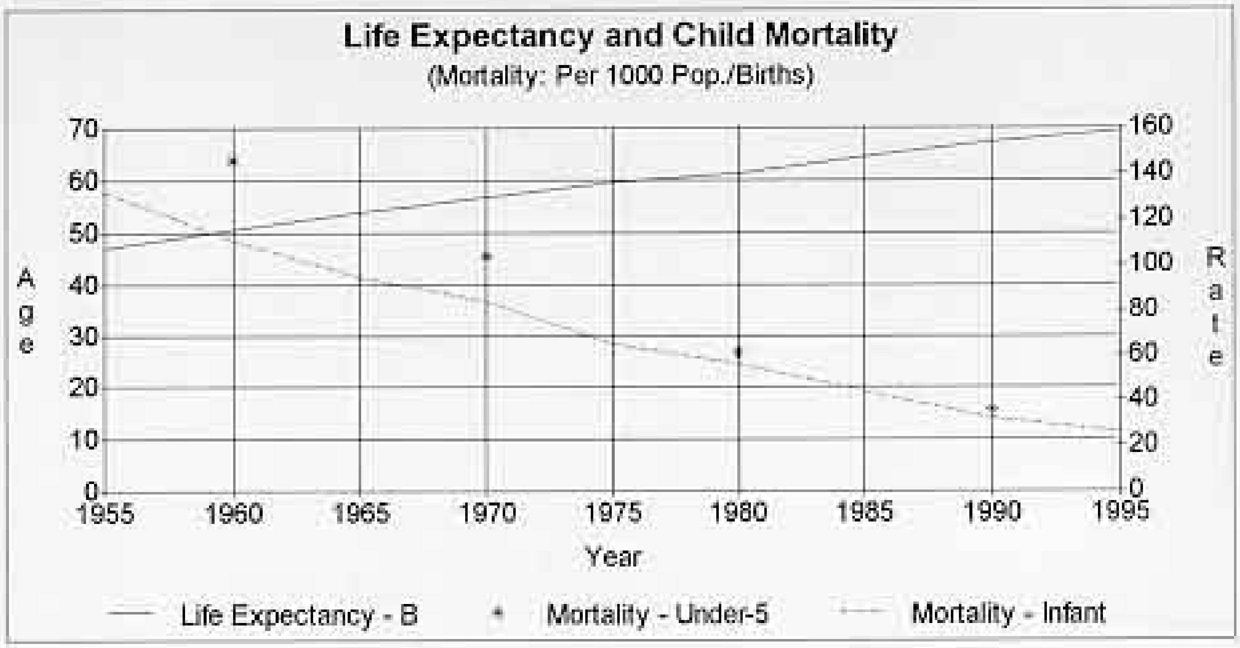


Fig. 2: Comparison of life expectancy and mortality of children under five in Thailand. The left axis corresponds with life expectancy; the right axis corresponds with mortality - Under 5 and mortality - infant. (Source: World Resources Database).

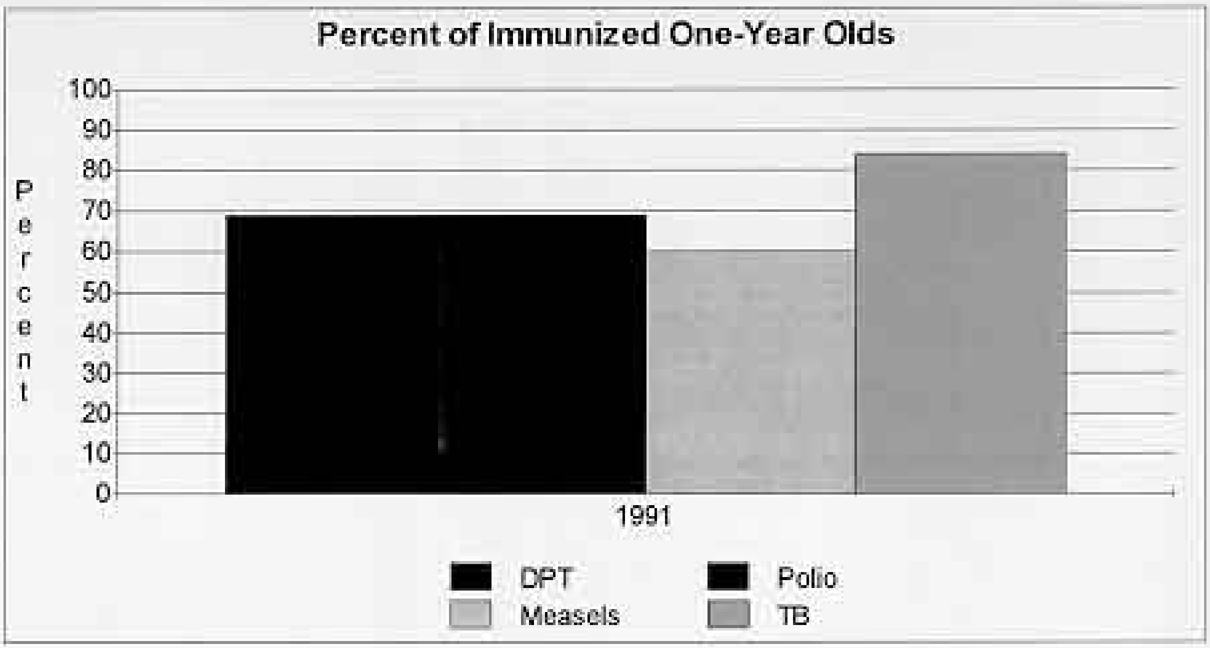


Fig. 3: Percentage of children receiving major immunizations in Thailand. (Source: World Resources Database).

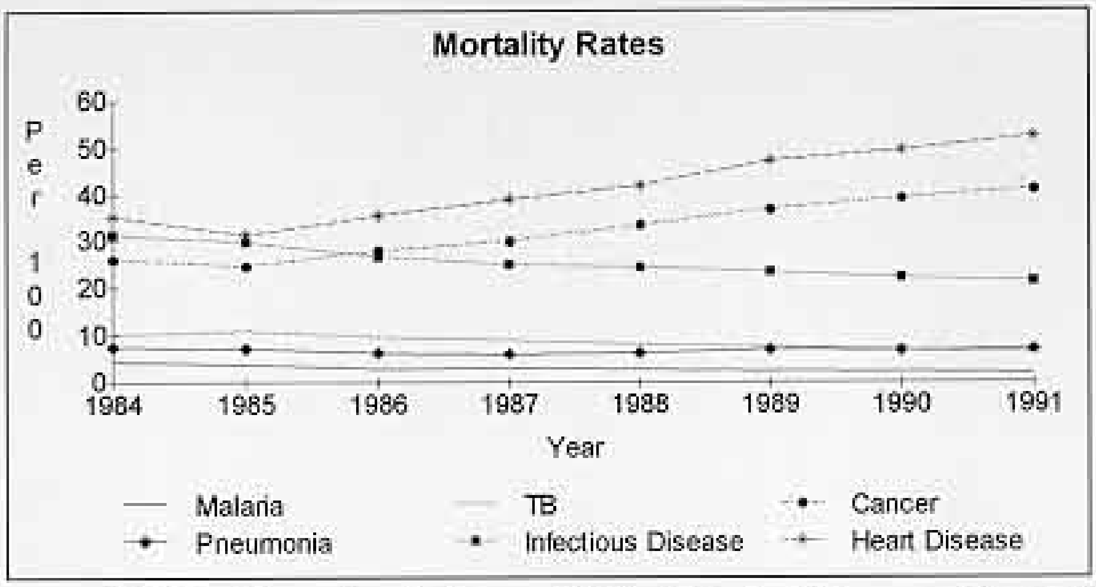


Fig. 4: Mortality rates for selected causes in Thailand. Data for 1987 was generated using statistics from other years and trends. (Source: International Medical Society of Japan).

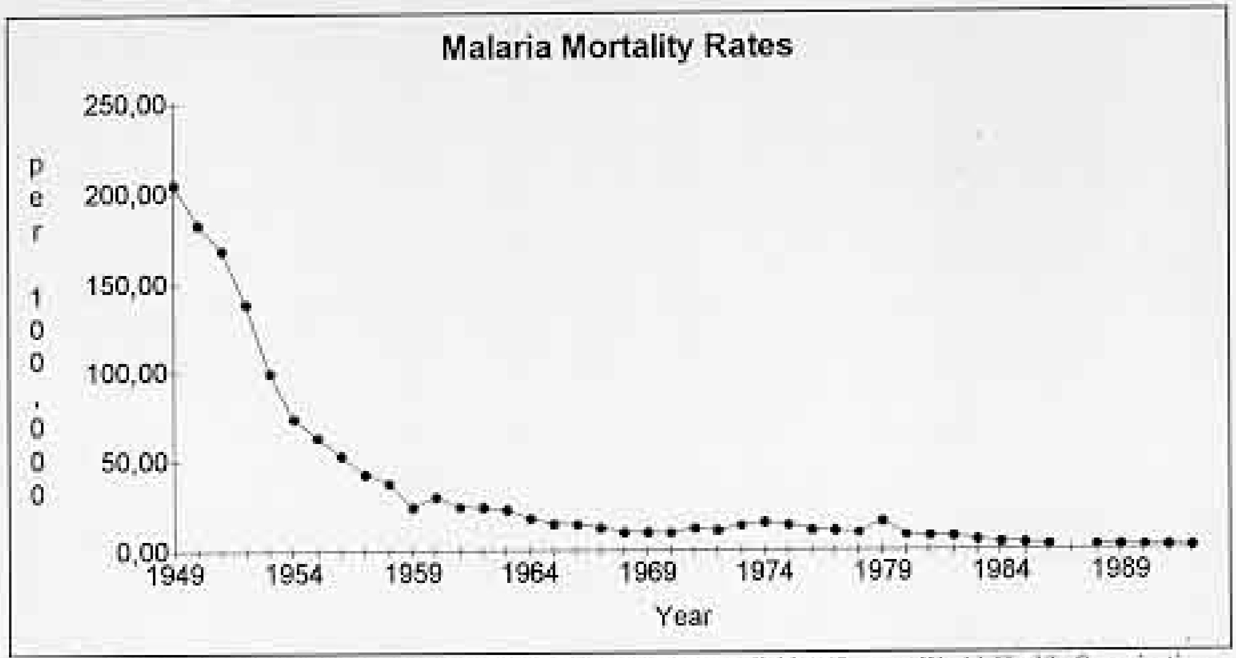


Fig. 5: Mortality rates for malaria. Data for 1987 was unavailable. (Source: World Health Organization, 1949-1985; International Medical Foundation of Japan, 1986-1992).

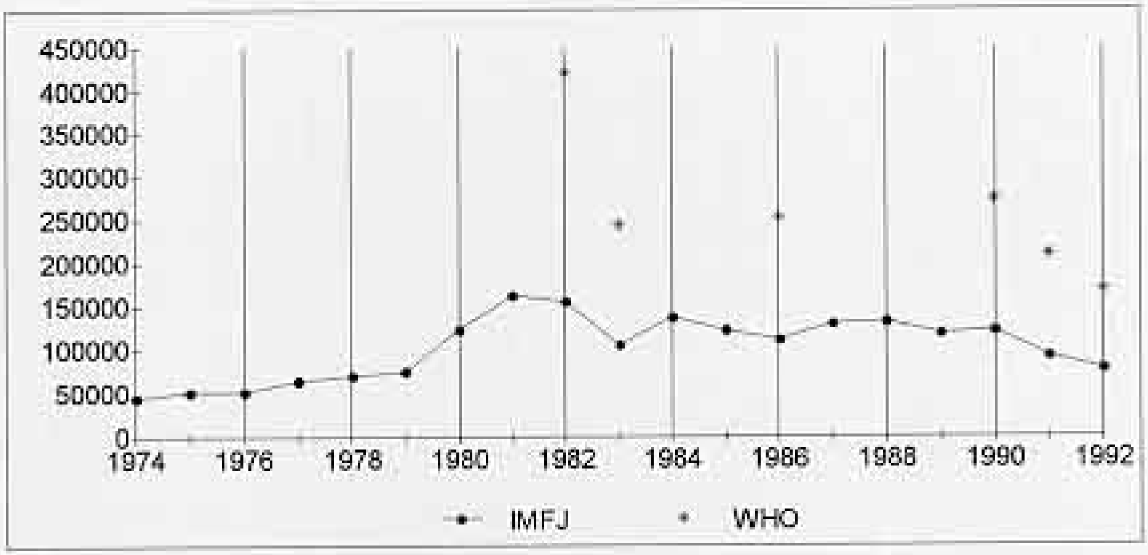


Fig. 6. Malaria morbidity statistics for Thailand. The vertical axis represents the number of cases; the horizontal axis represents the year. (Sources: International Medical Foundation of Japan and the World Health Organization).

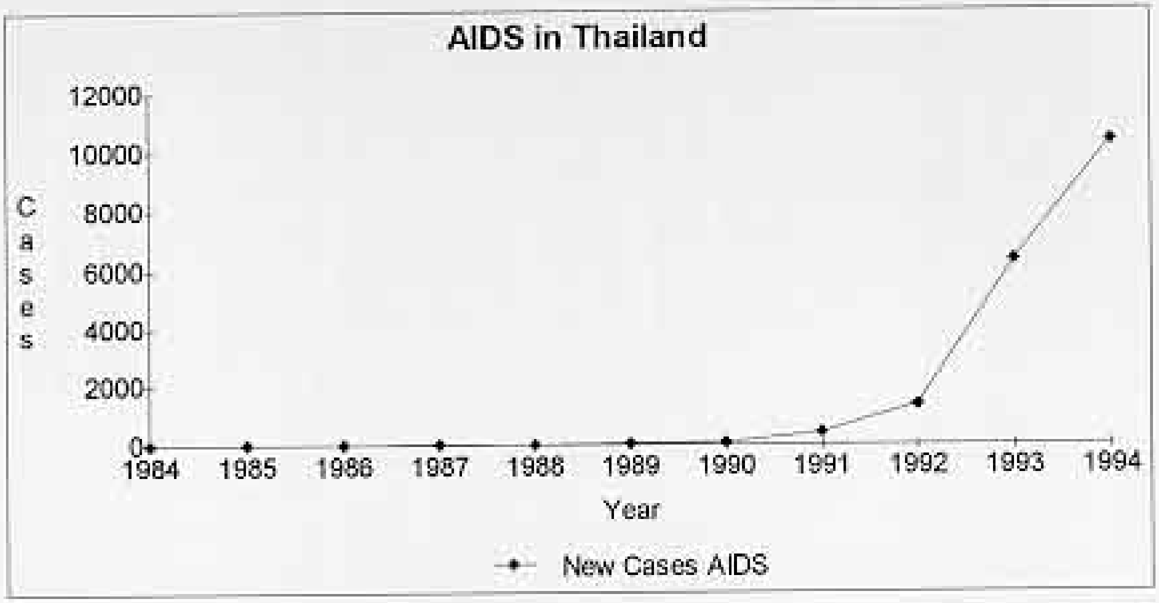
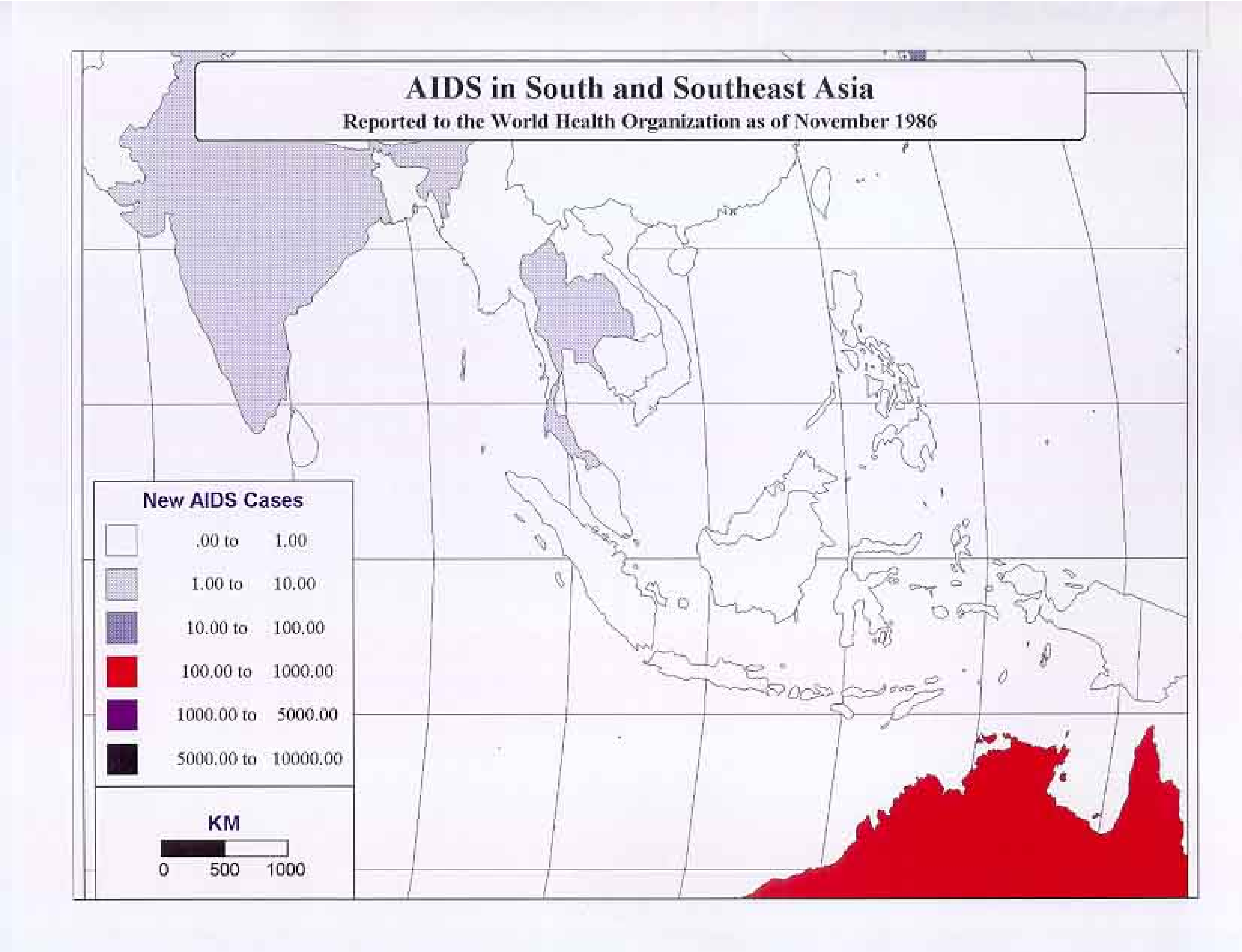
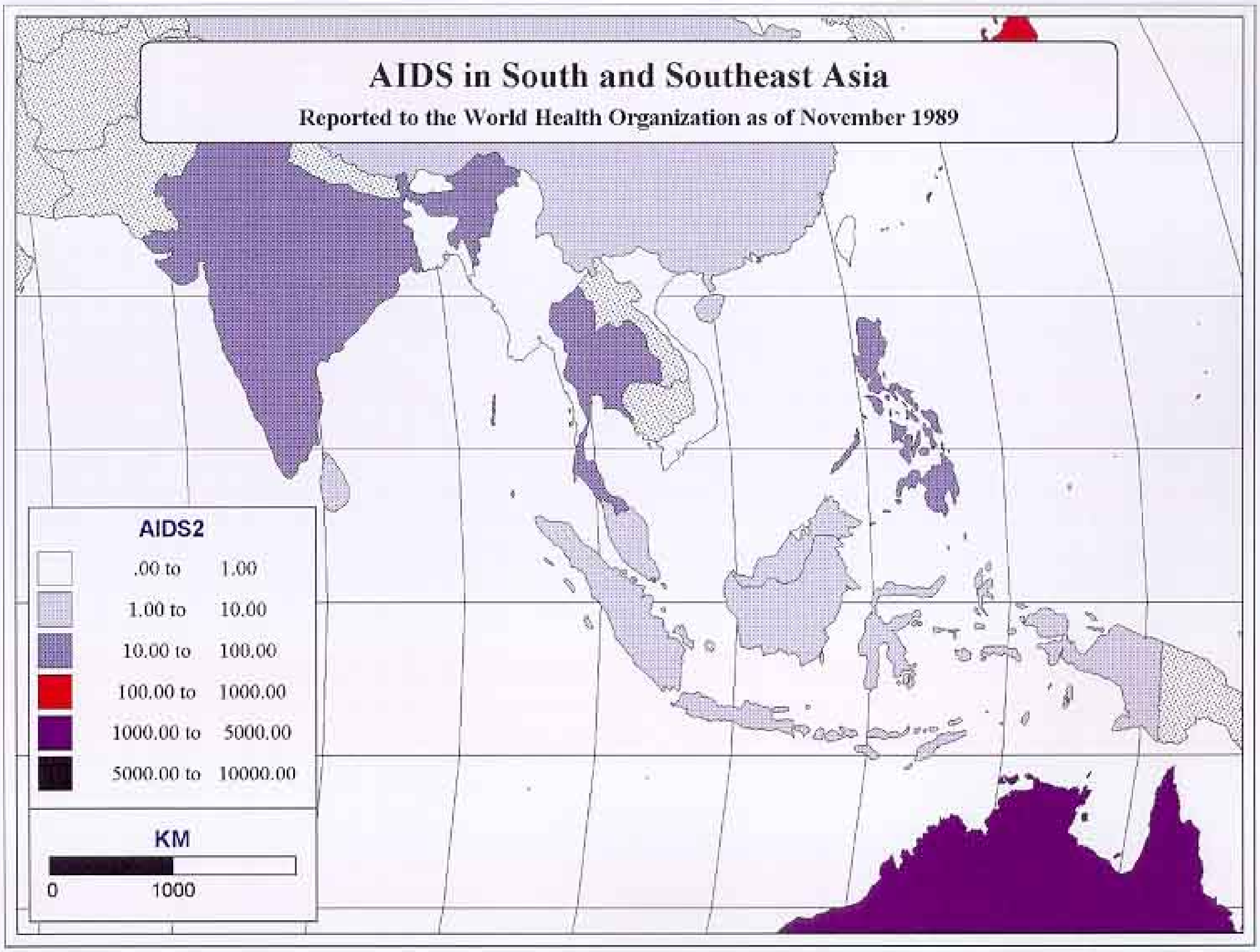
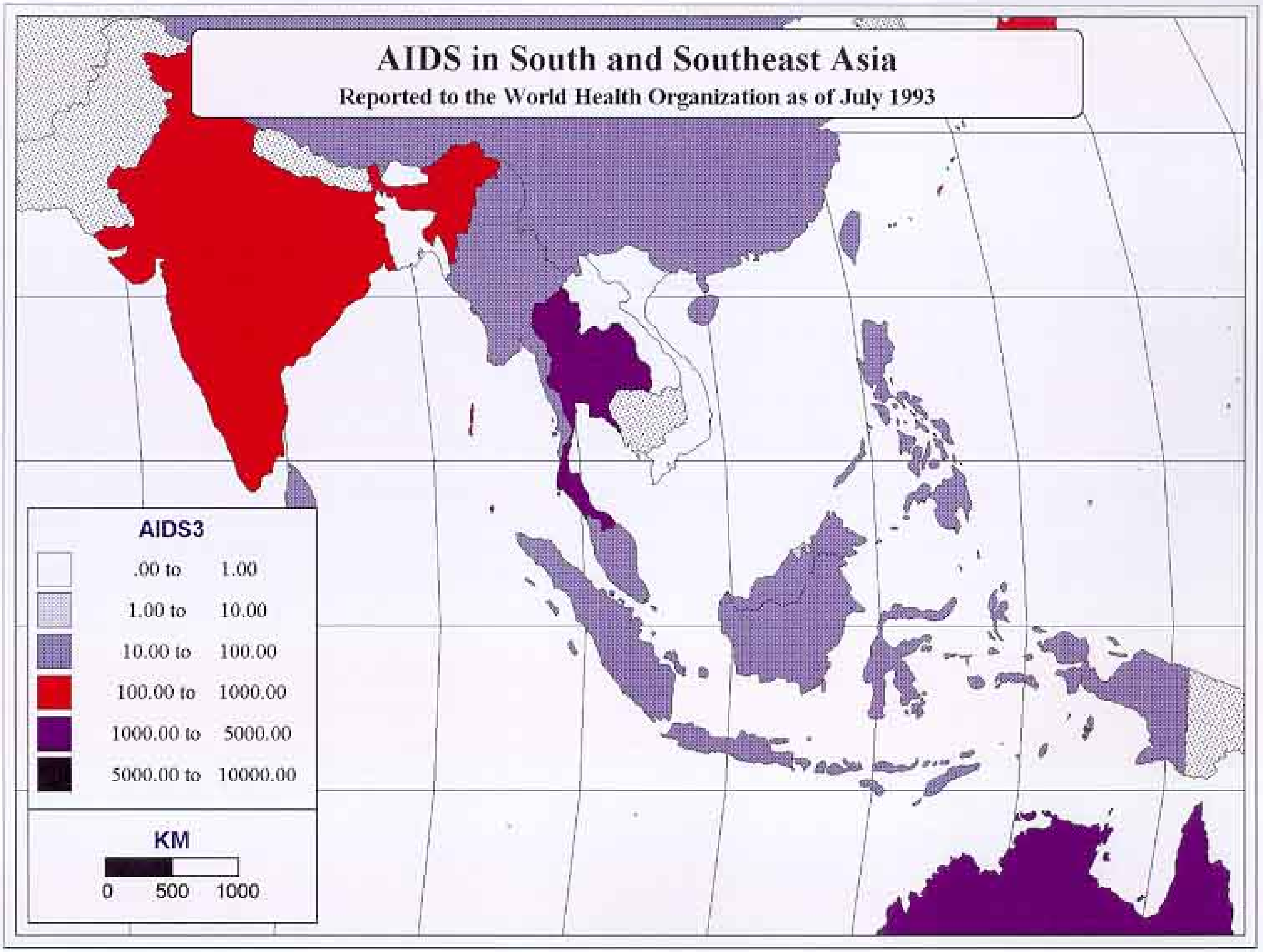


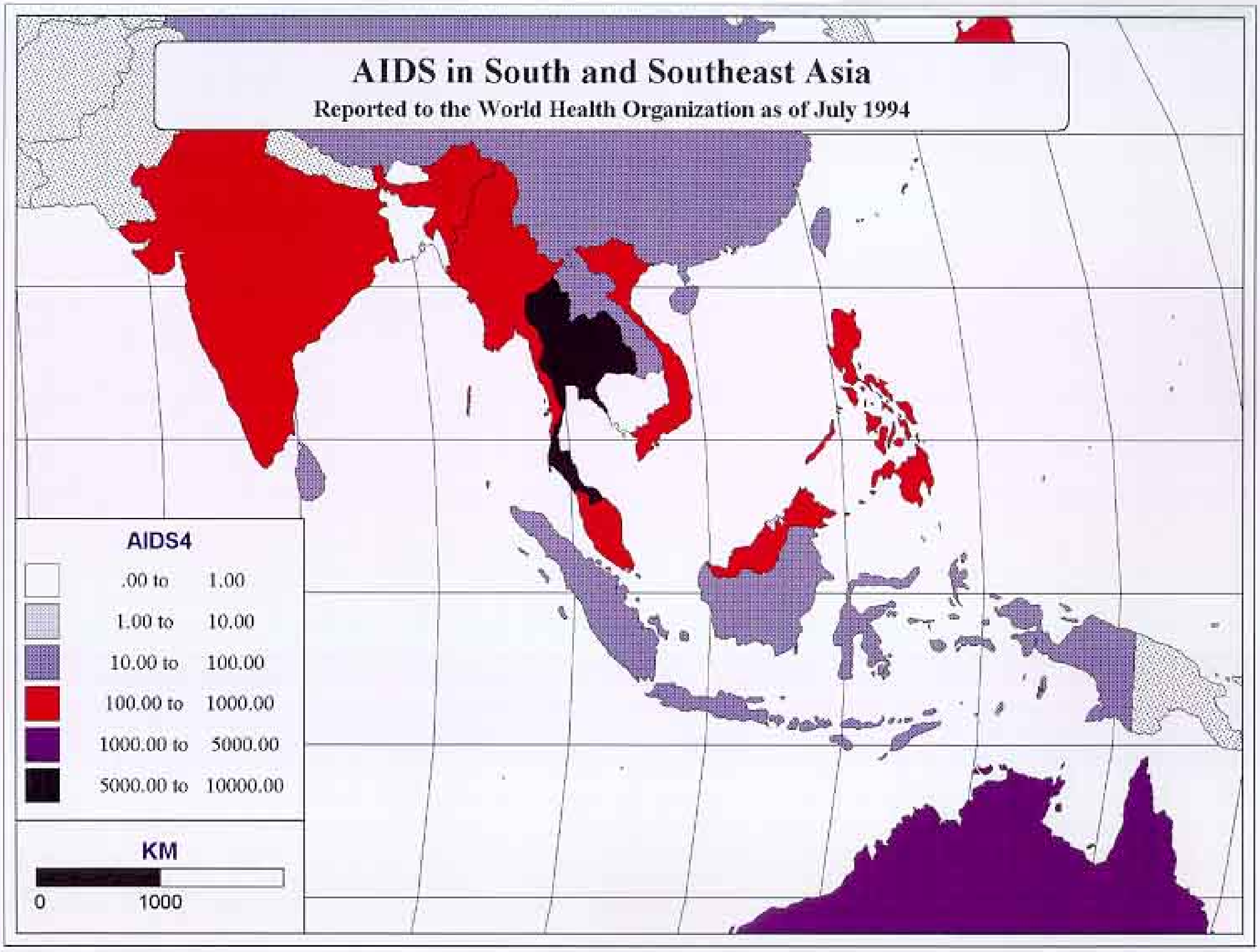
Fig. 7: New cases of AIDS reported in Thailand annually. Cases of AIDS-related complexes – conditions linked to the HIV virus and its weakening of the immune system – have not been included, since statistics for these are sketchy and unreliable. (Source: International Medical Foundation of Japan and the World Health Organization).



AIDS in South and Southeast Asia
Reported to the World Health Organization as of November 1986
New AIDS Cases
.00 to 1.00
1.00 to 10.00
10.00 to 100.00
100.00 to 1000.00
1000.00 to 5000.00
5000.00 to 10000.00
KM
0 500 1000


AIDS in South and Southeast Asia
Reported to the World Health Organization as of November 1989
AIDS2
.00 to 1.00
1.00 to 10.00
10.00 to 100.00
100.00 to 1000.00
1000.00 to 5000.00
5000.00 to 10000.00
KM
0
1000


AIDS in South and Southeast Asia
Reported to the World Health Organization as of July 1993
AIDS3
.00 to 1.00
1.00 to 10.00
10.00 to 100.00
100.00 to 1000.00
1000.00 to 5000.00
5000.00 to 10000.00
KM
0 500 1000


AIDS in South and Southeast Asia
Reported to the World Health Organization as of July 1994
AIDS4
.00 to 1.00
1.00 to 10.00
10.00 to 100.00
100.00 to 1000.00
1000.00 to 5000.00
5000.00 to 10000.00
KM
0
1000

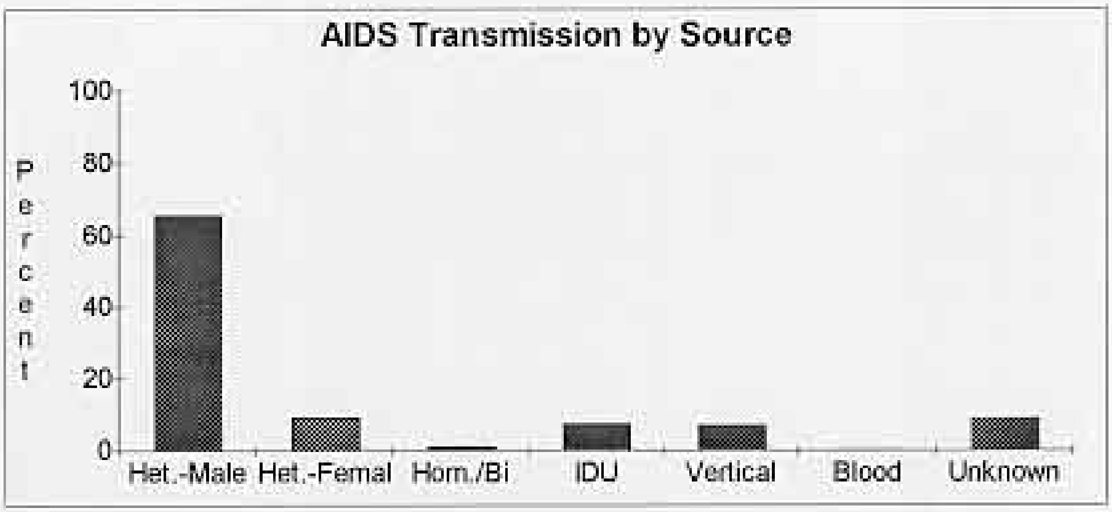


Fig. 8: Method of transmission in Thailand of HIV based on the category of the person who causes the infection. Abbreviations: Het.-Heterosexual; Hom.-Homosexual; Bi-Bisexual; IDU-Intravenous Drug User. The term vertical refers to children who have been infected through their mothers. (Source: Thai Ministry of Public Health, 1994).

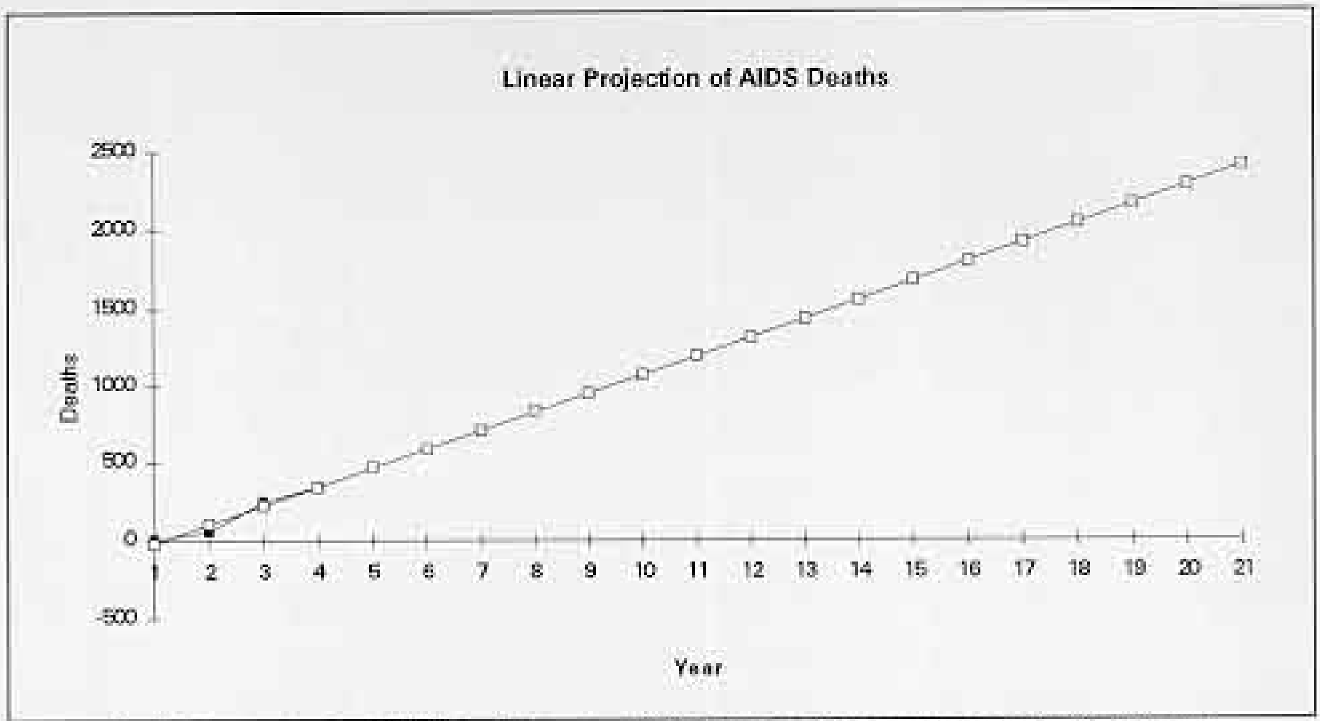


Fig. 9: Linear projection of AIDS deaths based on 1990-92 statistics. Year one corresponds with 1990; year 21 is a prediction for the year 2010. (Source: International Medical Foundation of Japan)

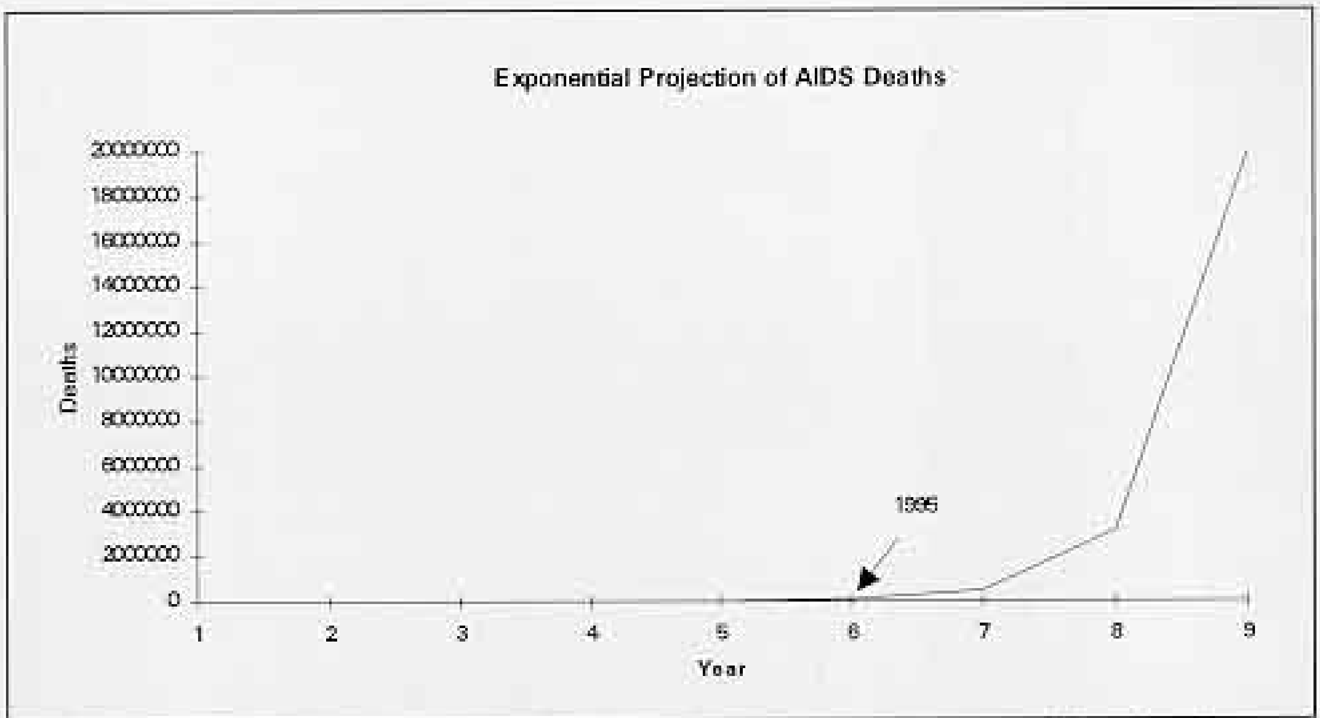


Fig. 10: Exponential projection of AIDS deaths for Thailand based on 1990-92 statistics. Year 1 corresponds to 1990; year 9 corresponds to 1998. The projection for deaths in the year 1999 exceeded the population of Thailand, and therefore has not been included. (Source: International Medical Foundation of Japan).

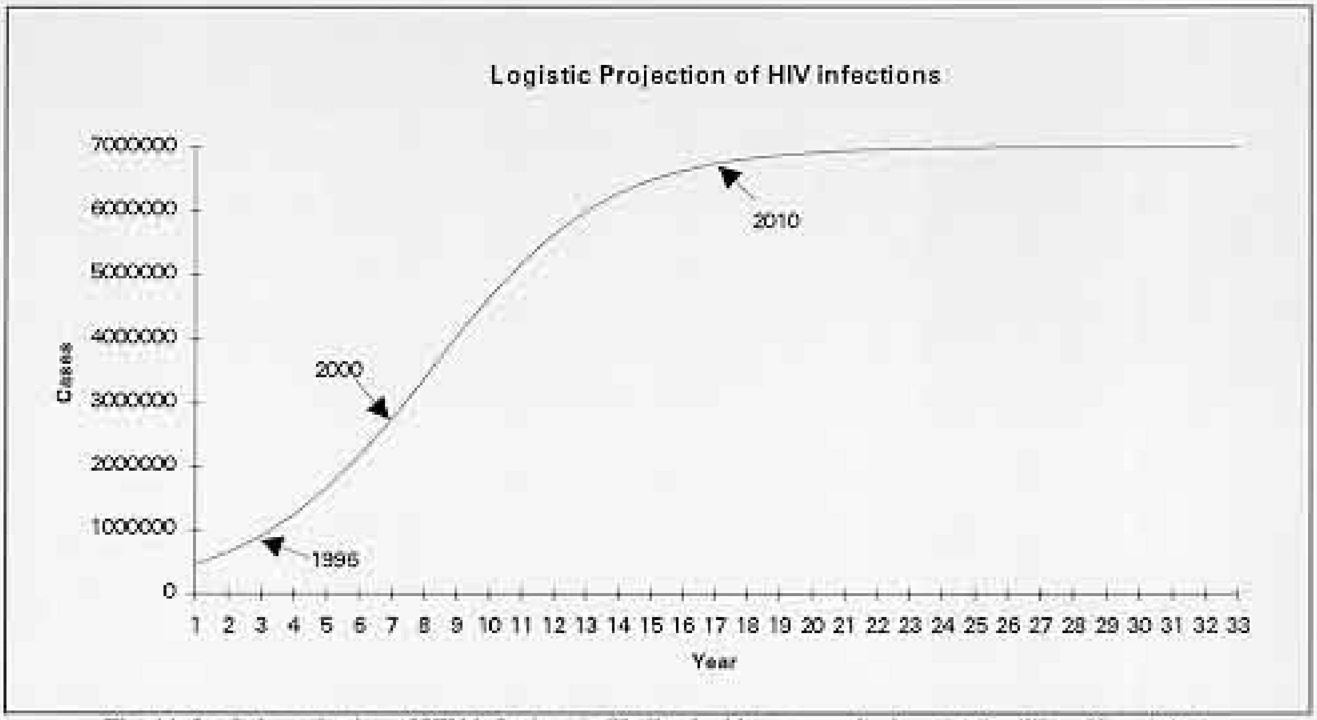


Fig. 11: Logistic projection of HIV infections in Thailand with an upper limit set at 7 million. Year 0 (not shown) is 1993. Year 33 is 2026.

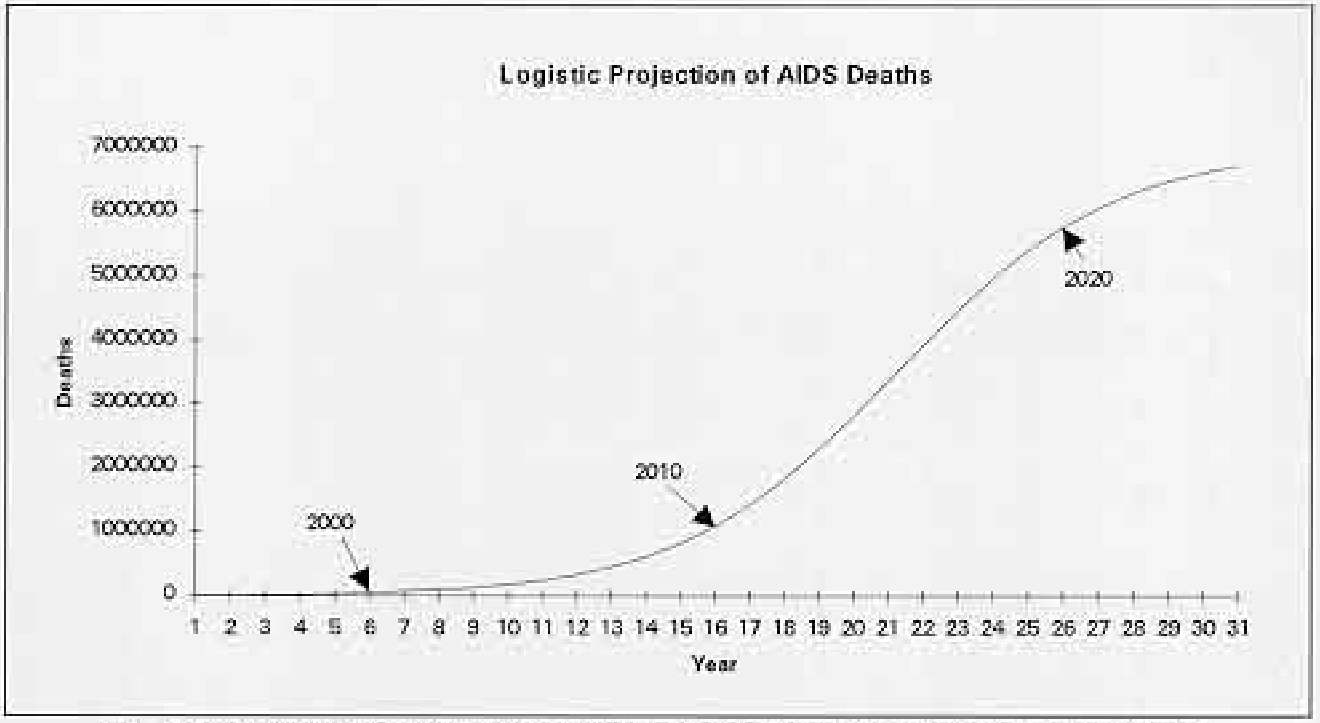


Fig. 12: Logistic projection of AIDS deaths in Thailand with an upper limit set at 7 million. Year 0 (not shown) is 1993. Year 31 is 2024.

NOTES

[1] Drake, p. 307.
[2] Review of the Health Situation in Thailand: Priority Ranking of Diseases, p. 61.
[3] The National Epidemiology Board of Thailand: The First Four Years (1987-1990), p. 44.
[4] World Resources Database, 1995 IBM-compatible version.
[5] See Drake for a more in-depth discussion of the demographic transition.
[6] Review of the Health Situation in Thailand: Priority Ranking of Diseases, p. 25
[7] Review of the Health Situation in Thailand: Priority Ranking of Diseases, p. 33
[8] Epidemiological Considerations for Planning Malaria Control in South-East Asian Region, p. 321.
[9] SEAMIC Health Statistics, 1993.
[10] Epidemiological Considerations for Planning Malaria Control in South-East Asian Region, p. 167.
[11] Ibid., p. 170-1.
[12] Epidemiological Considerations for Planning Malaria Control in South-East Asian Region, p. 175.
[13] Development of Strategies and Approaches to Malaria Control in South-East Asia, p. 29.
[14] Economic Implications of AIDS in Asia, p. 1.
[15] Human Immunodeficiency Virus Infection in Thailand, p. 17.
[16] Review of the Health Situation in Thailand: Priority Ranking of Diseases, p. 95.
[17] Human Immunodeficiency Virus Infection in Thailand, p. 18.
[18] HIV/AIDS Situation in Thailand. This statistic was obtained through the World Wide Web.
[19] Economic Implications of AIDS in Asia, p. 7
[20] Economic Implications of AIDS in Asia, p. v.
[21] The Impact of HIV/AIDS on World Population, p. 5.
[22] For an in-depth discussion of this issue, see Economic Implications of AIDS in Asia.
[23] Human Immunodeficiency Virus Infection in Thailand, p. 14.
[24] AIDS: Images of the Epidemic, p. 94.
[25] AIDS: Images of the Epidemic, p. 94.
[26] Economic Implications of AIDS in Asia, p. 151.
[27] Economic Implications of AIDS in Asia, p. 10-11.
[28] AIDS: Images of the Epidemic, p. 22.
[29] Economic Implications of AIDS in Asia, p. 83.
[30] "AIDS homes in," The Economist, p. 37.
[31] Division of Epidemiology, Thai Ministry of Public Health, 1992.
[32] Economic Implications of AIDS in Asia, p. 16. This statistic assumes that 1.5 million women will become infected with HIV and have an average of two children each.
[33] "Sex and Death in Thailand," Newsweek, p. 51.
[34] "Sex and Death in Thailand," Newsweek, p. 51.
[35] Economic Implications of AIDS in Asia, p. 31.
[36] The Impact of HIV/AIDS on World Population, pp. 17-20.
[37] SEAMIC, 1993.
[38] Economic Implications of AIDS in Asia, p. 72.

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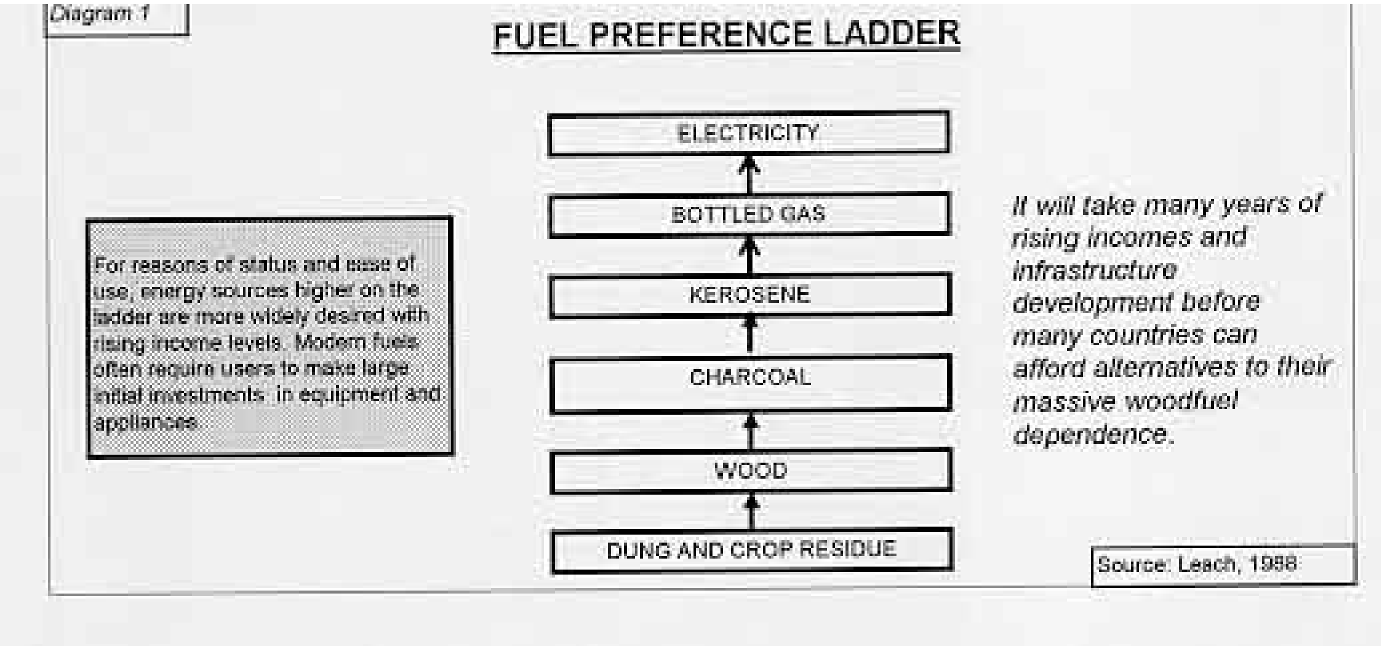
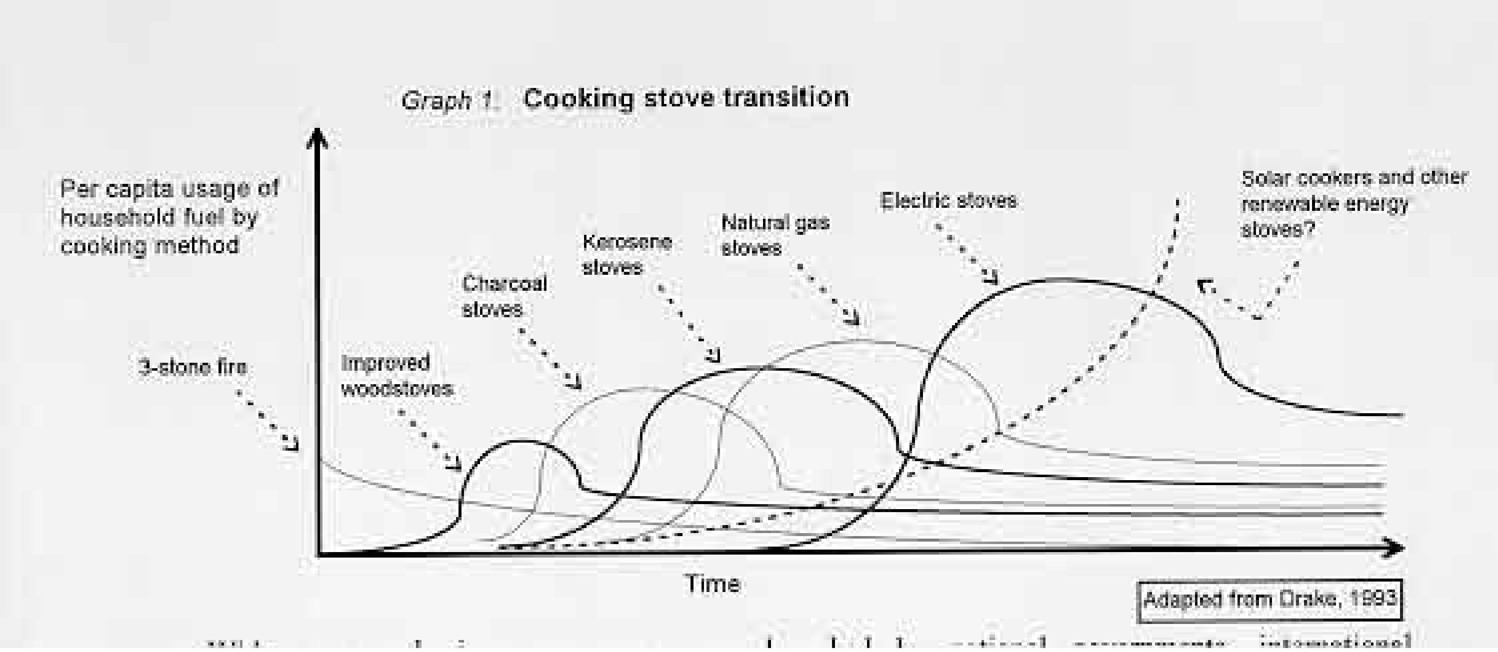
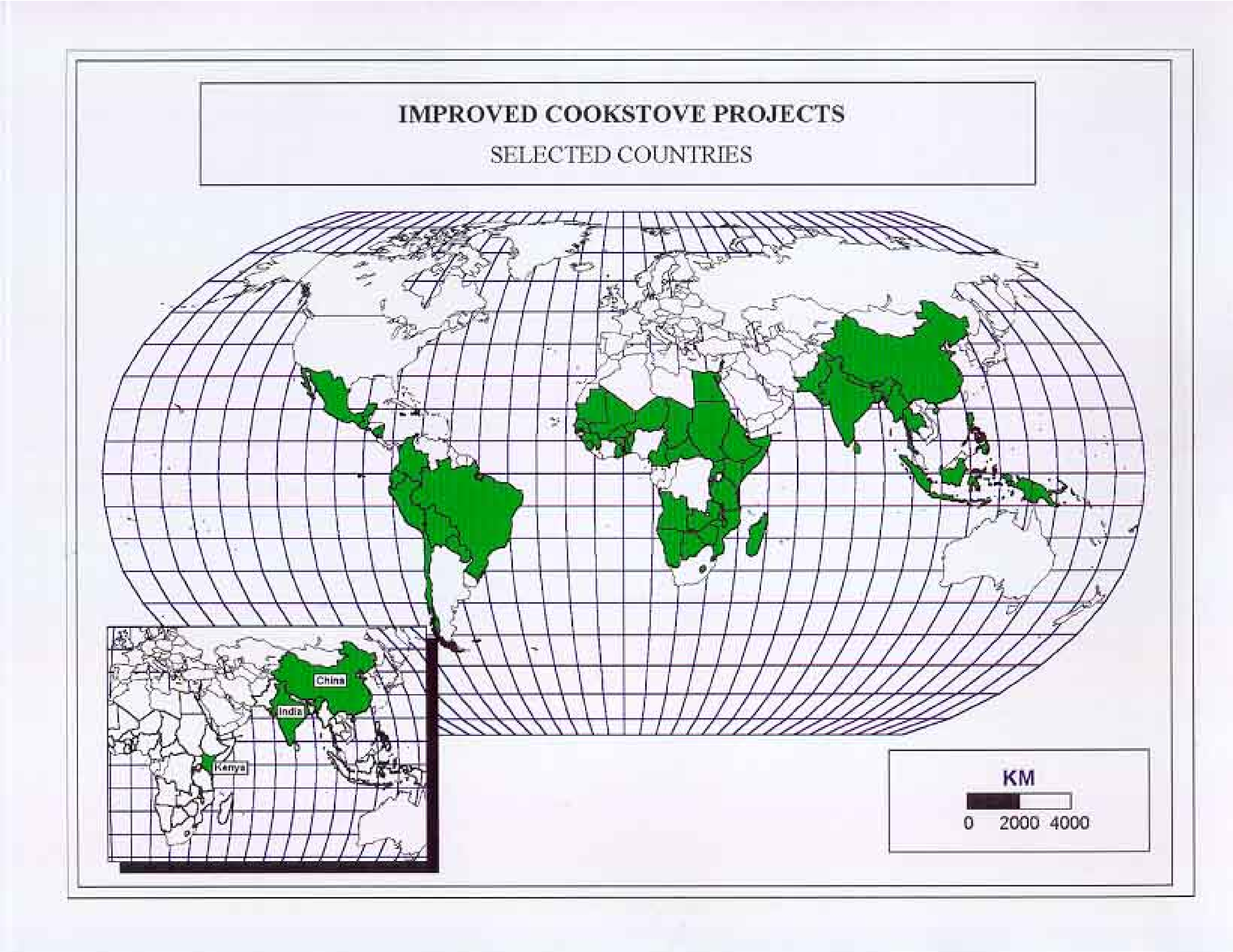
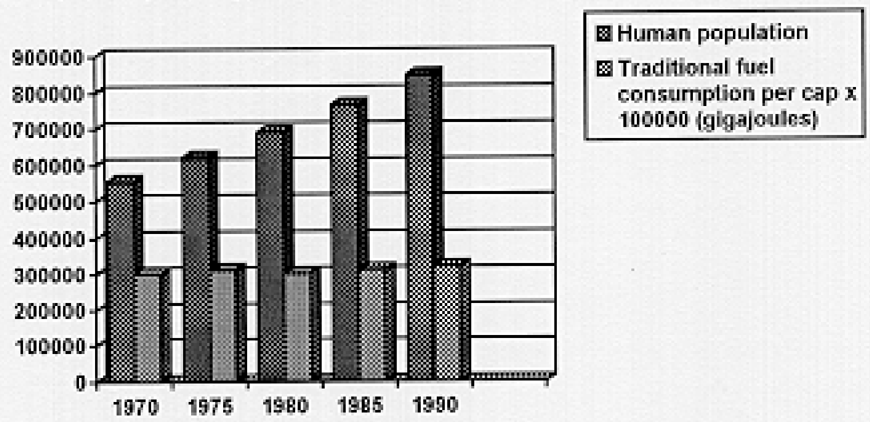


Diagram 1
FUEL PREFERENCE LADDER
ELECTRICITY
BOTTLED GAS
KEROSENE
CHARCOAL
WOOD
DUNG AND CROP RESIDUE
For reasons of status and ease of use, energy sources higher on the ladder are more widely desired with rising income levels. Modern fuels often require users to make large initial investments in equipment and appliances.
It will take many years of rising incomes and infrastructure development before many countries can afford alternatives to their massive woodfuel dependence.
Source: Leach, 1988

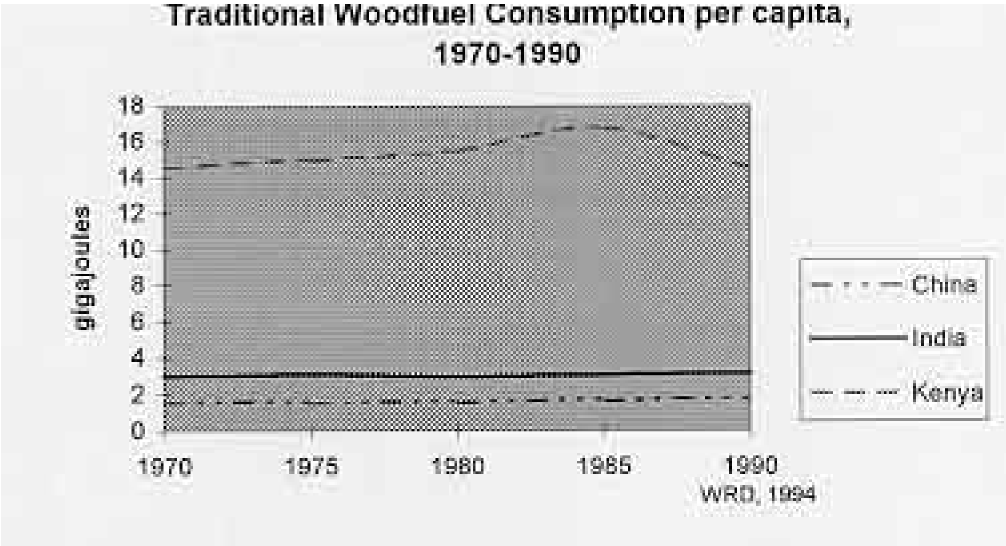

Graph 1. Cooking stove transition
Per capita usage of household fuel by cooking method
3-stone fire
Improved woodstoves
Charcoal stoves
Kerosene stoves
Natural gas stoves
Electric stoves
Solar cookers and other renewable energy stoves?
Time
Adapted from Drake, 1993

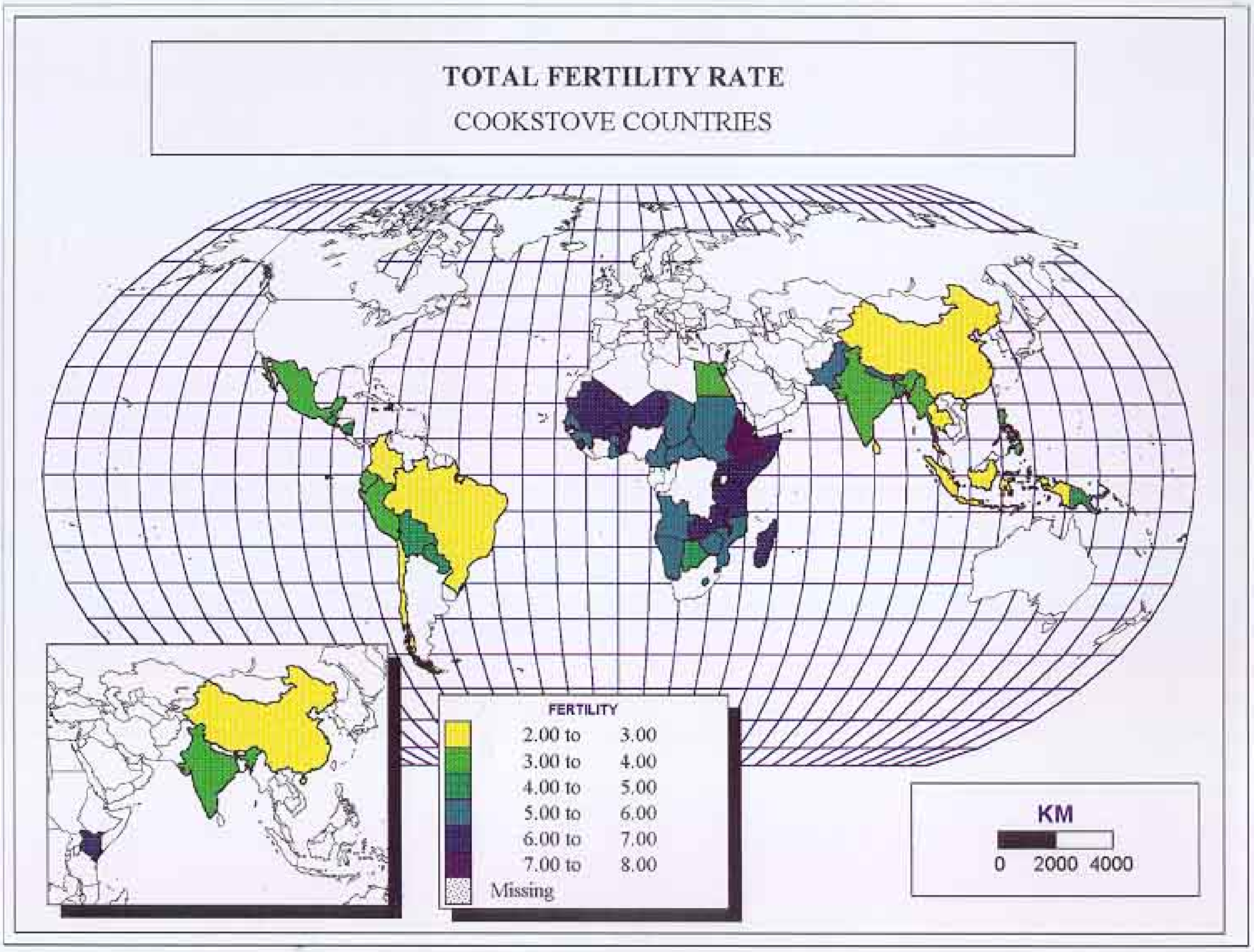

IMPROVED COOKSTOVE PROJECTS
SELECTED COUNTRIES
China
India
Kenya
KM
0
2000
4000

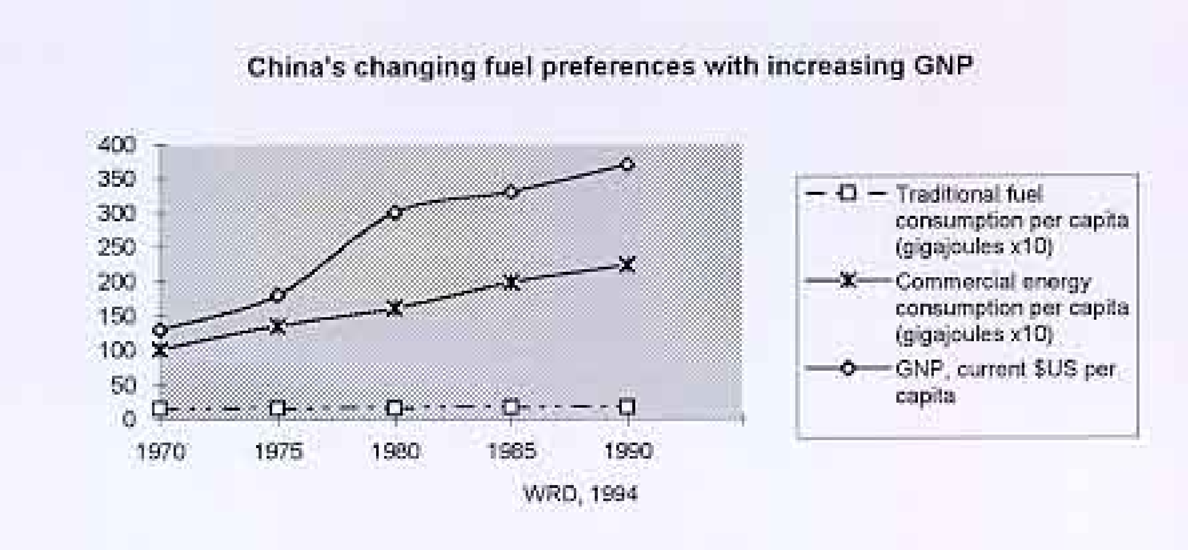
Graph 2: Population pressure on woodfuel in India



WRD, 1994


Traditional Woodfuel Consumption per capita, 1970-1990
gigajoules
18
16
14
12
10
8
6
4
2
0
1970
1975
1980
1985
1990
China
India
Kenya
WRD, 1994


TOTAL FERTILITY RATE
COOKSTOVE COUNTRIES
FERTILITY
2.00 to 3.00
3.00 to 4.00
4.00 to 5.00
5.00 to 6.00
6.00 to 7.00
7.00 to 8.00
Missing
KM
0 2000 4000


China's changing fuel preferences with increasing GNP
400
350
300
250
200
150
100
50
0
1970
1975
1980
1985
1990
WRD, 1994
Traditional fuel consumption per capita (gigajoules x10)
Commercial energy consumption per capita (gigajoules x10)
GNP, current $US per capita

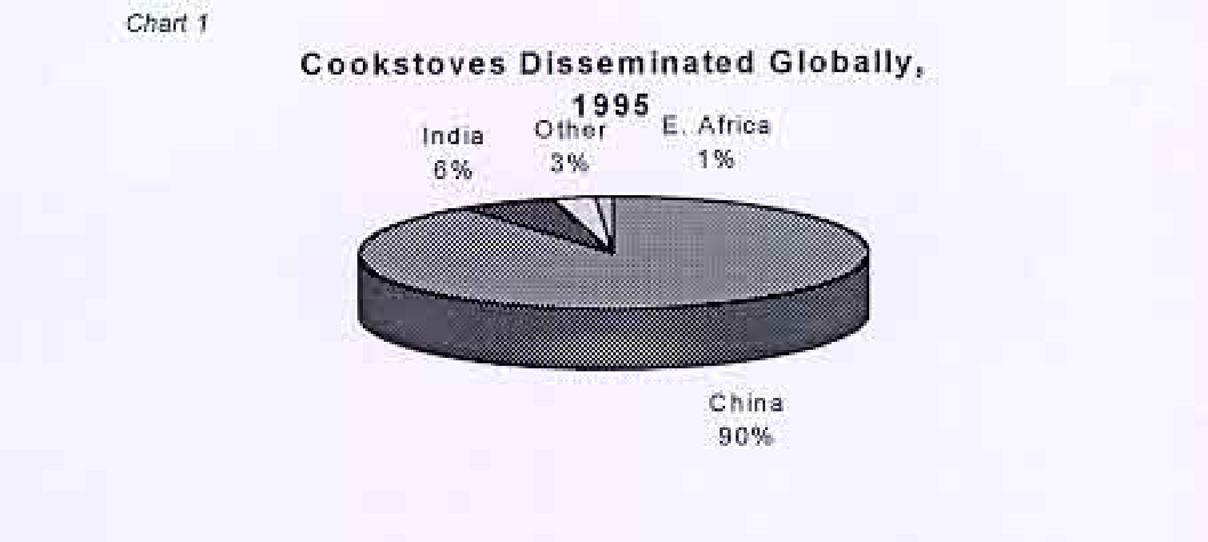


Chart 1
Cookstoves Disseminated Globally, 1995
India 6%
Other 3%
E. Africa 1%
China 90%

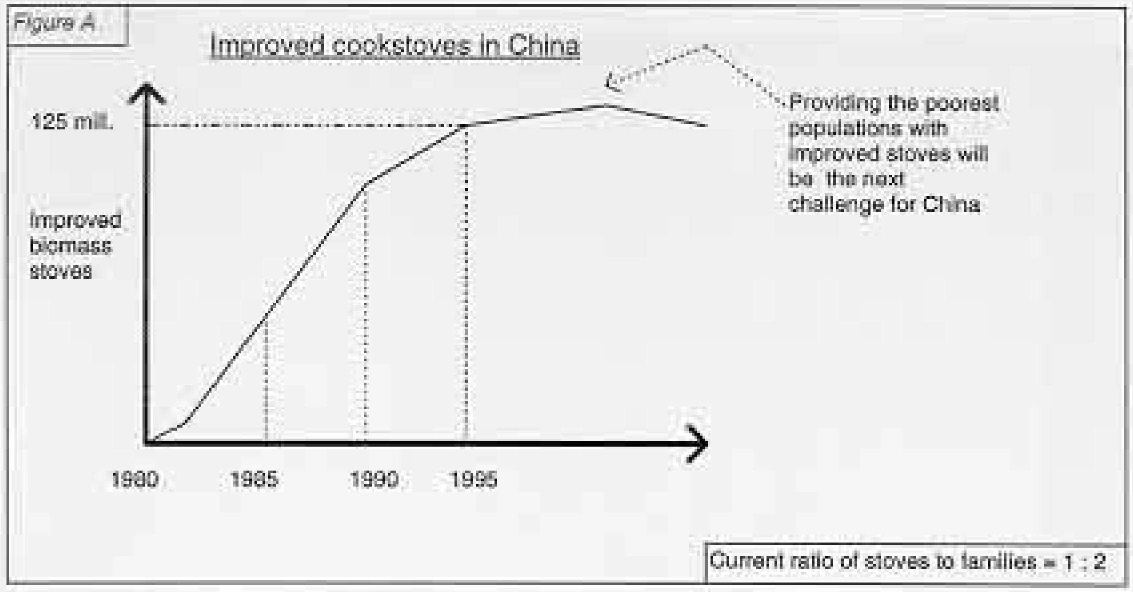


Figure A
Improved cookstoves in China
125 mill.
Improved biomass stoves
1980
1985
1990
1995
Providing the poorest populations with improved stoves will be the next challenge for China
Current ratio of stoves to families = 1 : 2

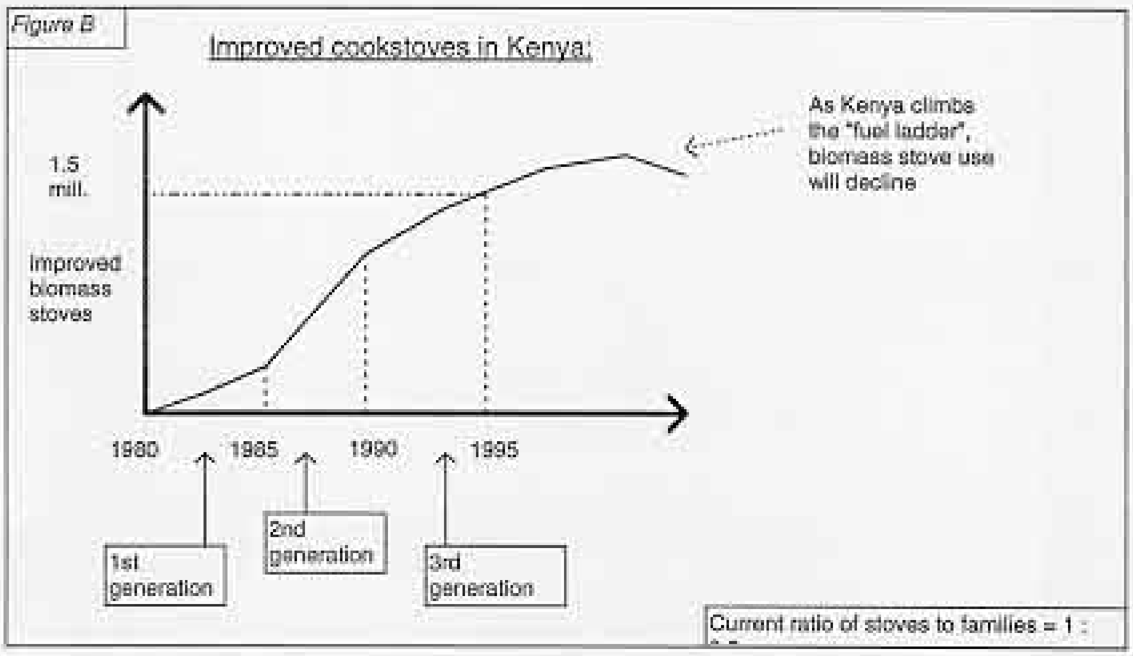


Figure B
Improved cookstoves in Kenya:
1.5 mill.
Improved biomass stoves
1980
1985
1990
1995
1st generation
2nd generation
3rd generation
As Kenya climbs the "fuel ladder", biomass stove use will decline
Current ratio of stoves to families = 1 :

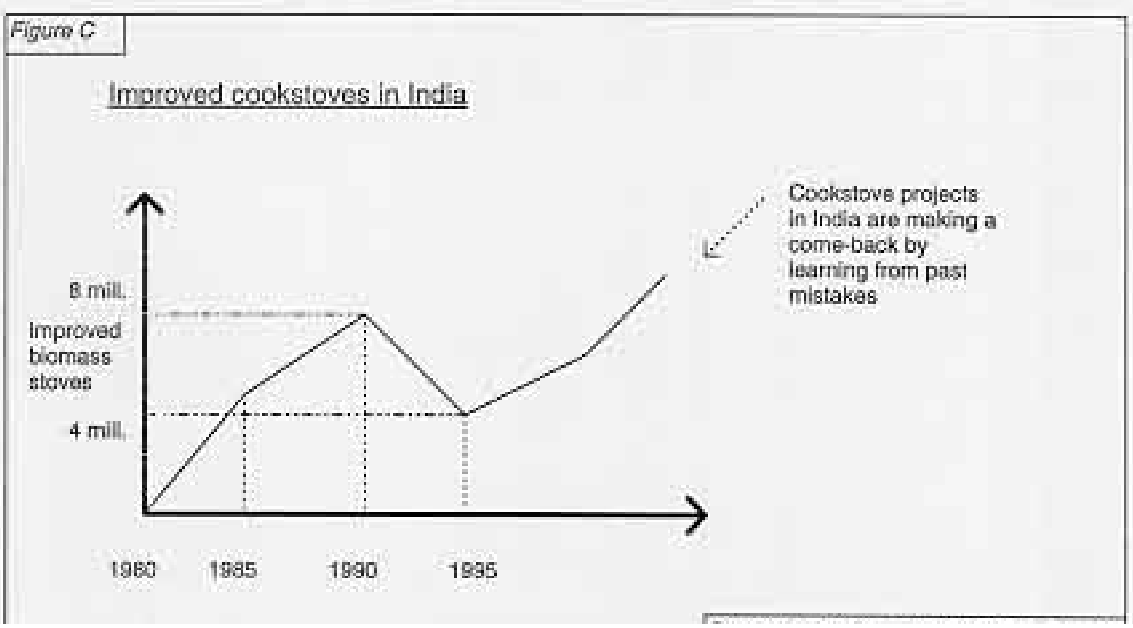
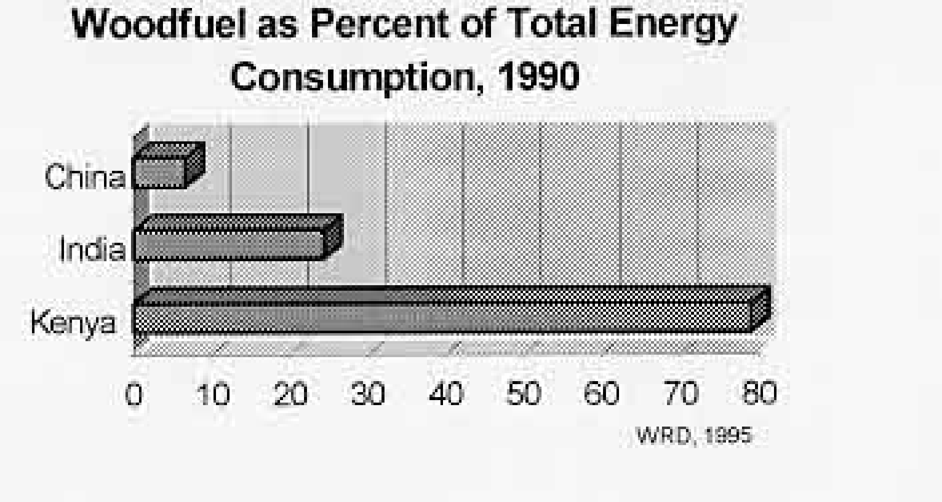


Figure C
Improved cookstoves in India
8 mill.
Improved biomass stoves
4 mill.
1980
1985
1990
1995
Cookstove projects in India are making a come-back by learning from past mistakes


1980
1985
1990
1995
Current ratio of stoves to families = 1 : 40


Woodfuel as Percent of Total Energy Consumption, 1990
China
India
Kenya
0 10 20 30 40 50 60 70 80
WRD, 1995

NOTES

[1] David Apter and Carl Rosberg (eds.): *Political Development and the New Realism in Sub-Saharan Africa*, University Press of Virginia, Charlottesville, VA, 1994.

[2] James S. Wunsch and Dele Olowu (eds.) *The Failure of the Centralized State*, Westview Press, Boulder, CO 1990.

[3] At the time of independence, both Uganda and Tanzania were among the least urbanized nations in Africa. A significant proportion of their population resided in the countryside. Urban centers were primarily colonial administrative forts.

[4] Charles Becker, Andrew Hamer and Andrew Morrison : *Beyond Urban Bias in Africa: Urbanization in the Era of Structural Adjustment*, Heinemann, Portsmouth, NH, 1994.

[5]Lester R. Brown: State of the World, W.W. Norton and Company, New York, NY, 1990-95.

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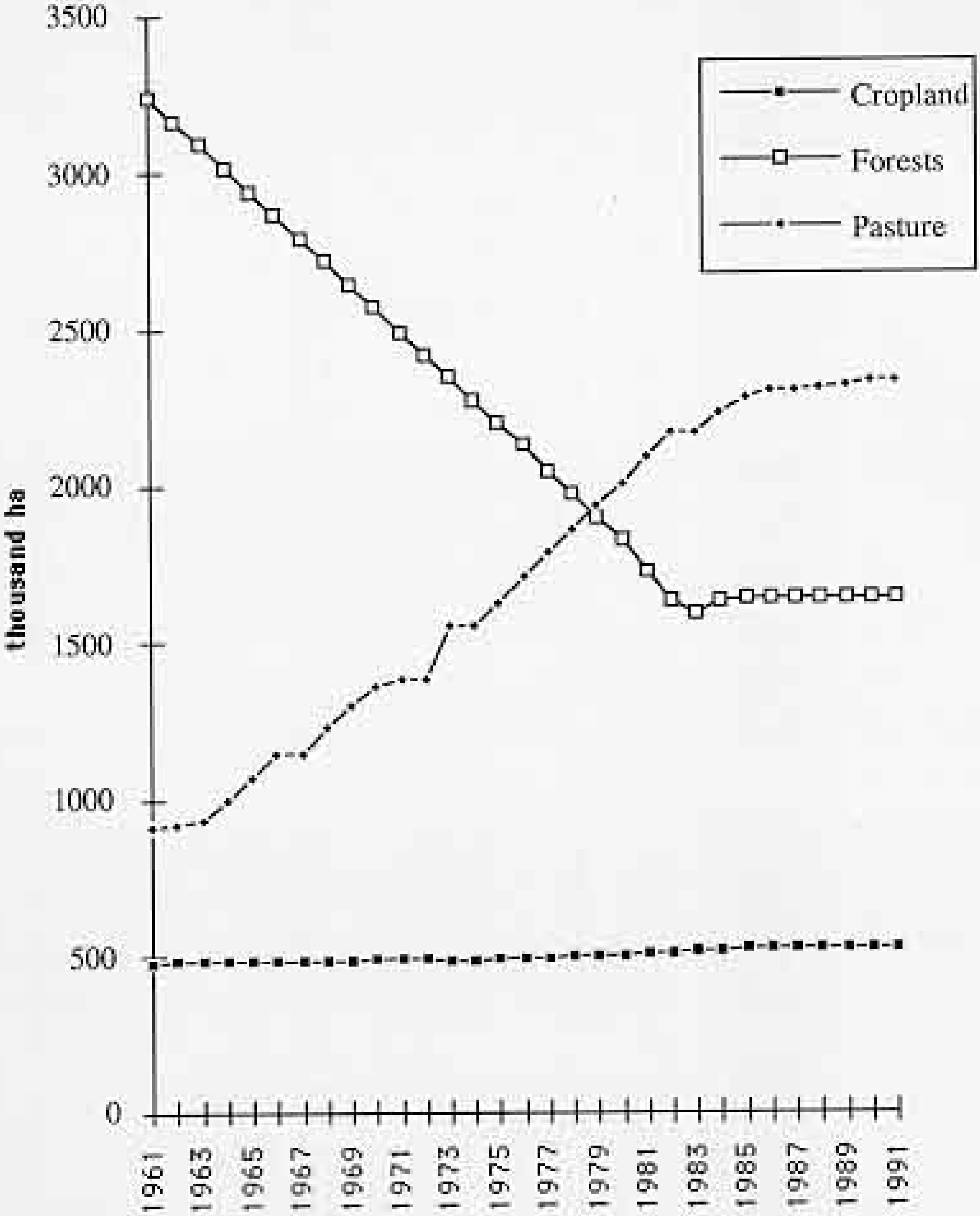

Figure 2: The Forestry Transition in Costa Rica.

Source: World Resources Institute, 1994.

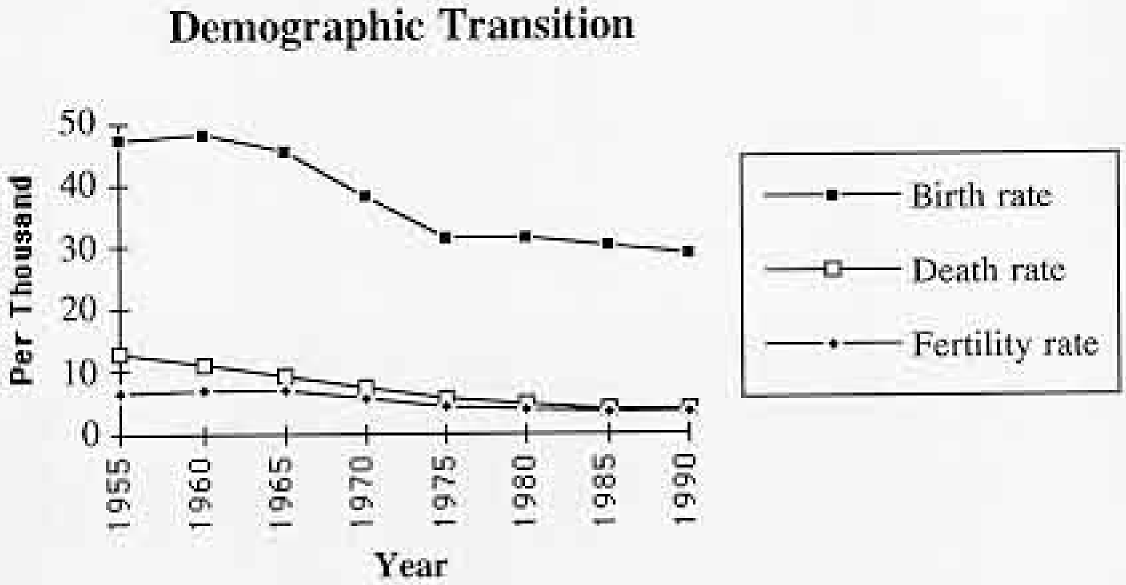

Figure 3: The Demographic Transition for Costa Rica.

Source: World Resources Institute, 1994.

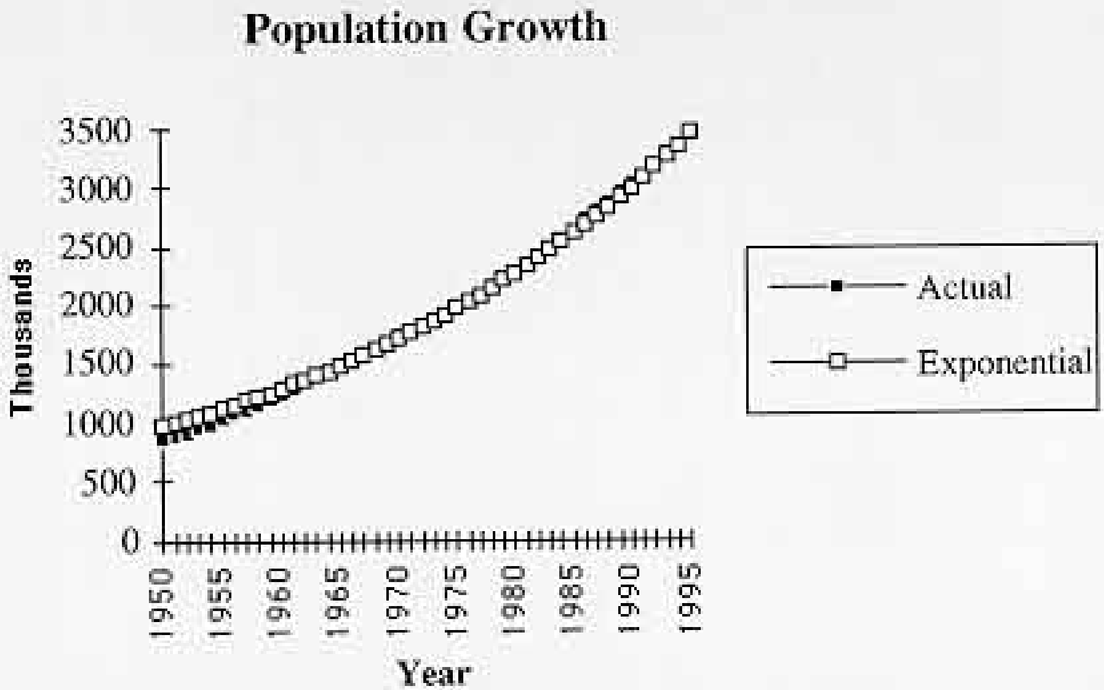

Figure 4: Actual and Projected Population of Costa Rica.

Source: World Resources Institute, 1994.

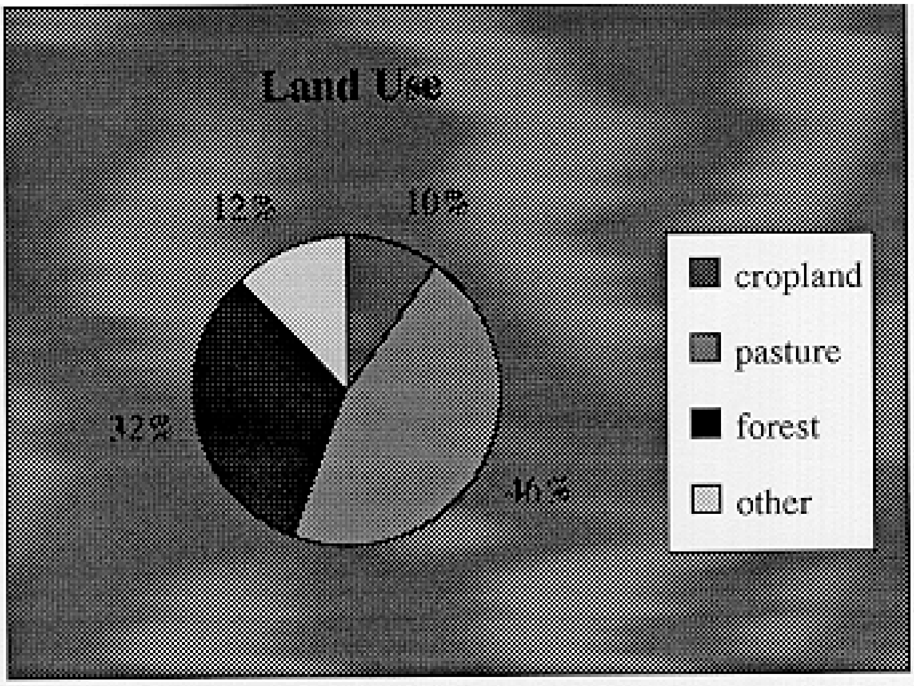

Figure 5: Land Use/Land Cover in Costa Rica.

Source: World Resources Institute, 1994.

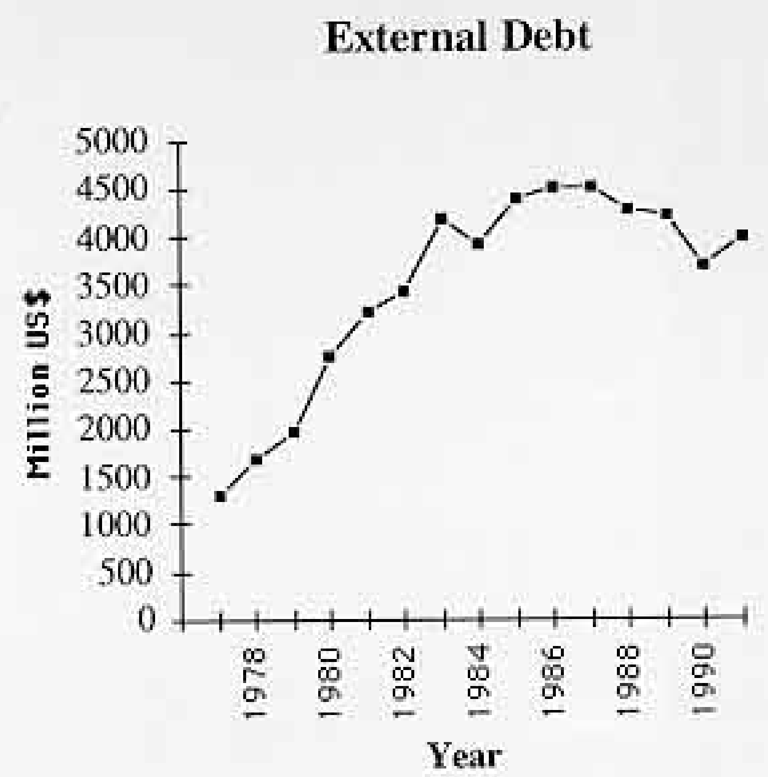

Figure 6: External Debt of Costa Rica.

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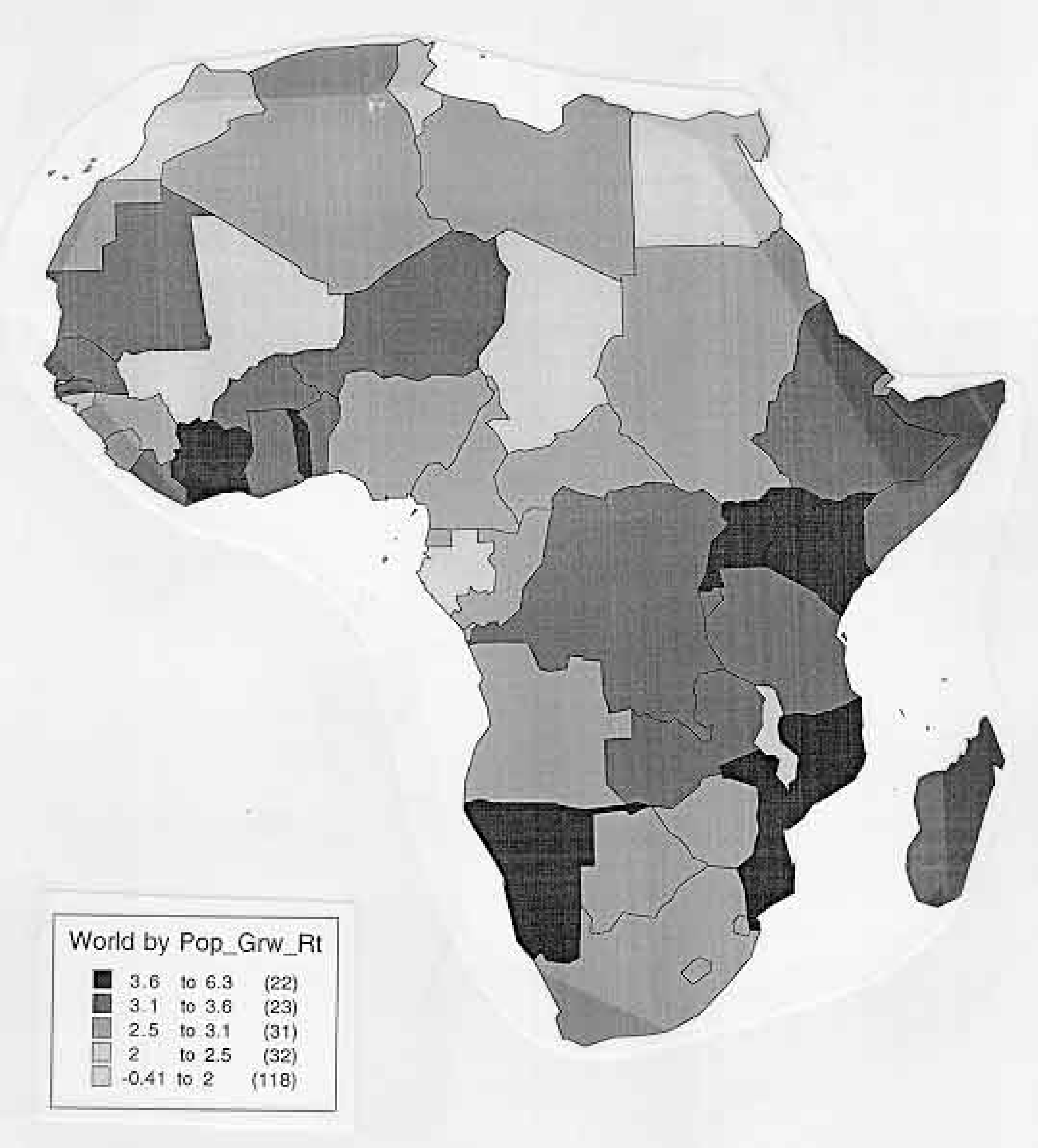


Figure 1. Thematic Map of Africa by Population Growth Rate.

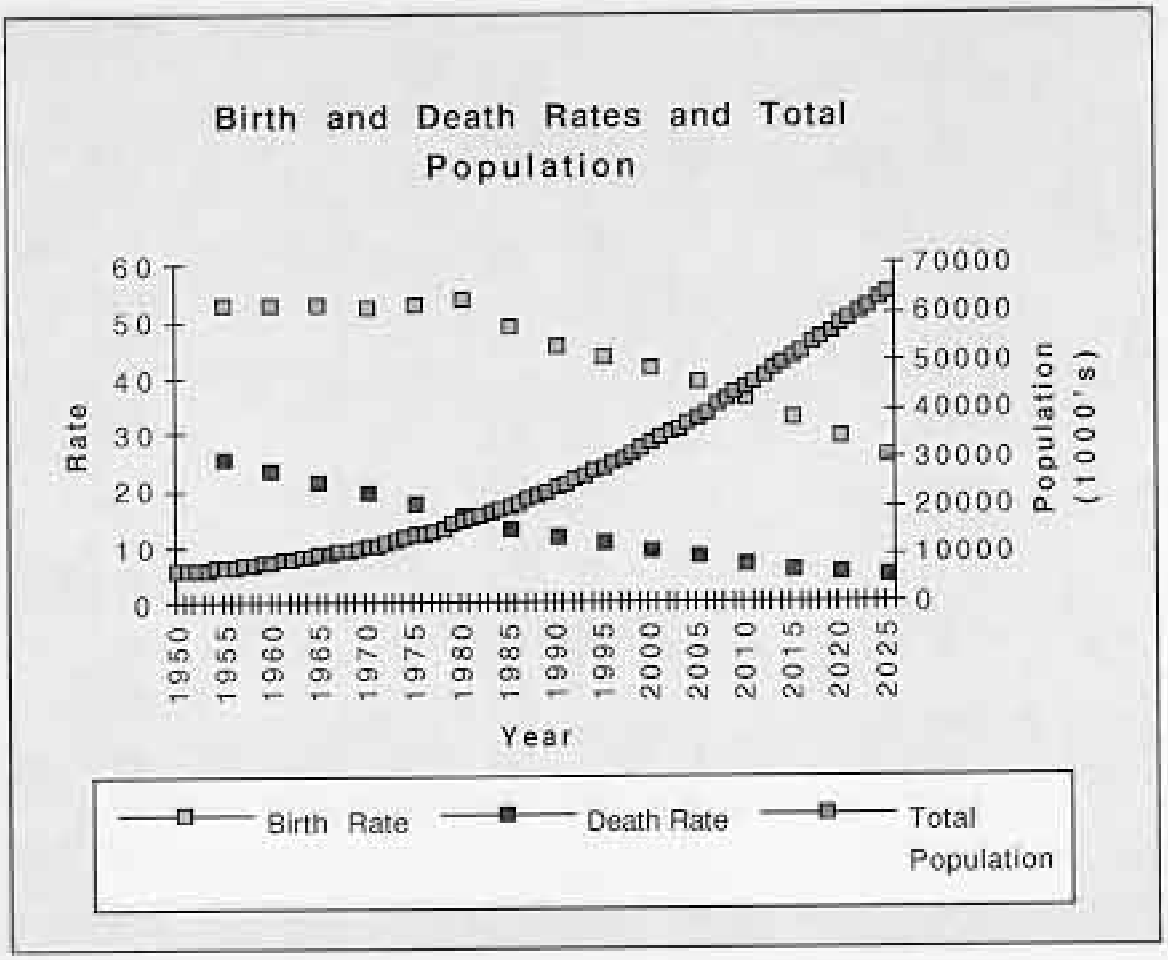
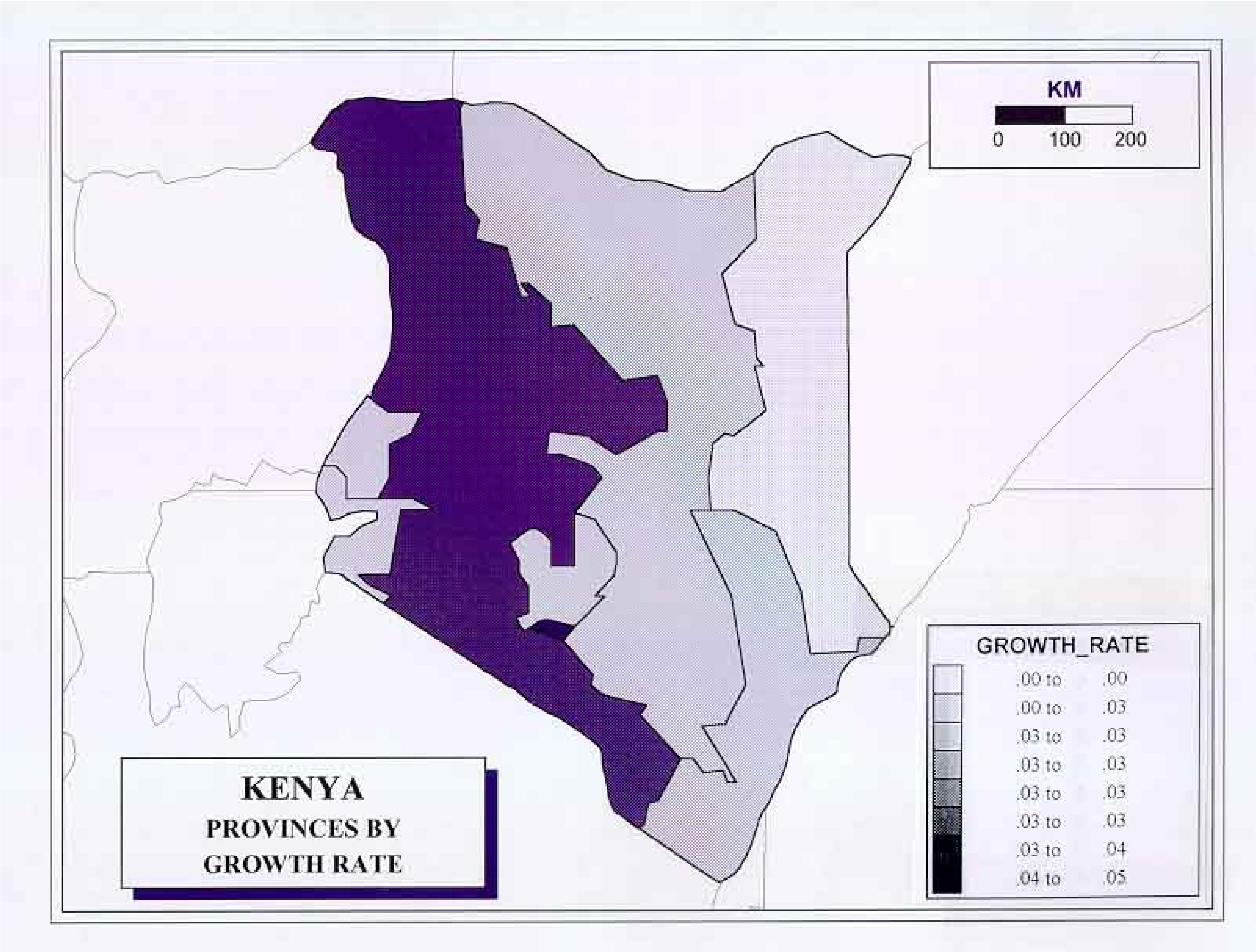


Figure 2. Birth rates and death rates superimposed on total population. Date source: World Resources Data Base 1994-95.

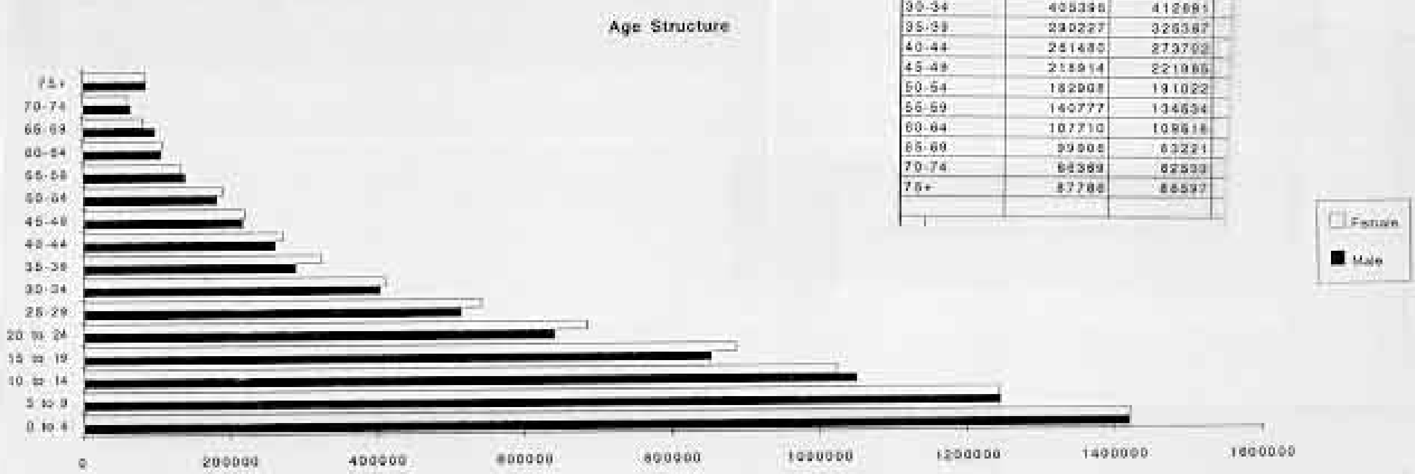

KM
0
100
200
GROWTH_RATE
.00 to .00
.00 to .03
.03 to .03
.03 to .03
.03 to .03
.03 to .03
.03 to .04
.04 to .05
KENYA
PROVINCES BY
GROWTH RATE

Measures of Fertility and Mortality

Period	Total Fertility Rate	Probability of Dying by Age 5 (per 1,000)	Life Expectancy at Birth (years)
ca. 1940[a]	5.5	270	37
1958-1962[a]	7.0	220	43
1965-1969[a]	7.6	190	49
1975-1979[a]	7.9	150	54
1985-1989[b]	6.7	110	NA

Figure 4. Fertility Rate, Probability of Dying and Life Expectancy. From: Brass and Jolly.

Figure 5. Age Structure.



Age group	Male	Female
0 to 4	1422021	1421385
5 to 9	1247091	1244748
10 to 14	1050932	1023639
15 to 19	854120	887722
20 to 24	641401	686093
25-29	514451	541281
30-34	405396	412891
35-39	290227	326387
40-44	261480	273702
45-49	215914	221986
50-54	182908	191022
55-59	140777	134634
60-64	107710	109616
65-69	99908	83221
70-74	64389	62533
75+	87786	86597

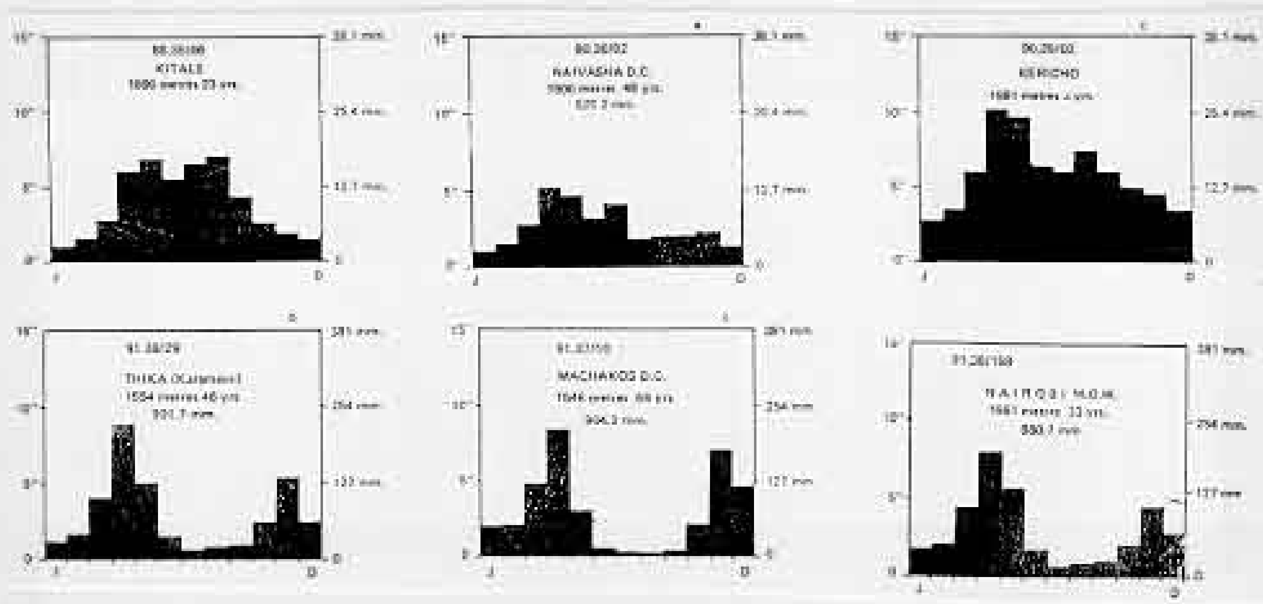
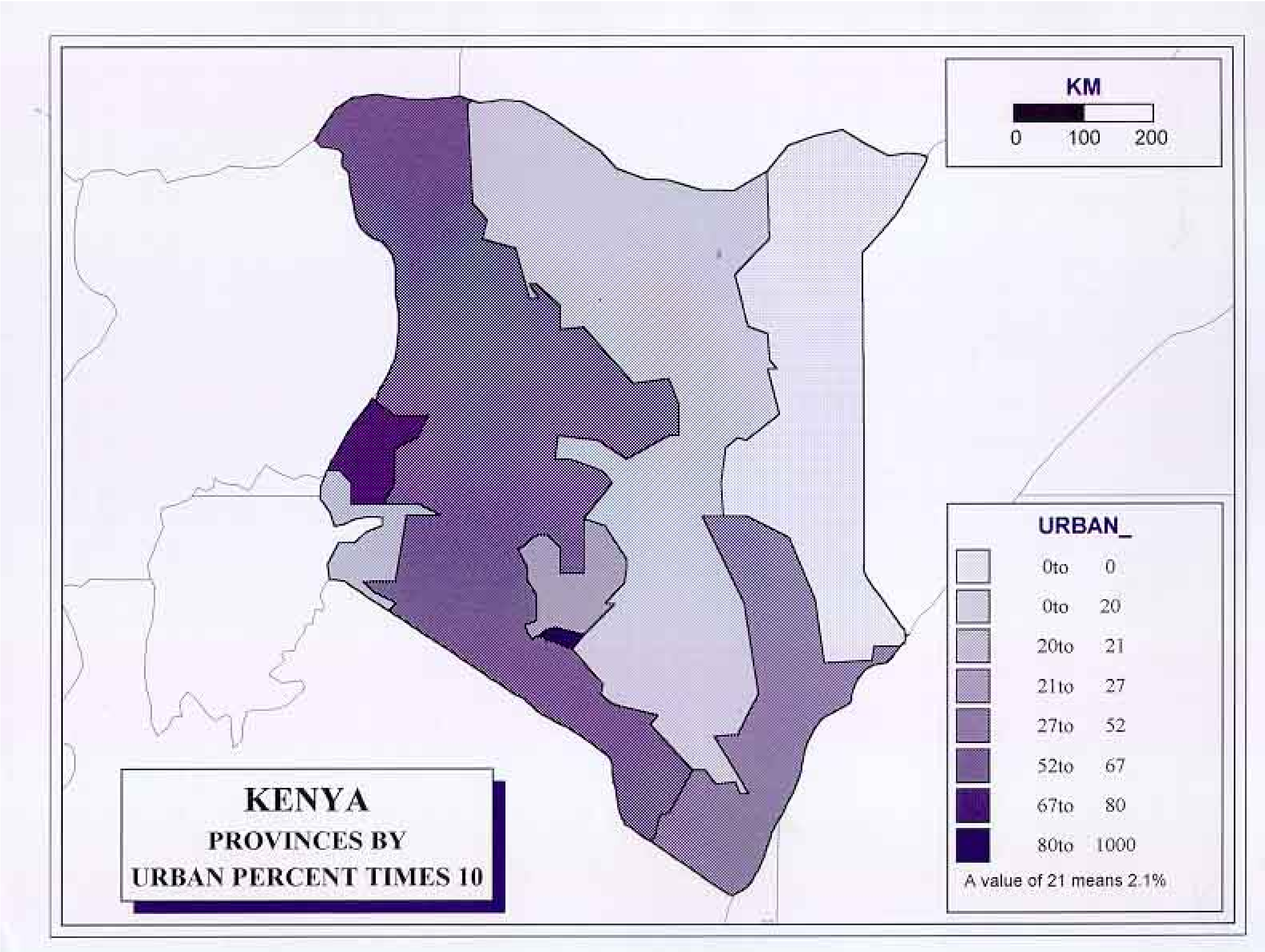


Figure 6. Monthly rainfall data by district. From Odingo.

Figure 7. Map of Kenya


KM
0
100
200
URBAN_
0to 0
0to 20
20to 21
21to 27
27to 52
52to 67
67to 80
80to 1000
A value of 21 means 2.1%
KENYA
PROVINCES BY
URBAN PERCENT TIMES 10

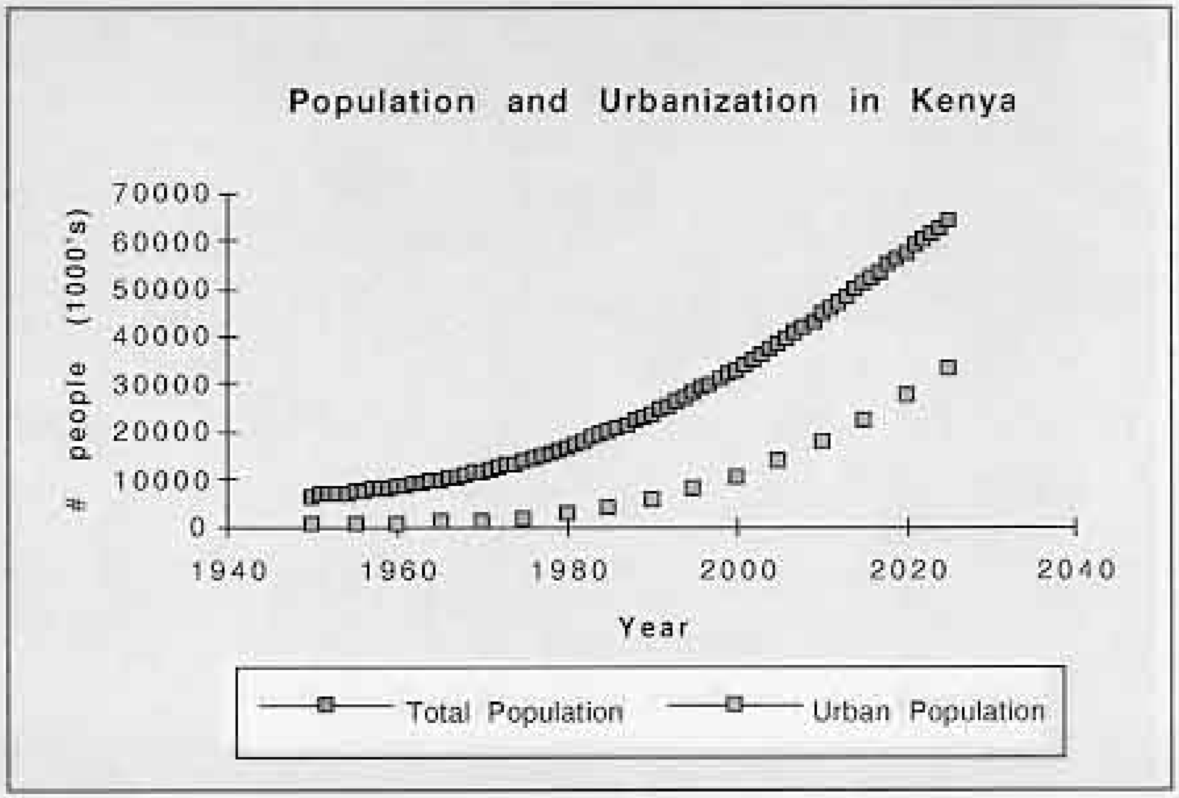


Figure 9. Growth in Urban Population versus Total Population Growth. Data source: World Resources Data base 1994-95.

	Urban population (millions)		Rural population (millions)		Average annual increase rate, 1950–70 (percentage)	
	1950	1970	1950	1970	Urban population	Rural population
World	703·2	1 358·3	1 782·5	2 275·9	3·29	1·22
More developed	439.2	699.1	418.0	390·1	2·32	0·34
Less developed	264·0	659·2	1 364·5	1 885·8	4·58	1·64
South Asia	112·5	233·1	585·9	892·7	3·64	2·11
East Asia	100·8	274·9	556·2	655·0	5·02	0·82
Europe	208·9	293·7	183·1	168·4	1·70	0·42
Africa	30·5	76·7	186·8	267·7	4·62	1·80
Soviet Union	71·2	138·6	108·9	104·0	3·33	0·22
North America	105·8	169·1	60·3	58·5	2·34	0·15
Latin America	65·7	159·2	96·7	124·1	4·42	1·25
Oceania	7·8	13·1	4·8	6·2	2·62	1·31

Figure 10. Demographic trends worldwide. From Ominde 1984 (Population and Development in Kenya)

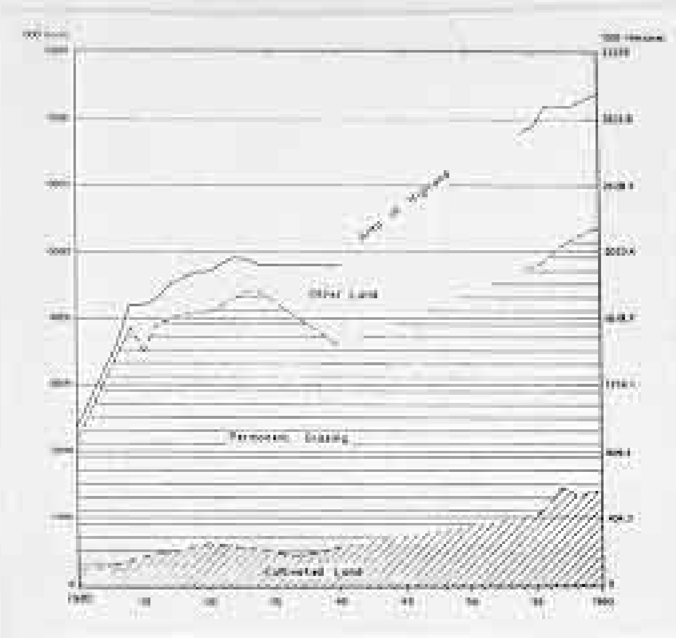


Figure 11. Land use changes in the Kenya Highlands between 1920 and 1960. From Odingo.

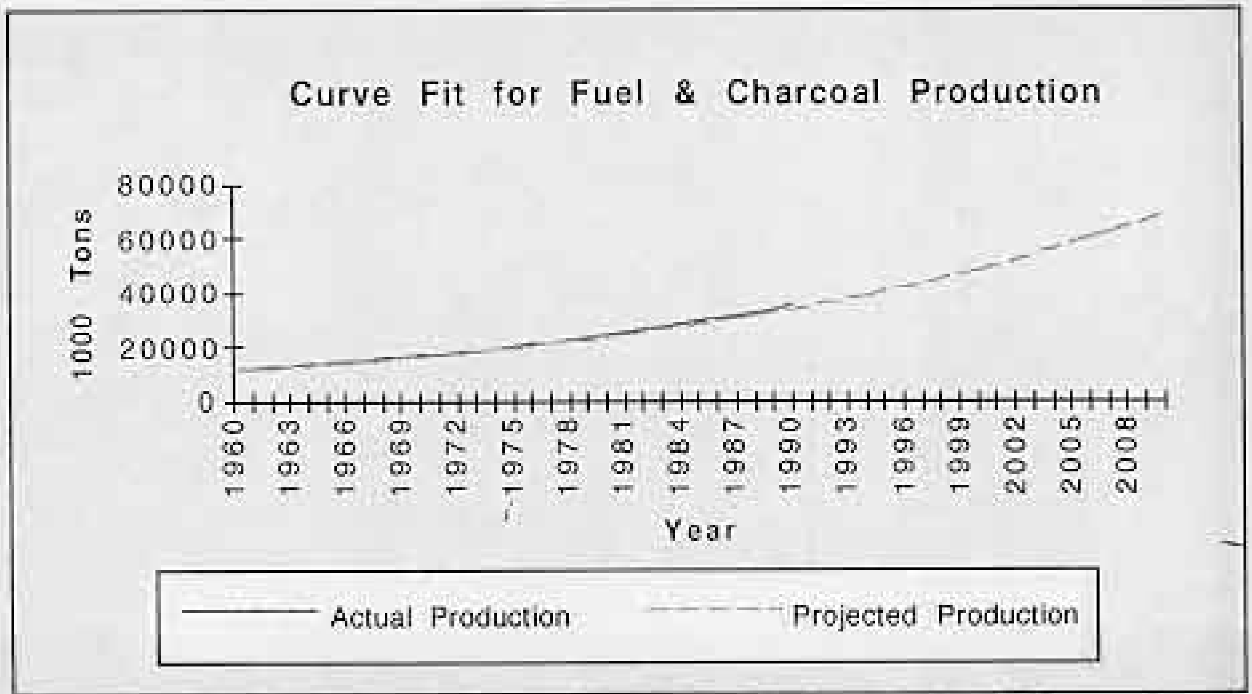


Figure 12. Curve fit and actual data for Charcoal and Fuel Production in Kenya. Data source: World Resources Data Base 1994-95.

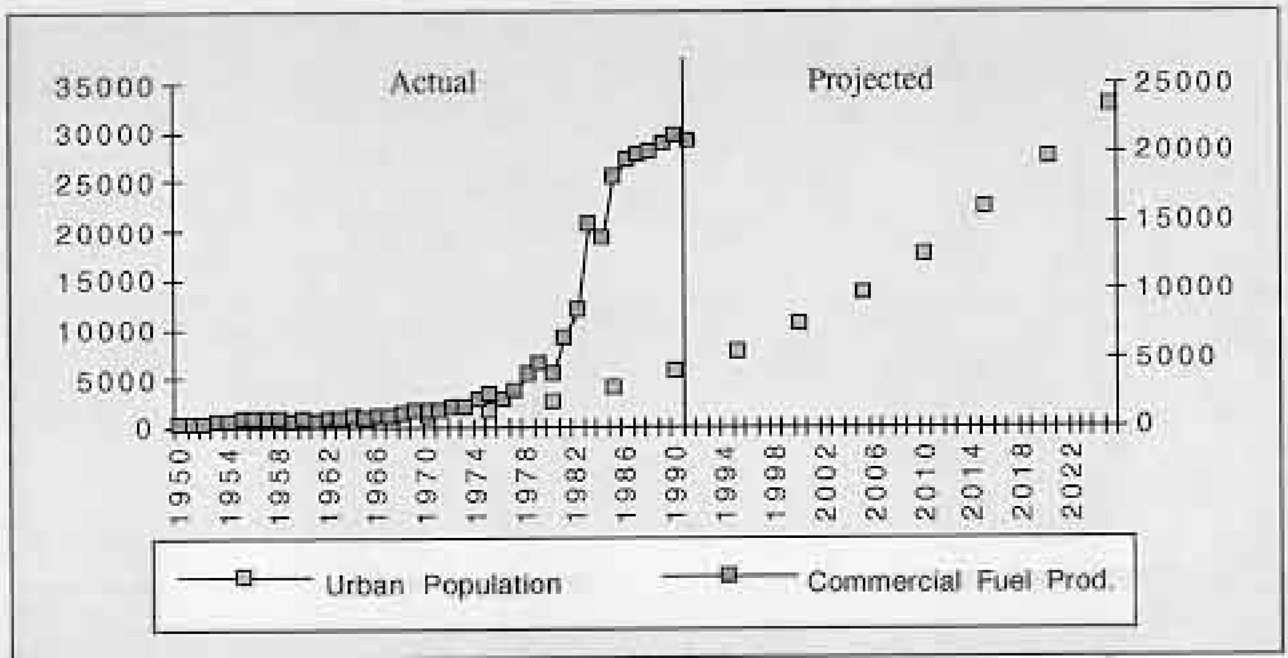


Figure 13. Commercial Fuel Production and Urban Population in Kenya. Data Source: World Resources Data Base. [A logistic curve might also be fit.]

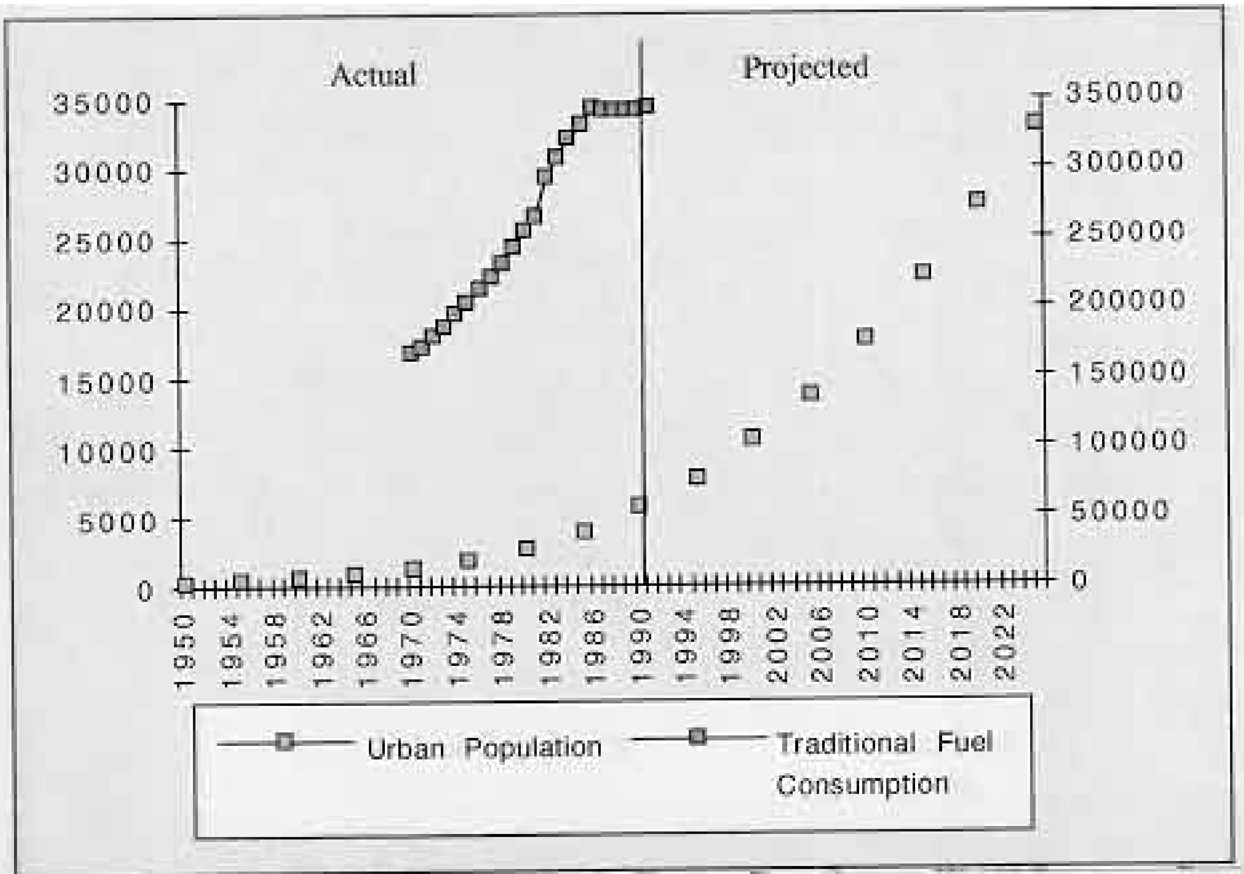


Figure 14. Traditional Fuel Consumption in Kenya. Data Source: World Resources Data Base 1994-95. [A logistic curve might also be fit.]

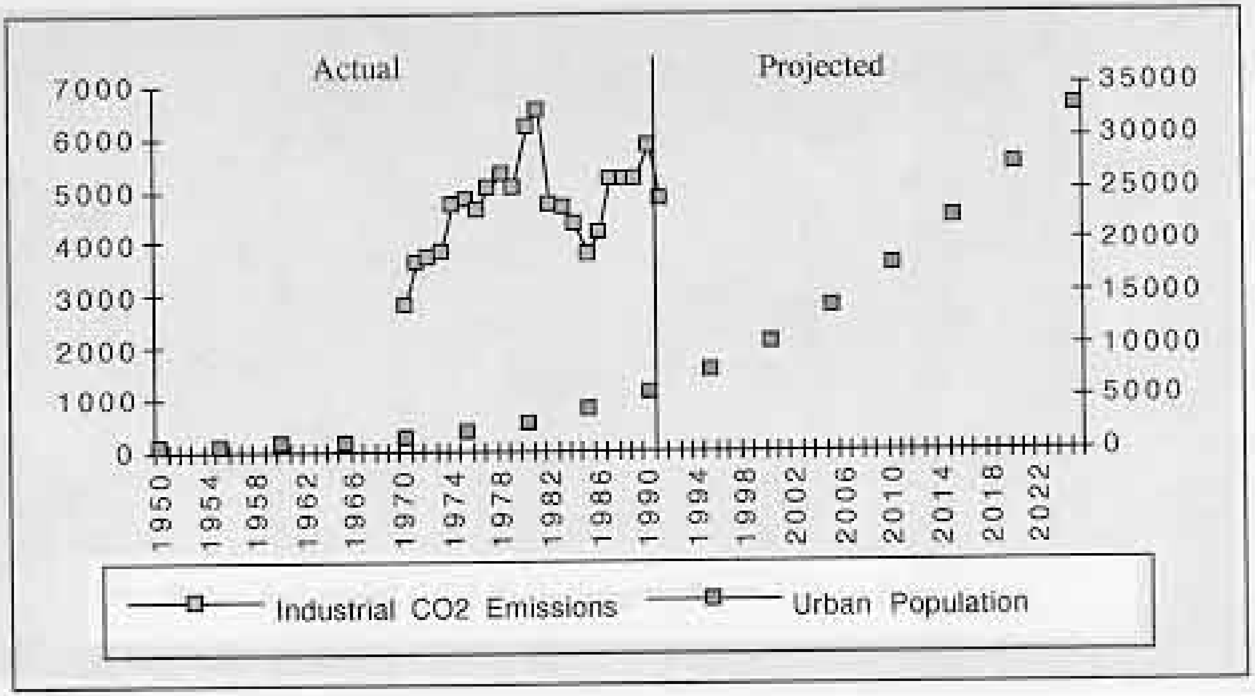


Figure 15. Industrial CO_2 Emissions and Urban Population in Kenya. Data source: World Resources Data Base 1994-95. [Compare this curve to the graphs of the rainfall data, Figure 6.]

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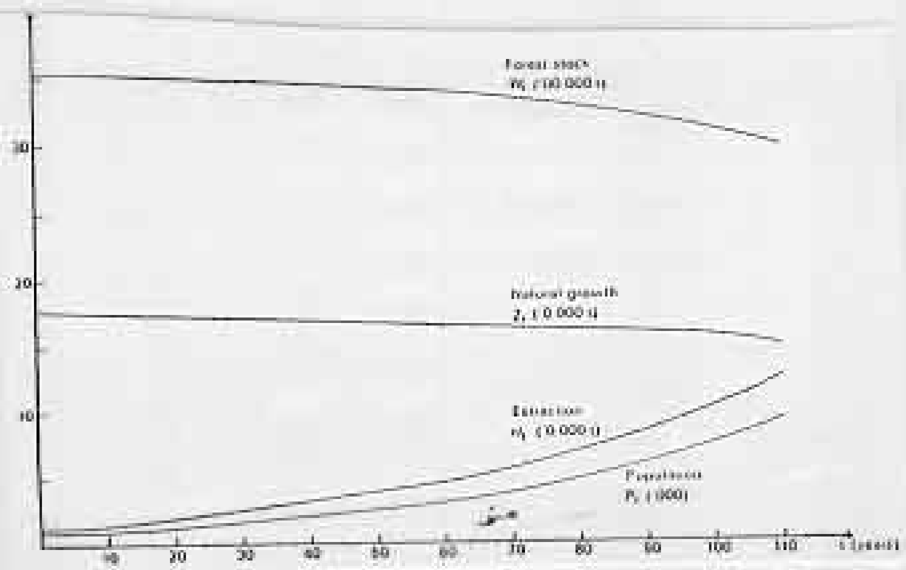
Figure 1:



Source: Reiger, 1988.

As is expected the extraction curve has a close similarity to the population curve. Since th

Figure 2:

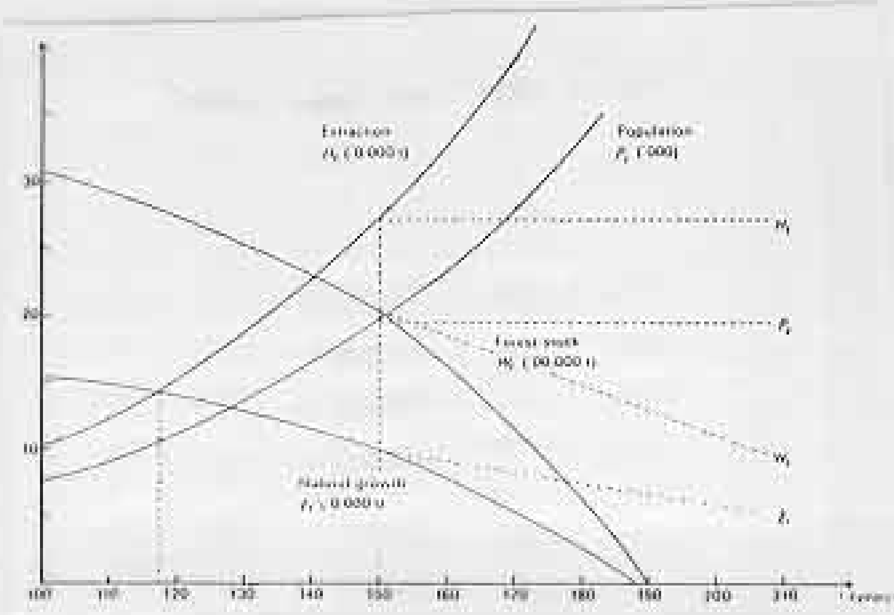
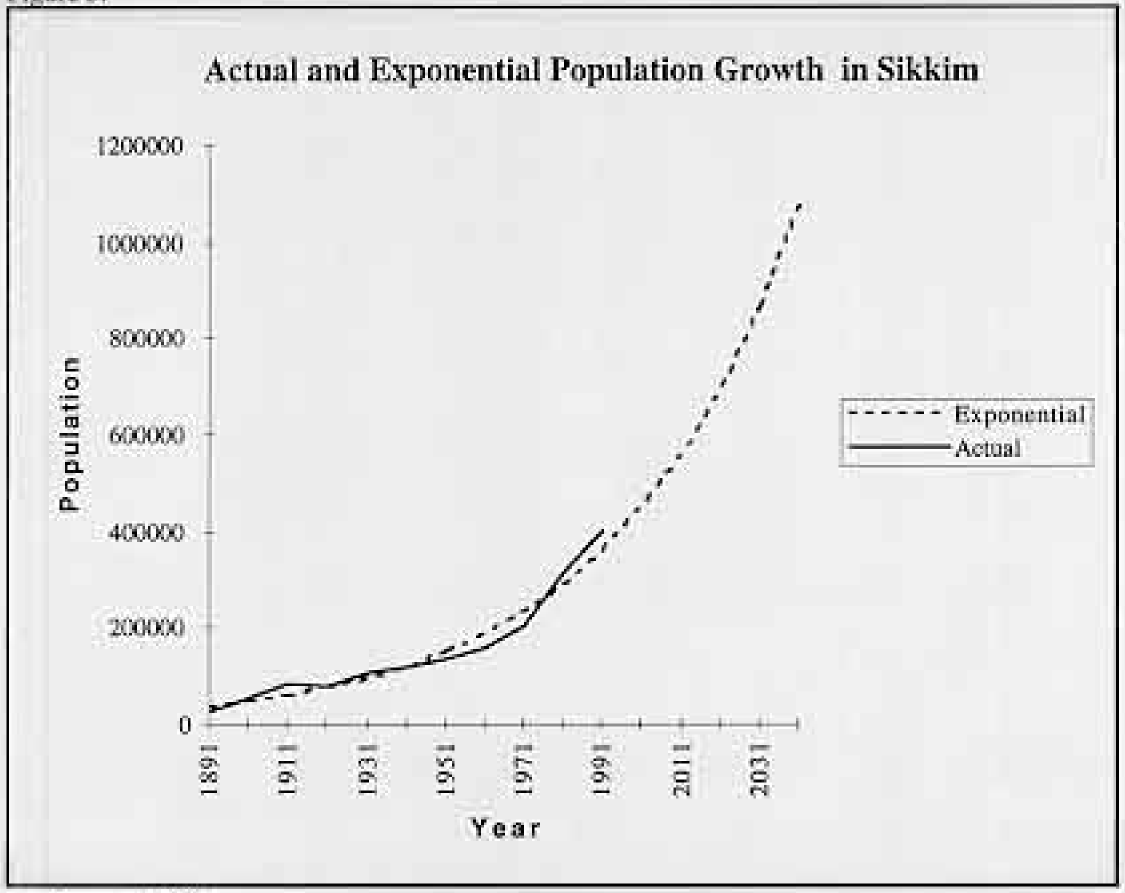
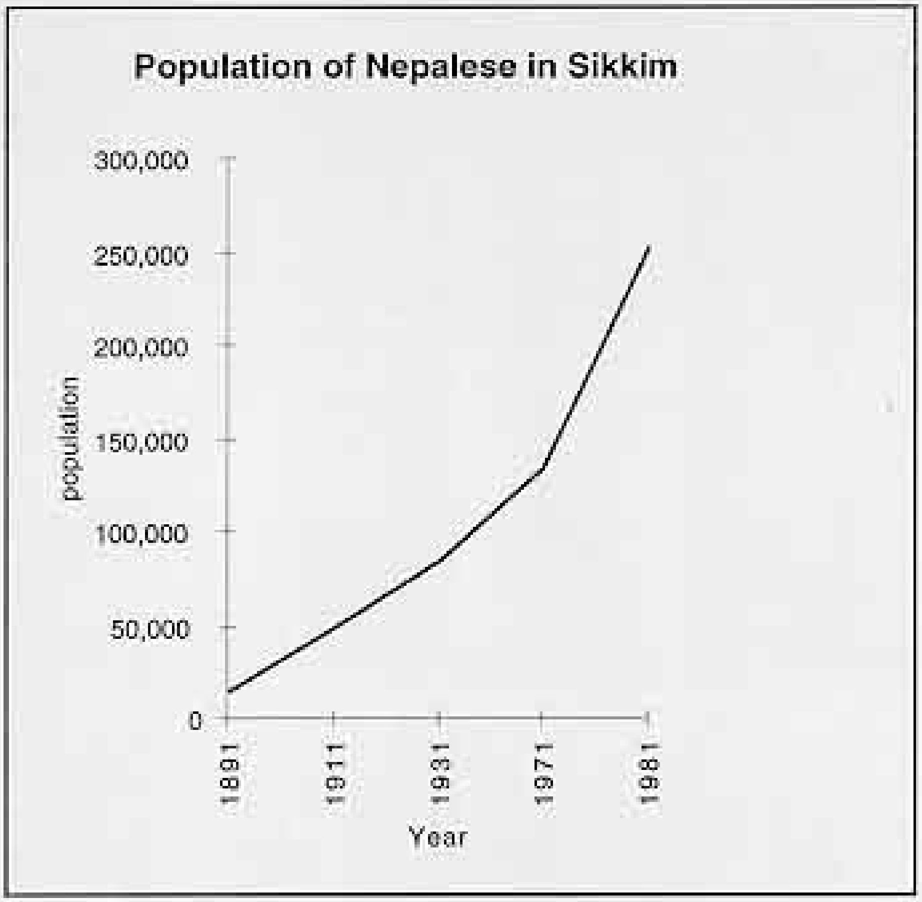

Extraction
Population
Forest stock
Natural growth
10
20
30
100
110
120
130
140
150
160
170
180
190
200
210

Figure 3:



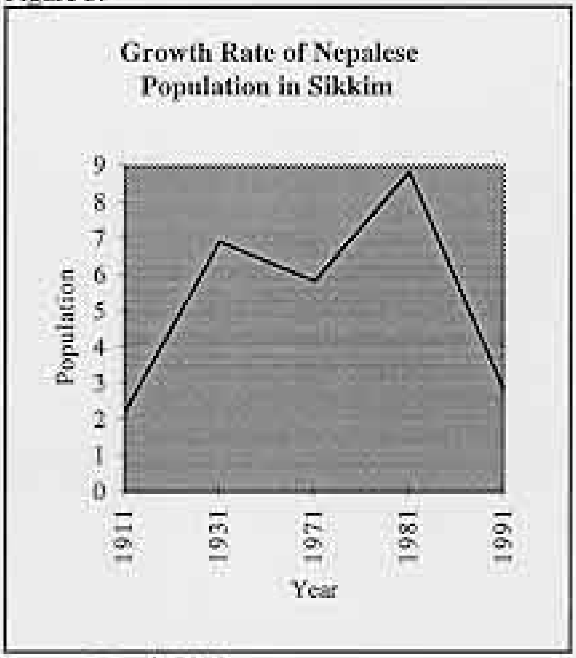
Source: Karan, 1989.

Figure 4:



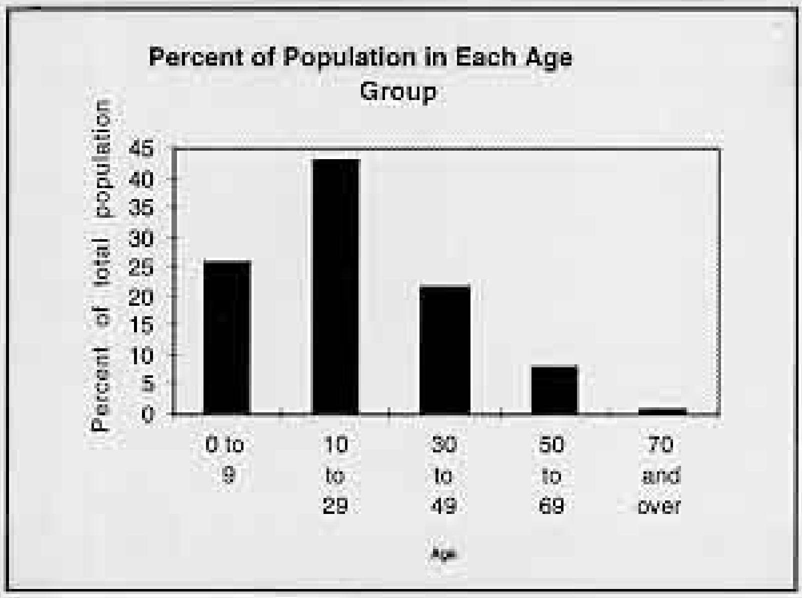
Source: Desai, 1988.

Figure 5:



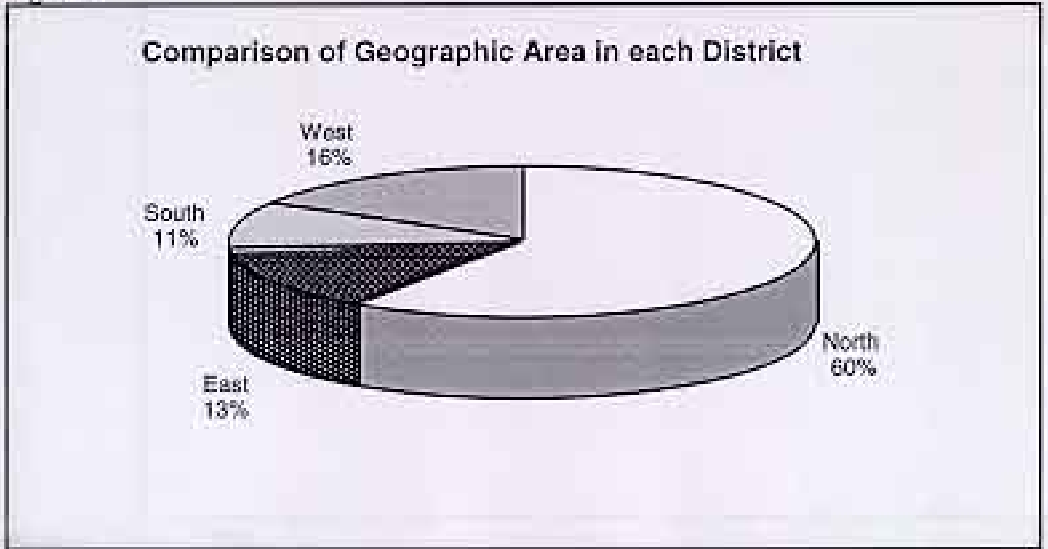
Source: Desai, 1988.

Figure 6:



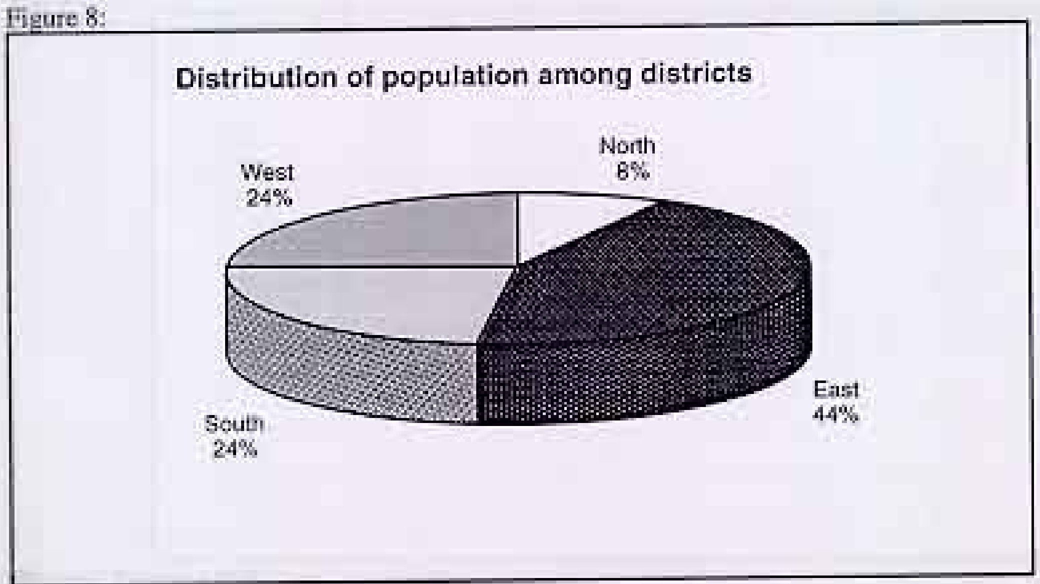
Source: Desai, 1988.

Figure 7:



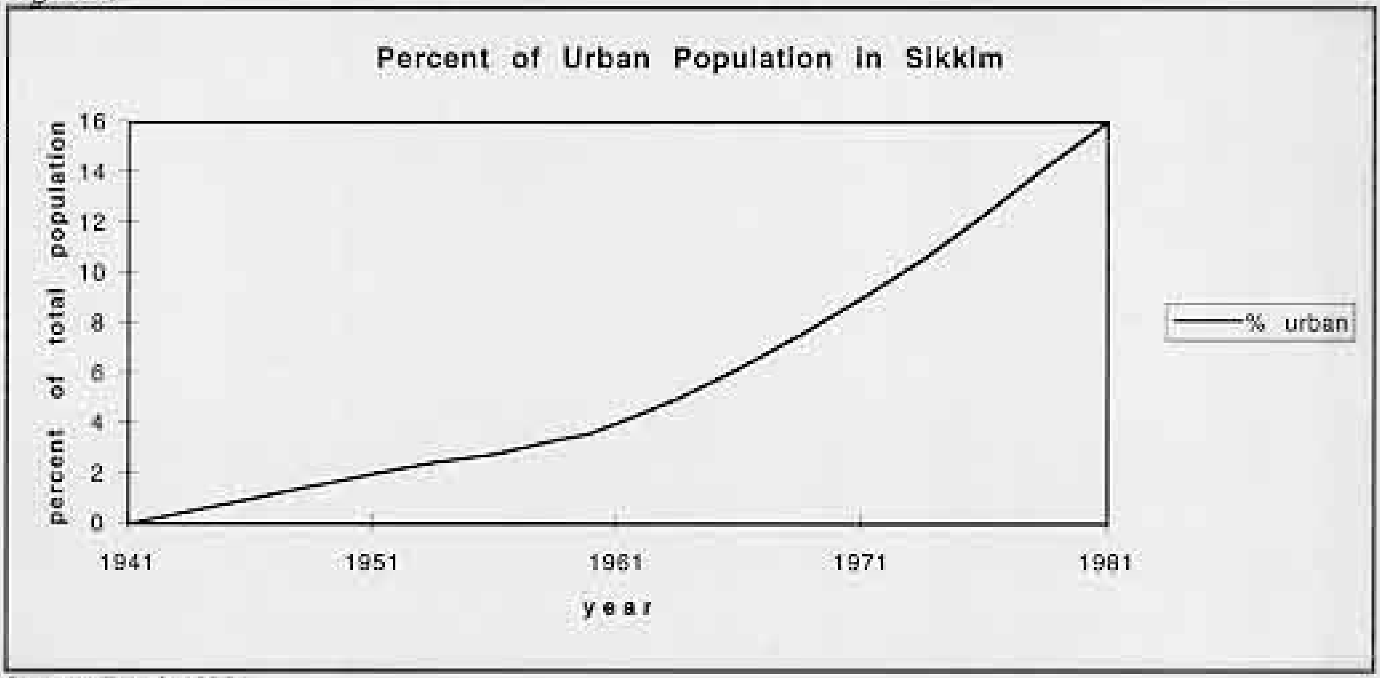
Source: Desai, 1988.

Figure 8:



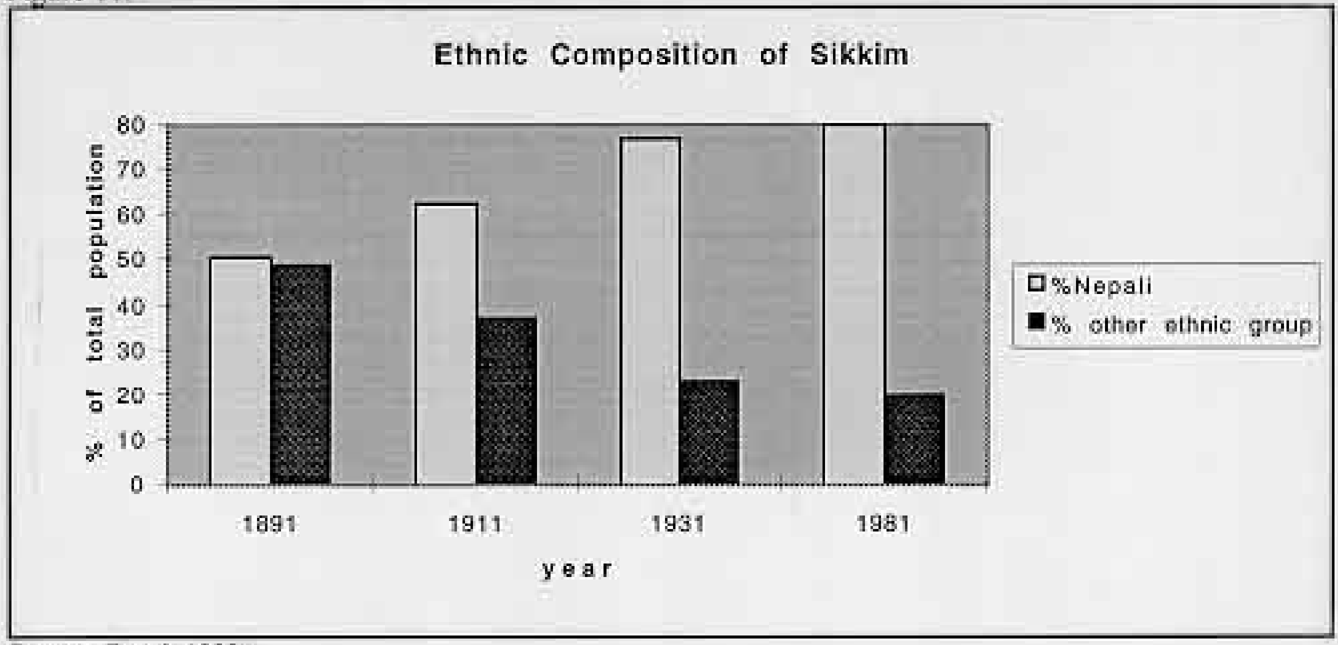
Source: Desai, 1988.

Figure 9:



Source: Desai, 1988.

Figure 10:



Source: Desai, 1988.

Figure 11:

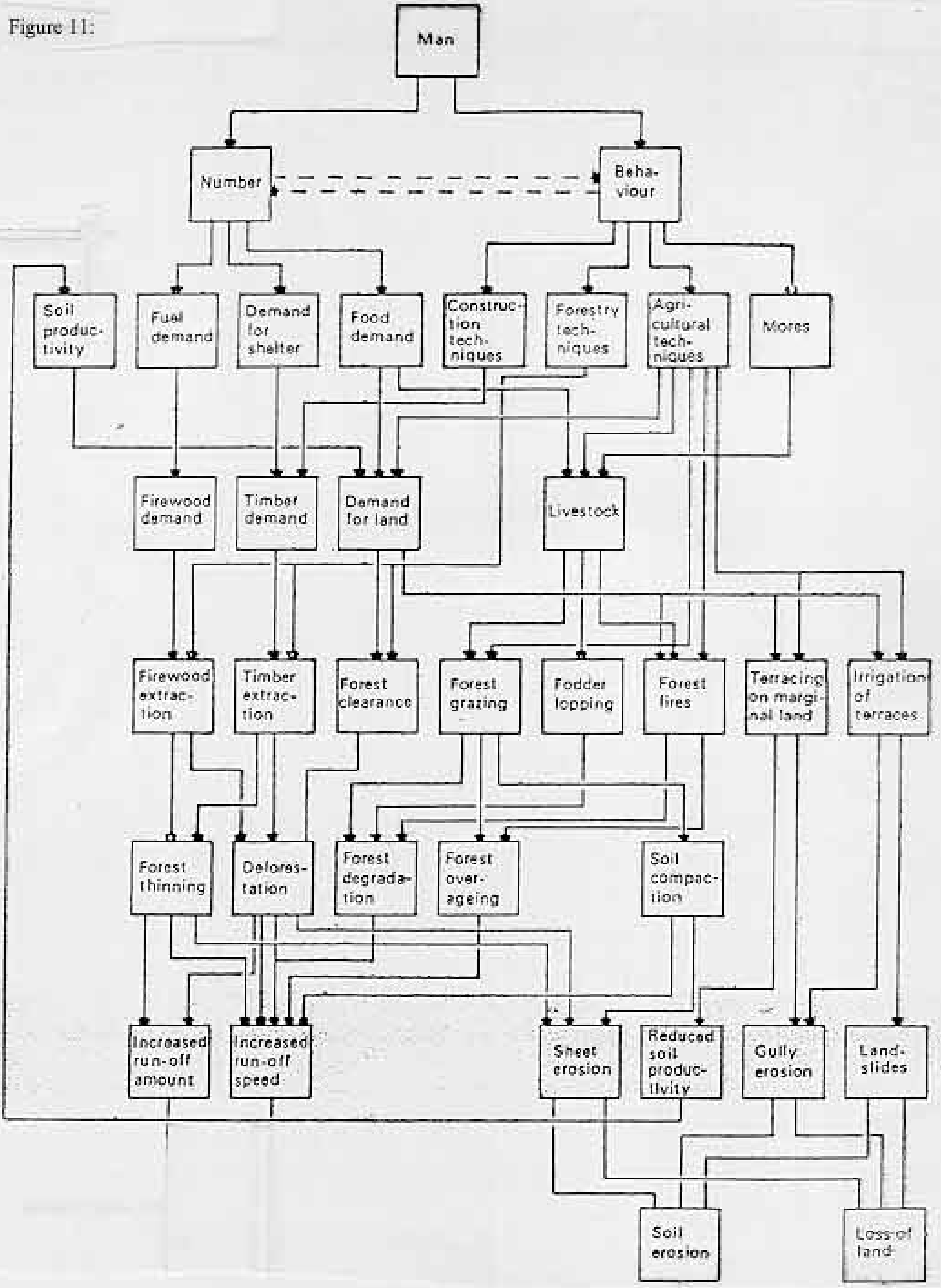
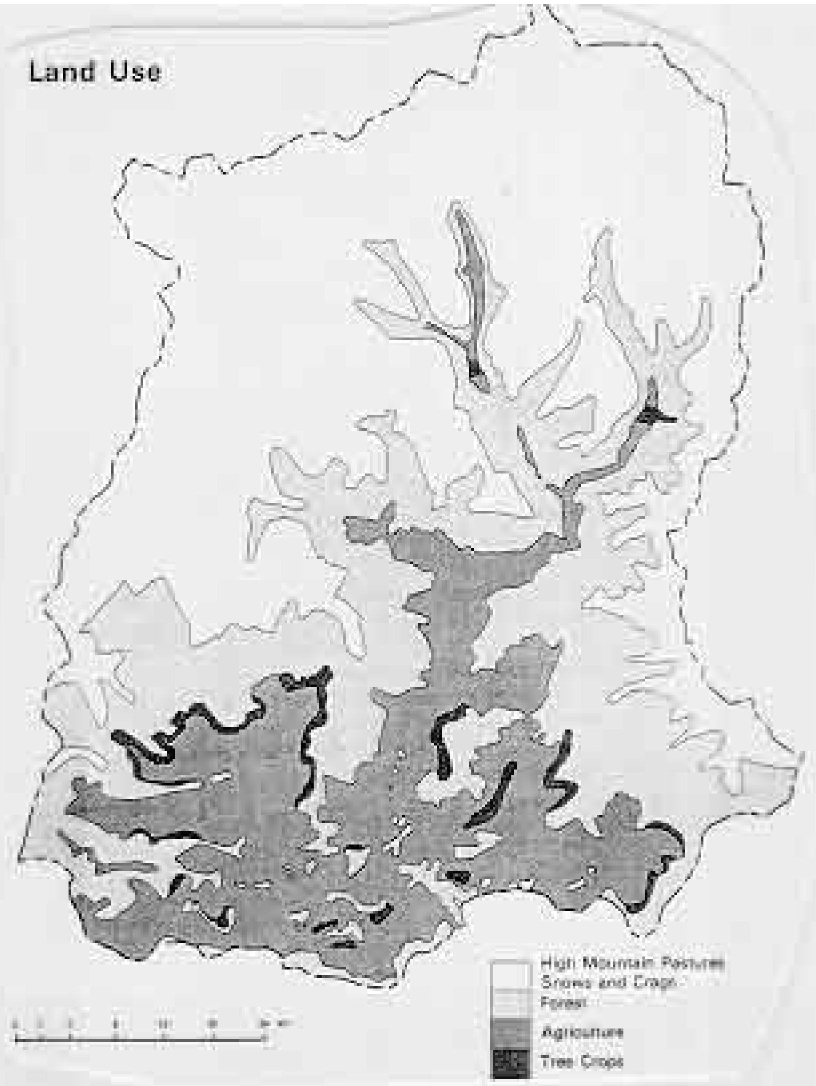
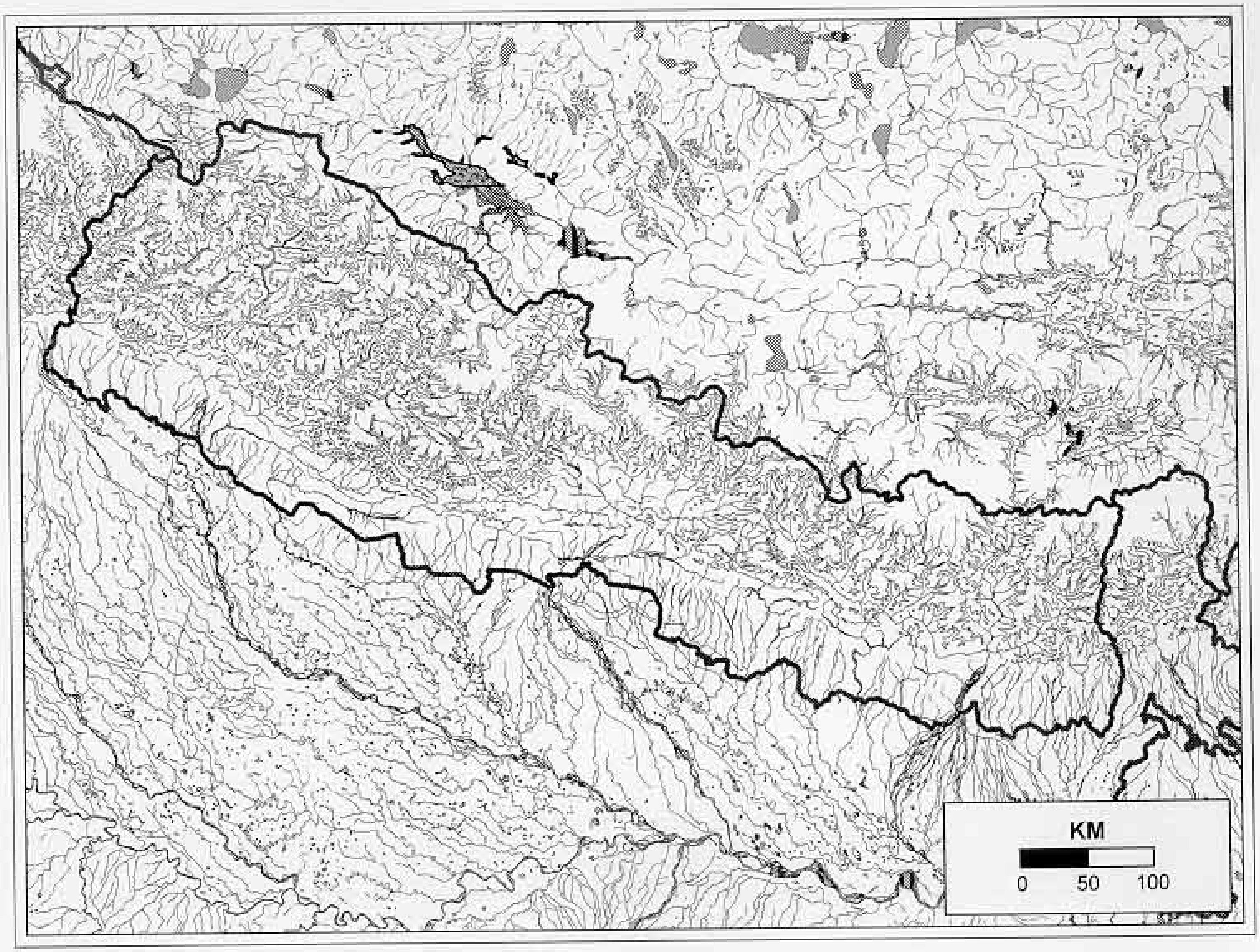
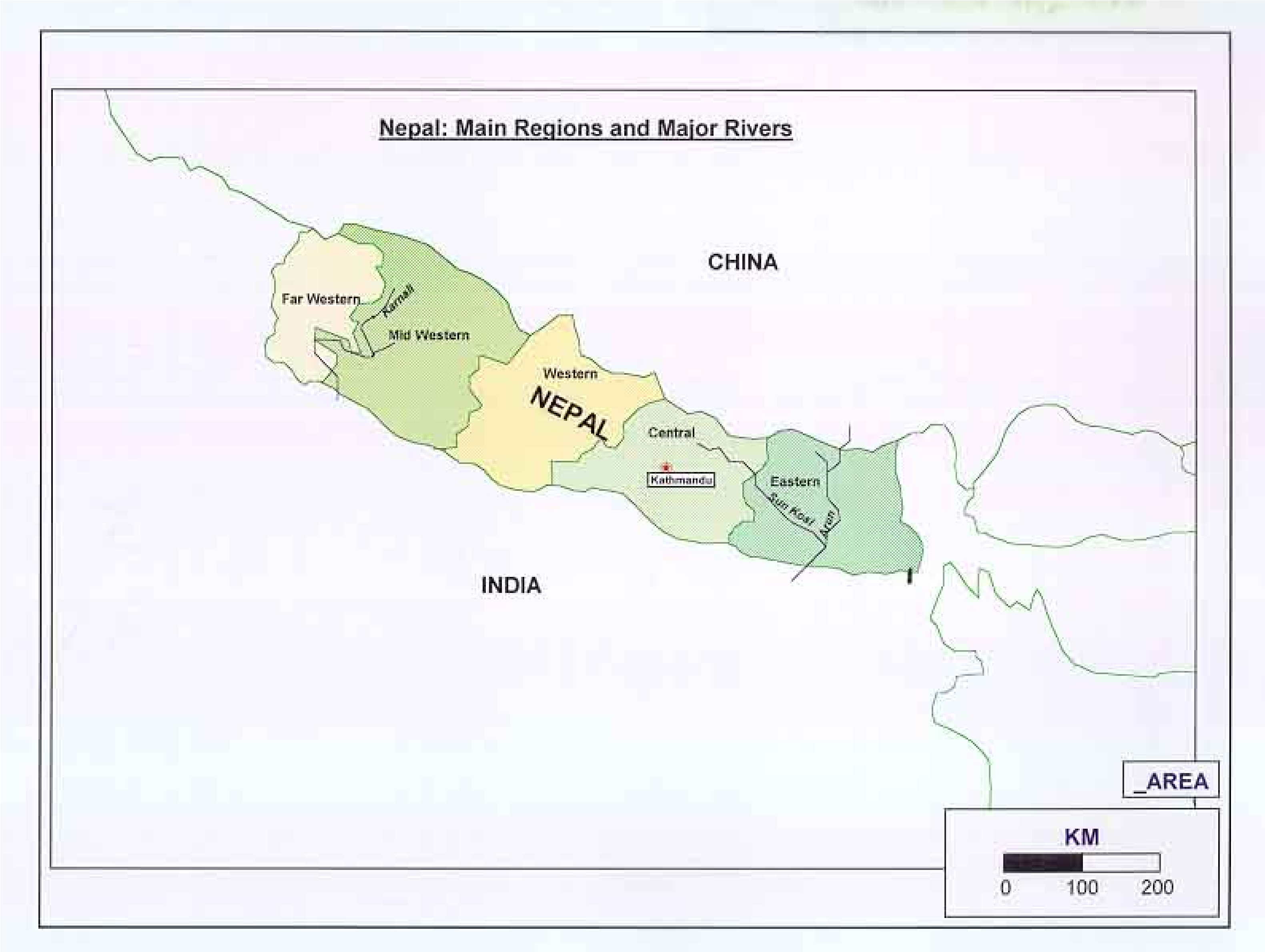

Man
Number
Behaviour
Soil productivity
Fuel demand
Demand for shelter
Food demand
Construction techniques
Forestry techniques
Agricultural techniques
Mores
Firewood demand
Timber demand
Demand for land
Livestock
Firewood extraction
Timber extraction
Forest clearance
Forest grazing
Fodder lopping
Forest fires
Terracing on marginal land
Irrigation of terraces
Forest thinning
Deforestation
Forest degradation
Forest over-ageing
Soil compaction
Increased run-off amount
Increased run-off speed
Sheet erosion
Reduced soil productivity
Gully erosion
Landslides
Soil erosion
Loss of land

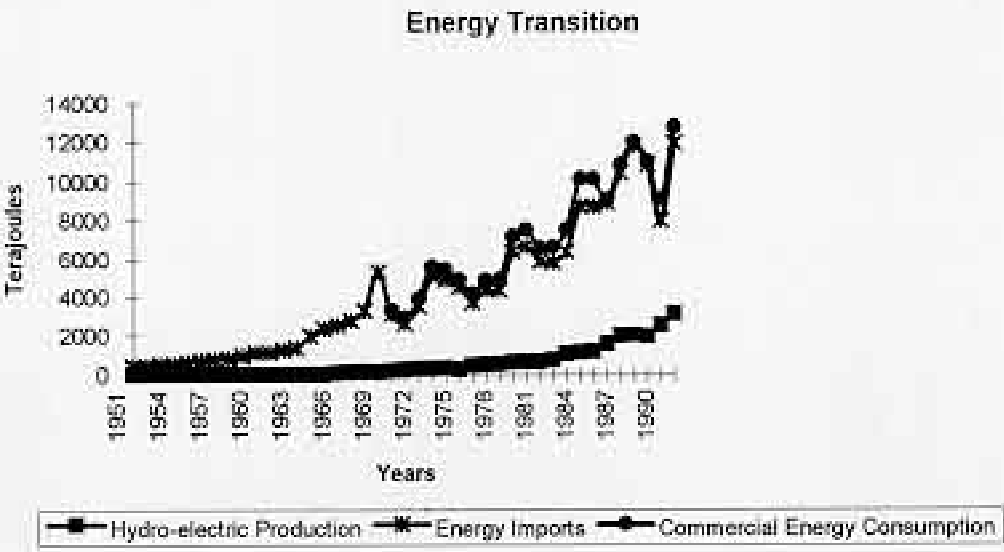
Figure 12:


Land Use
High Mountain Pastures
Snows and Crags
Forest
Agriculture
Tree Crops


Sikkim
District Names and
Rural Population Density
DENSITY
1 to 50
51 to 100
101 to 150
NEPAL
North Sikkim
CHINA - TIBET
Mangan
West Sikkim
Gangtok
South Sikkim
East Sikkim
Gyalshing
BHUTAN
Namchi
WEST BENGAL
KM
0
10
20


KM
0
50
100


Nepal: Main Regions and Major Rivers
CHINA
Far Western
Karnali
Mid Western
Western
NEPAL
Central
Kathmandu
Eastern
Sun Kosi
Arun
INDIA
_AREA
KM
0
100
200



Source: World resource Database, 1995

Figure 2.

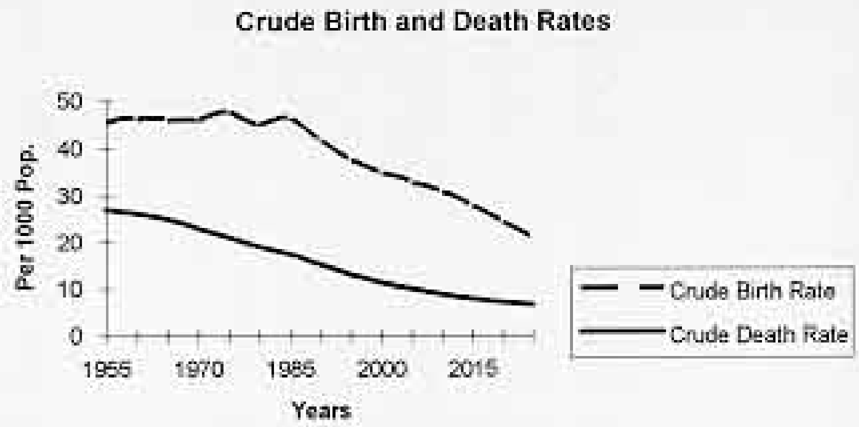
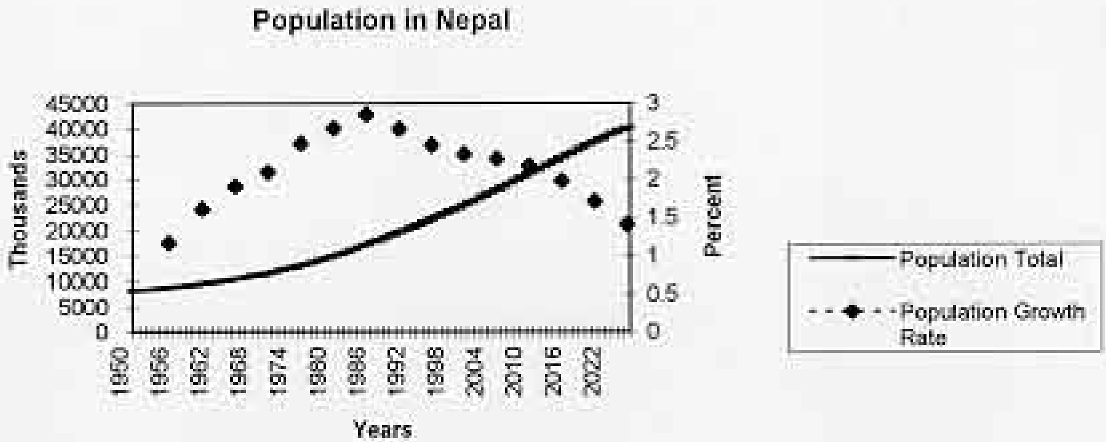
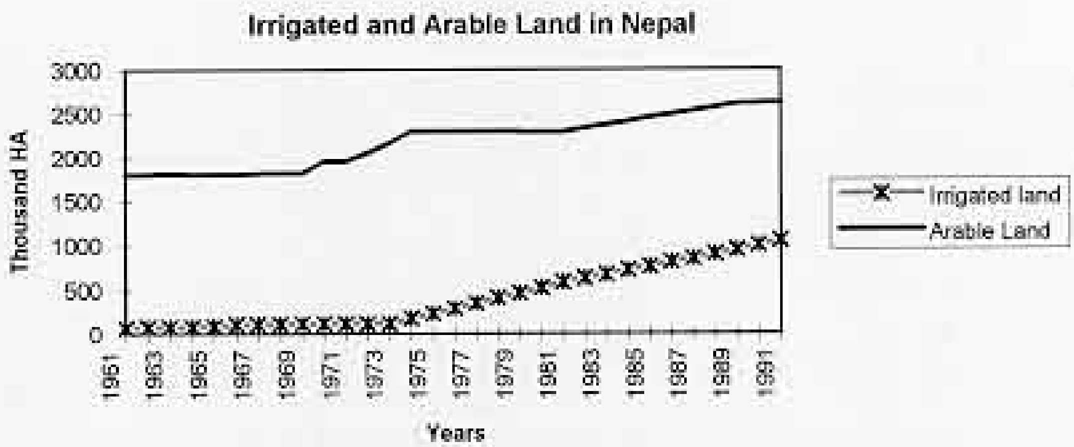

Crude Birth and Death Rates
50
40
30
20
10
0
Per 1000 Pop.
1955
1970
1985
2000
2015
Years
Crude Birth Rate
Crude Death Rate

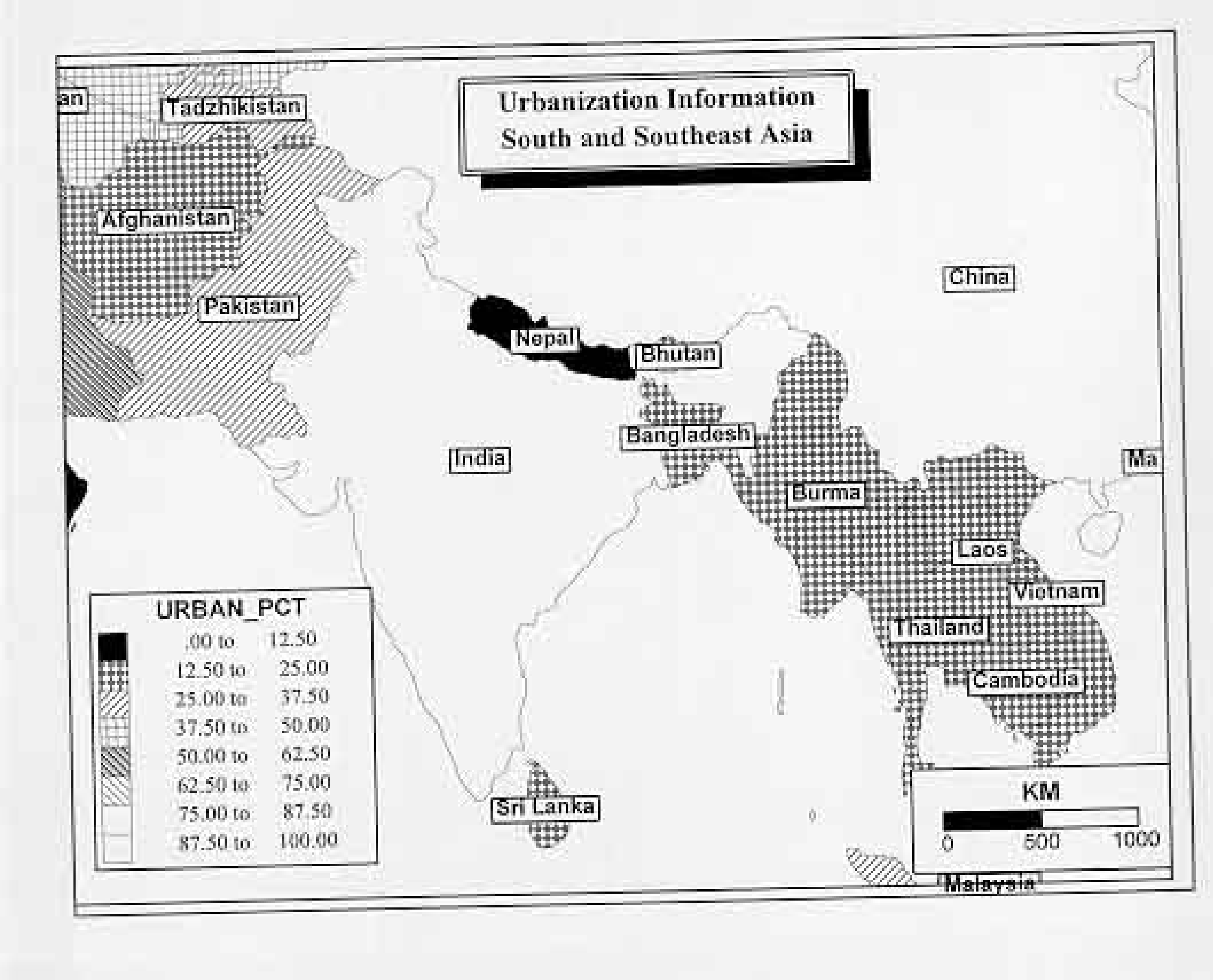
Figure 3.



Source: WRD, 1995

Figure 4.


Irrigated and Arable Land in Nepal
3000
2500
2000
1500
1000
500
0
Thousand HA
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
Years
Irrigated land
Arable Land


Urbanization Information
South and Southeast Asia
Tadzhikistan
Afghanistan
Pakistan
Nepal
Bhutan
China
Bangladesh
India
Burma
Laos
Vietnam
Thailand
Cambodia
Sri Lanka
Malaysia
Ma
URBAN_PCT
.00 to 12.50
12.50 to 25.00
25.00 to 37.50
37.50 to 50.00
50.00 to 62.50
62.50 to 75.00
75.00 to 87.50
87.50 to 100.00
KM
0 500 1000

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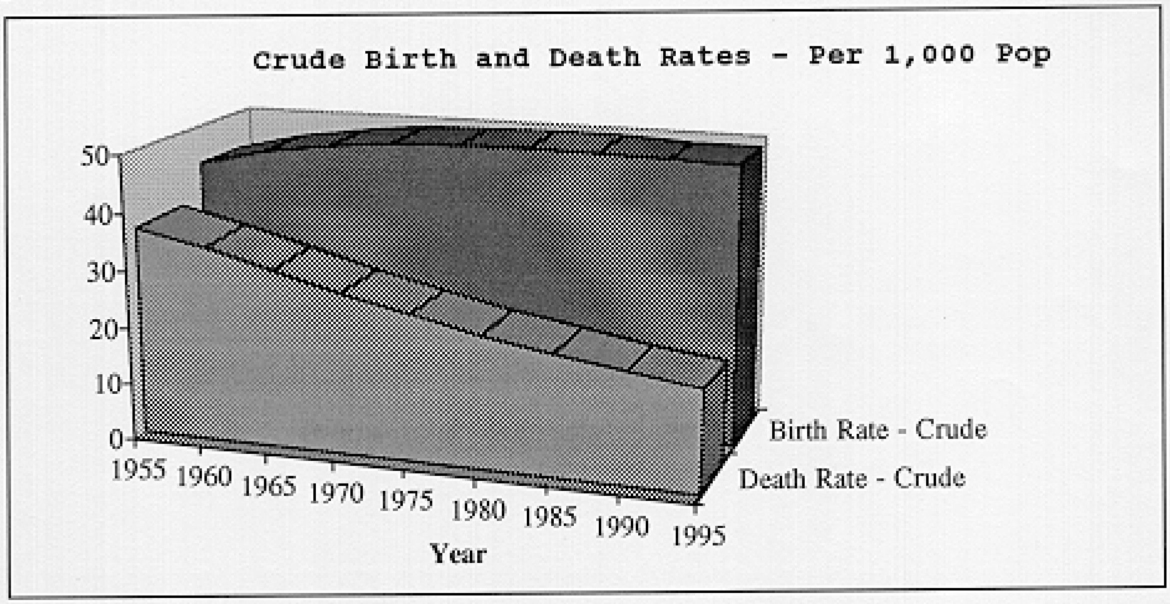
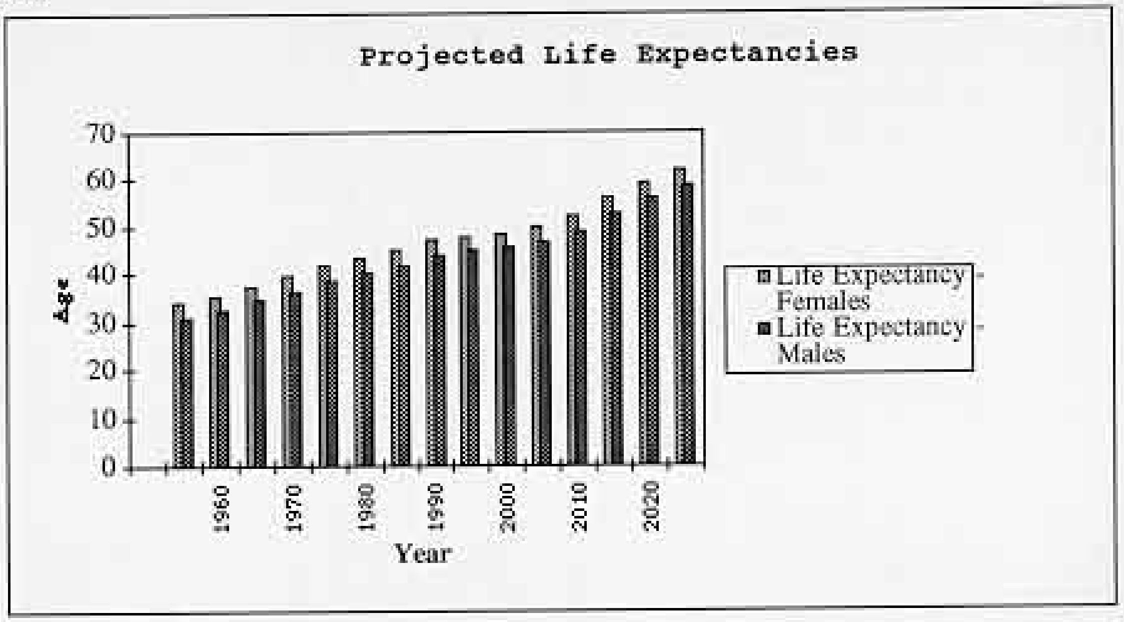
________-- "Foreign Aid and The Role of NGO's in the Development Process of Nepal" Nepal Foundation for Advanced Studies, 1992.

Figure 1



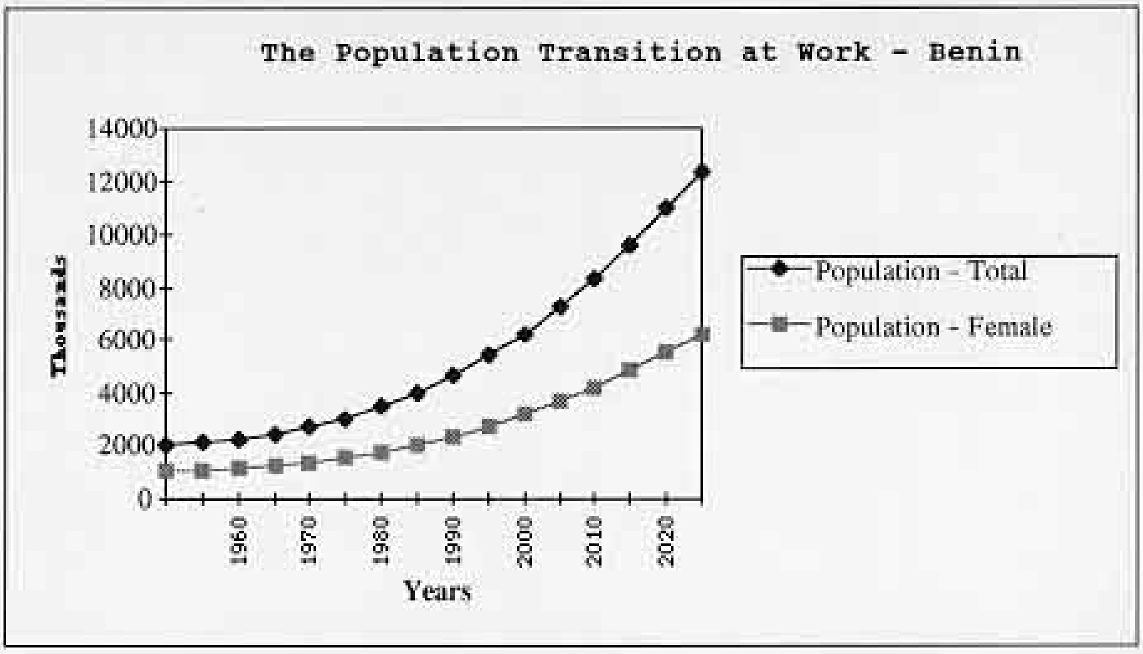
Source: World Resource Database, 1994.

Figure 2



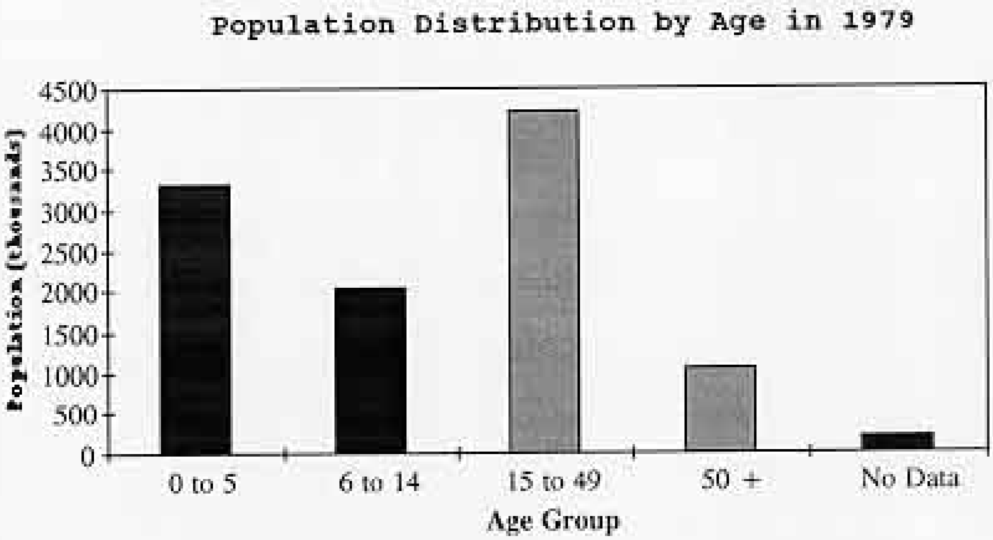
Source: World Resource Database, 1994.

Figure 3



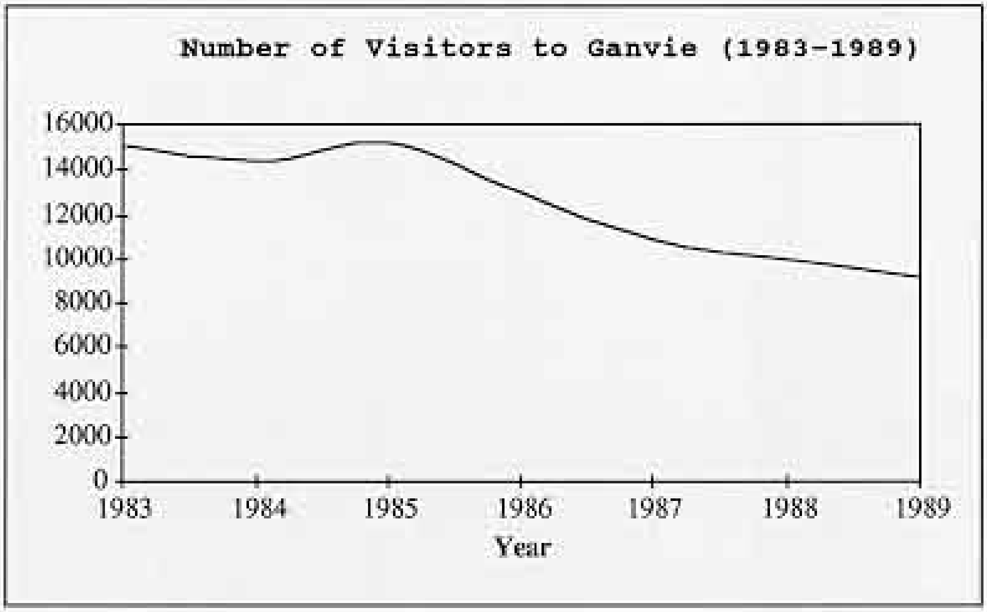
Source: World Resource Database, 1994.

Figure 4



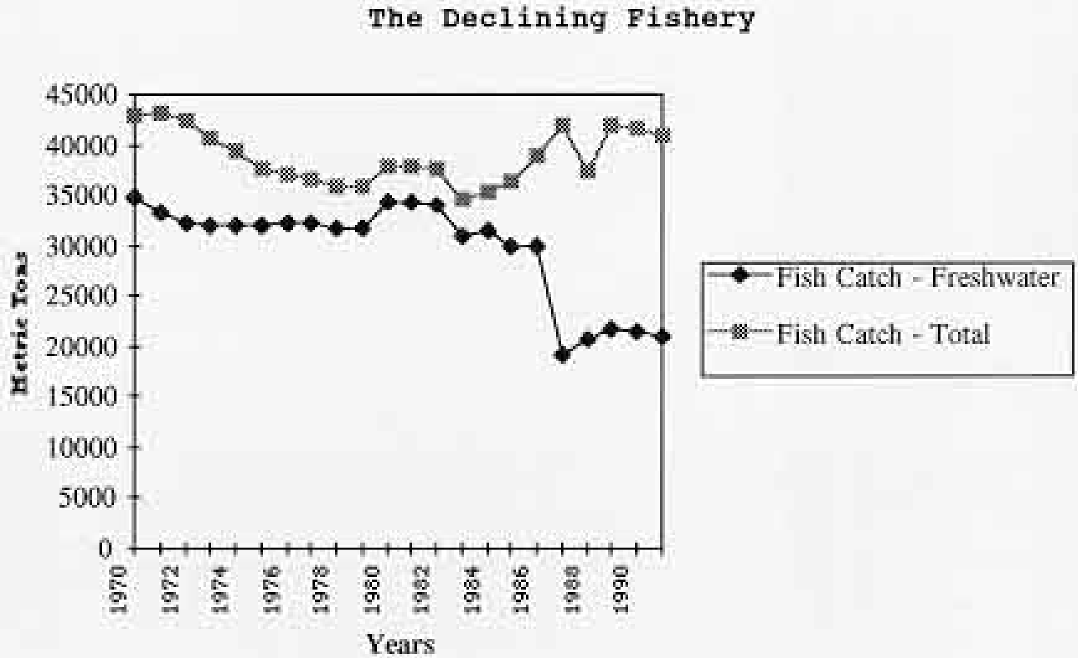
Source: Radji, 1991.

Figure 5



Source: Radji, 1991.

Figure 6



Source: World Resource Database, 1994.

Source: World Resource Database, 1994.

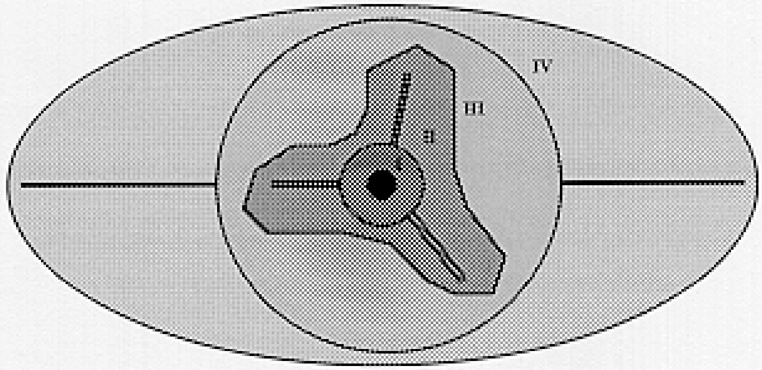


Figure 1, Intraurban Transport Eras and Metropolitan Growth Patterns: (I) Walking-Horsecar Era, (II) Electric Streetcar Era, (III) Recreational Auto Era, (IV) Freeway Era.
Source: Peter O. Muller, Transportation and Urban Form: Stages in the Spatial Evolution of the American Metropolis.

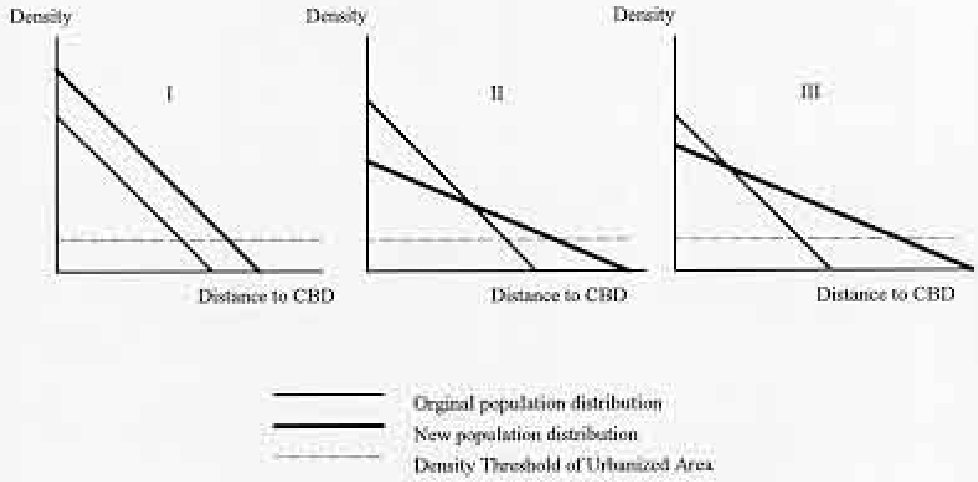


Figure 2, Type of Urban Area Expansion: (I) Pure Growth (increased population are even distributed), (II) No Growth, Redistribution (no change in total population), and (III) Growth + Redistribution (net gain in population and population redistribution)

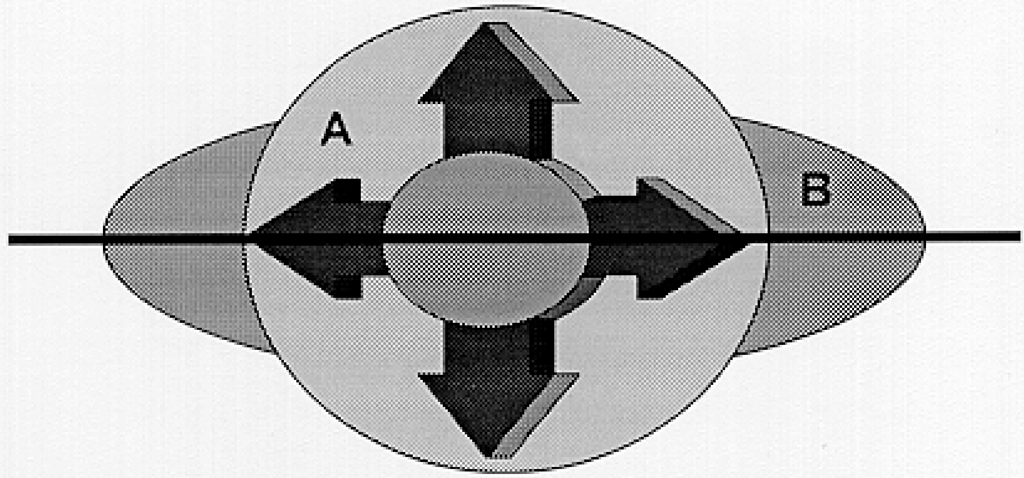


Figure 3, The concept of Spatial Correlation Effects

FIGURE 4, URBANIZED AREA EVOLUTION : 1960 - 1990

Oklahoma City, Oklahoma

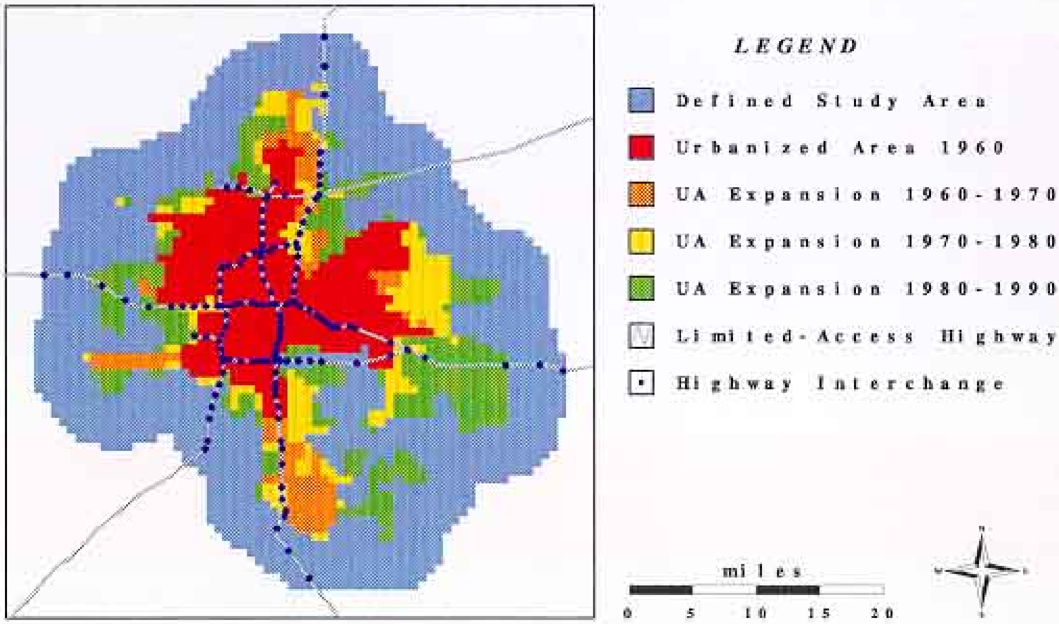
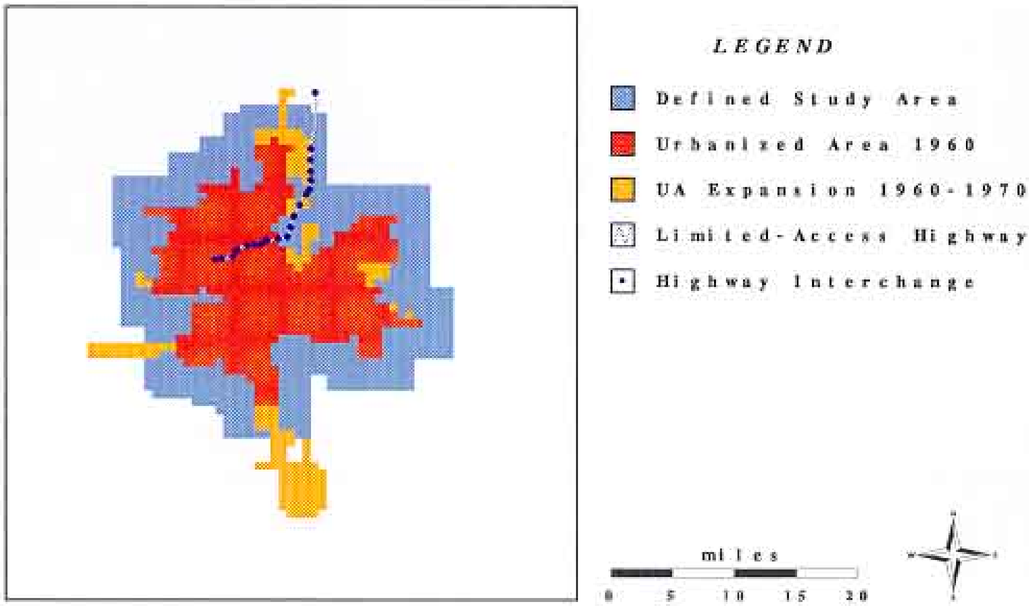


FIGURE 5, URBANIZED AREA EVOLUTION : 1960 - 1970

Oklahoma City, Oklahoma



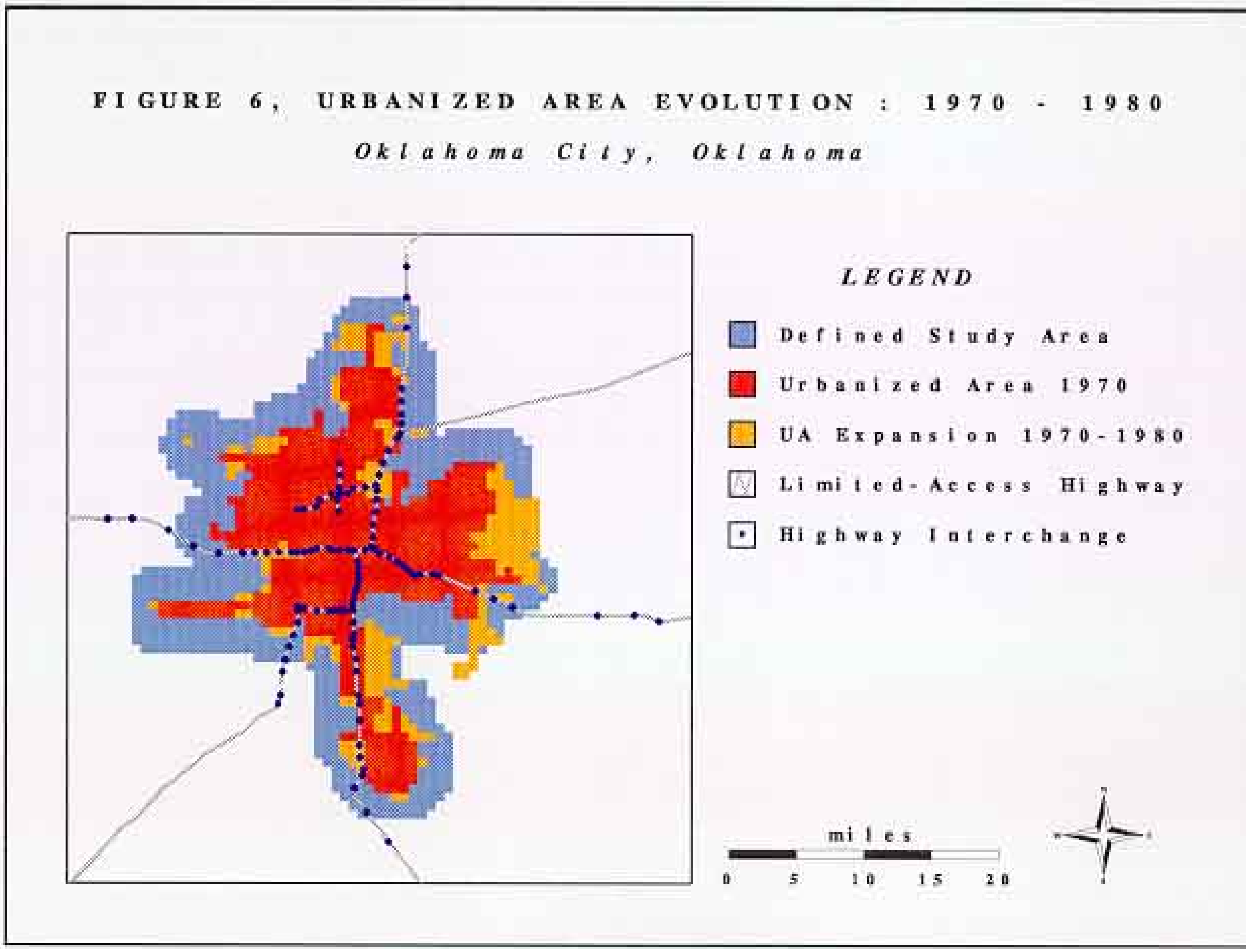


FIGURE 6, URBANIZED AREA EVOLUTION : 1970 - 1980
Oklahoma City, Oklahoma
LEGEND
Defined Study Area
Urbanized Area 1970
UA Expansion 1970-1980
Limited-Access Highway
Highway Interchange
miles
0
5
10
15
20

FIGURE 7, URBANIZED AREA EVOLUTION : 1980 - 1990

Oklahoma City, Oklahoma

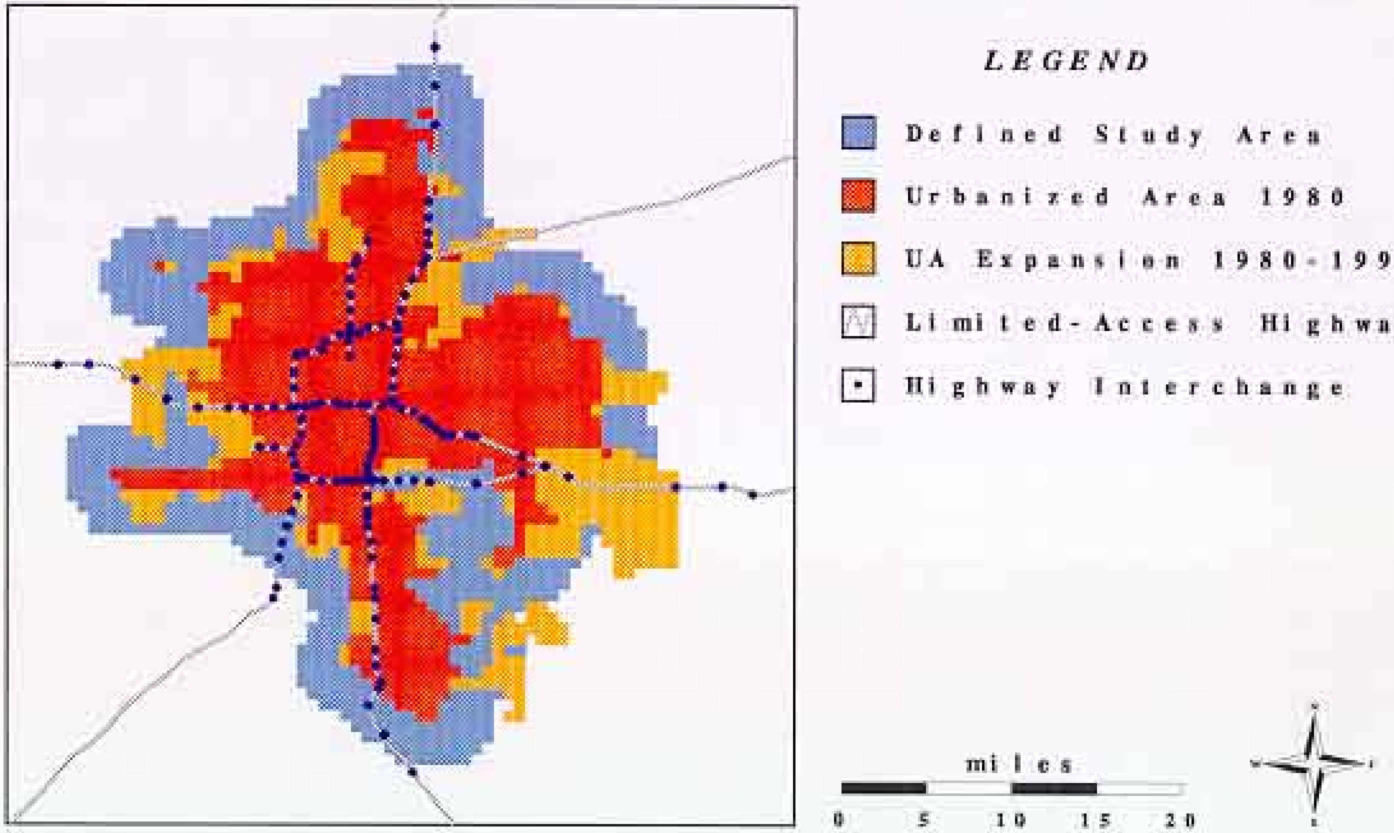


FIGURE 8, URBANIZED AREA EVOLUTION : 1960 - 1980

Oklahoma City, Oklahoma

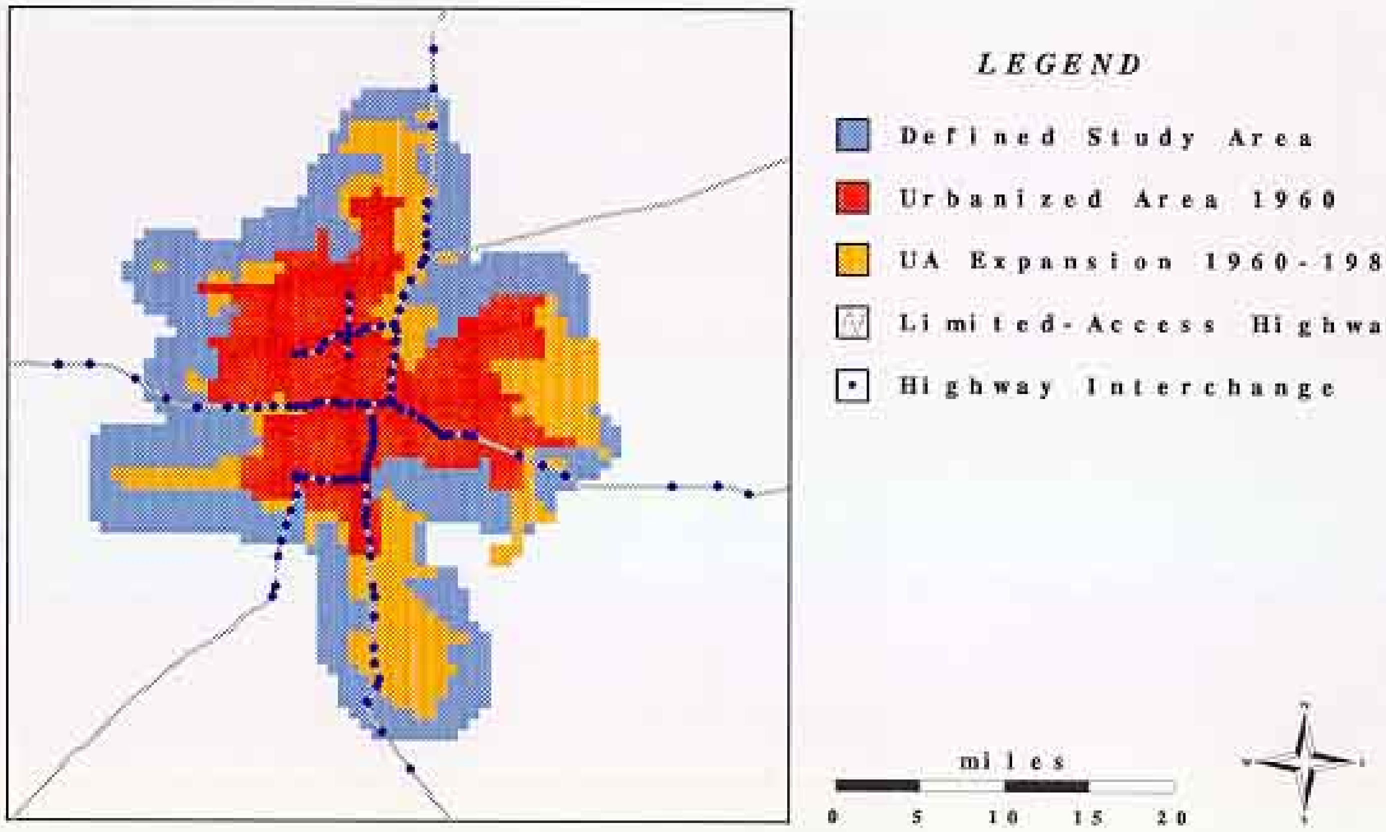
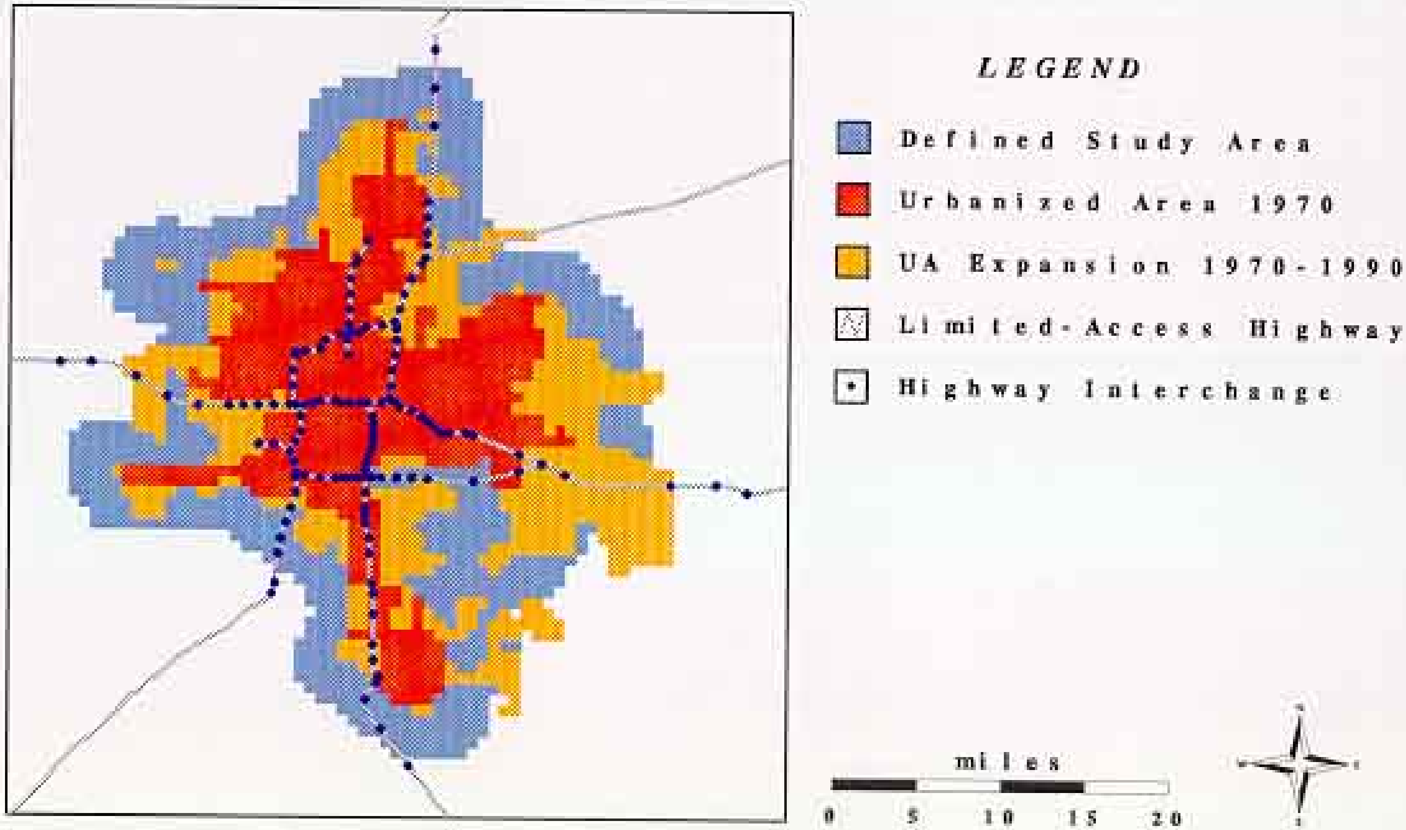


FIGURE 9, URBANIZED AREA EVOLUTION : 1970 - 1990

Oklahoma City, Oklahoma



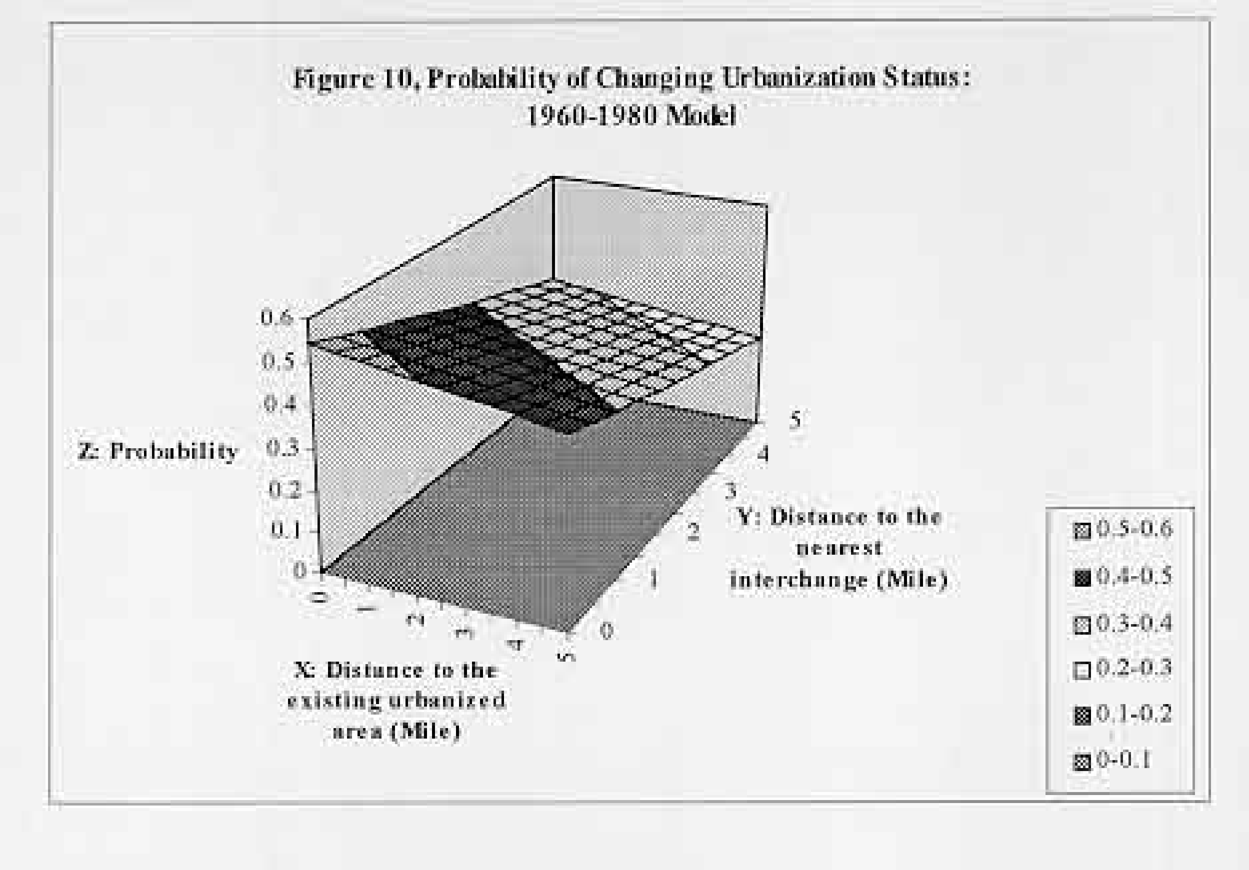


Figure 10, Probability of Changing Urbanization Status: 1960-1980 Model
Z: Probability
0.6
0.5
0.4
0.3
0.2
0.1
0
Y: Distance to the nearest interchange (Mile)
0
1
2
3
4
5
X: Distance to the existing urbanized area (Mile)
0
1
2
3
4
5
0.5-0.6
0.4-0.5
0.3-0.4
0.2-0.3
0.1-0.2
0-0.1

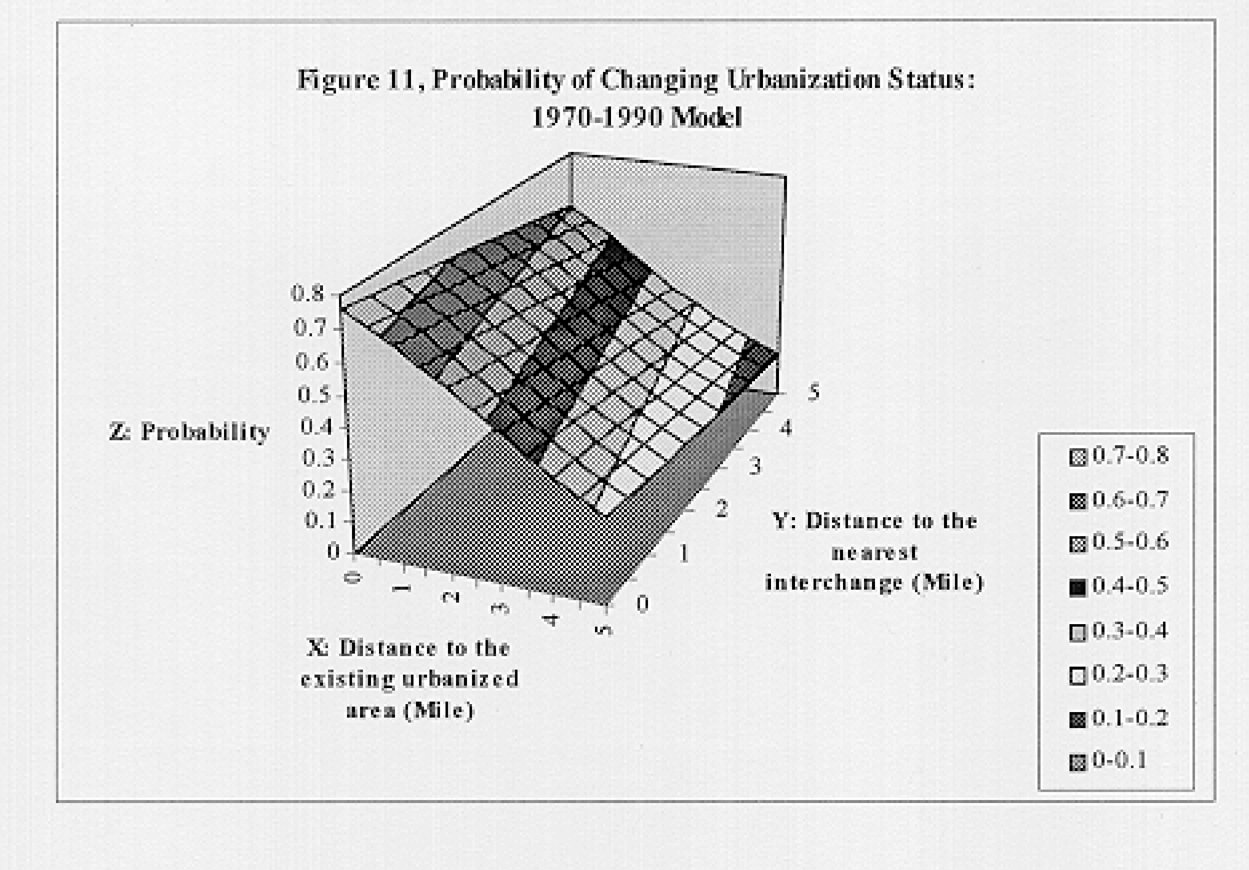


Figure 11, Probability of Changing Urbanization Status:
1970-1990 Model
Z: Probability
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
X: Distance to the existing urbanized area (Mile)
0
1
2
3
4
5
Y: Distance to the nearest interchange (Mile)
0
1
2
3
4
5
0.7-0.8
0.6-0.7
0.5-0.6
0.4-0.5
0.3-0.4
0.2-0.3
0.1-0.2
0-0.1

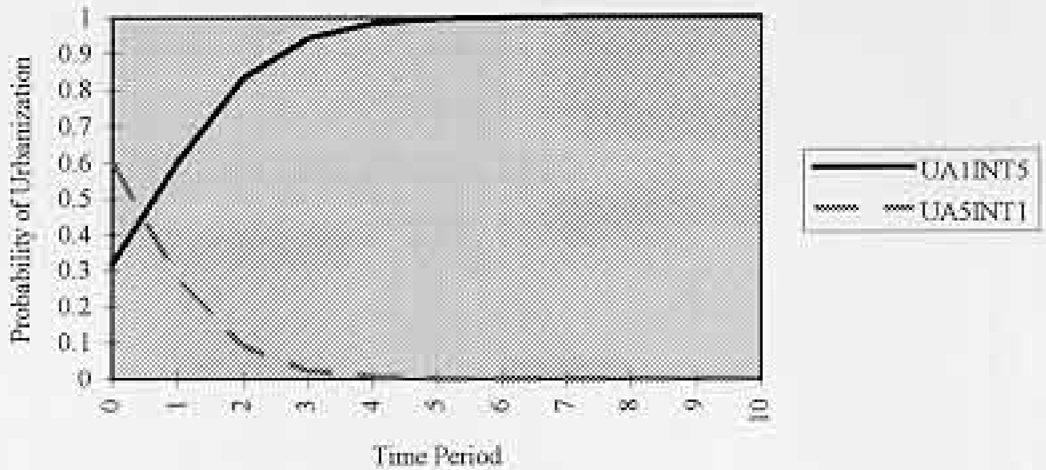


Figure 12, Transitional Trend of Probability of Urbanization
Note: UA1INT5 stands for lands with one mile away from existing urbanized area and five miles from the nearest interchange. UA5INT1 stands for land with five miles away from existing urbanized area and one mile from the nearest interchange.

NOTES

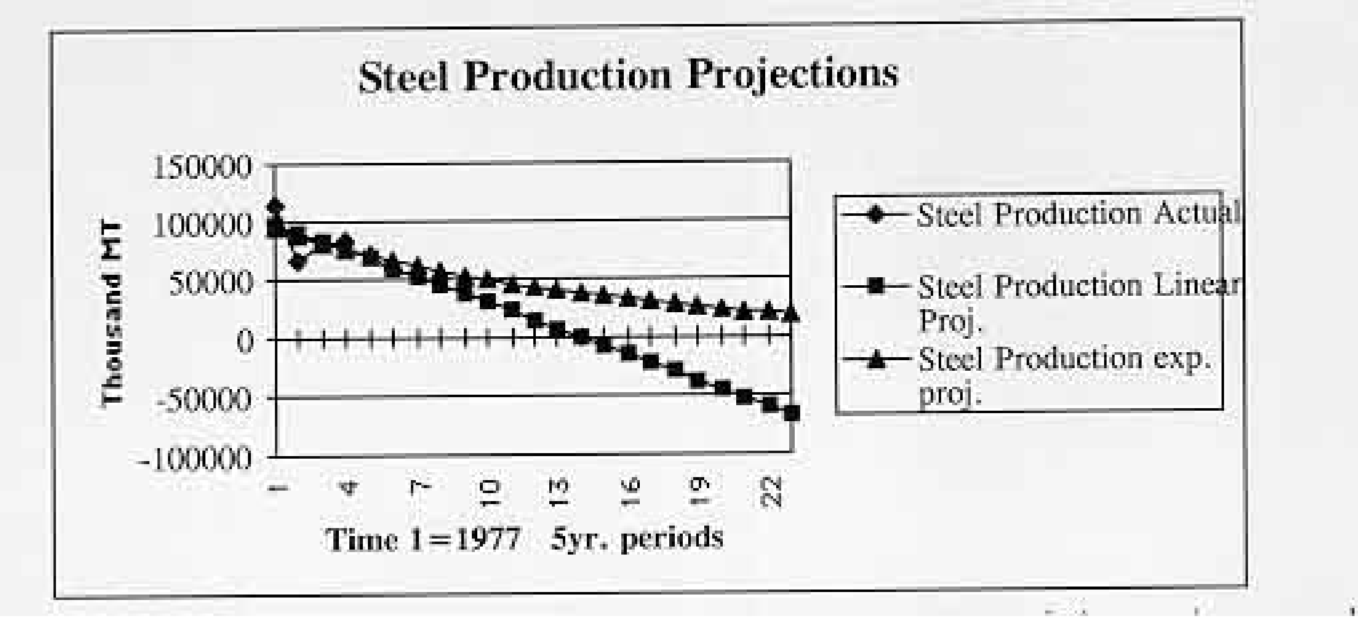
[1] The definition of "urbanized area" (UA) by the Bureau of Census is as follows: A UA comprises one or more places ("central places") and the adjacent densely settled surrounding territory ("urban fringe") that together have a minimum of 50,000 persons. The urban fringe generally consists of contiguous territory having a density of least 1,000 persons per square mile. The urban fringe also includes outlying territory of such density if it was connected to the core of the contiguous area by road and is within 1 1/2 road miles of that core, or within 5 road miles of the core but separated by water or other undevelopable territory. Other territory with a population density of fewer than 1,000 people per square mile is included in the urban fringe if it eliminates an enclave or closes an indentation in the boundary of the urbanized of a place, one or more contiguous census blocks with a population density of at least 1,000 persons per square mile or (2) inclusion of a place containing census blocks they have at least 50 percent of the population of the place and a density of at least 1,000 persons per square mile.

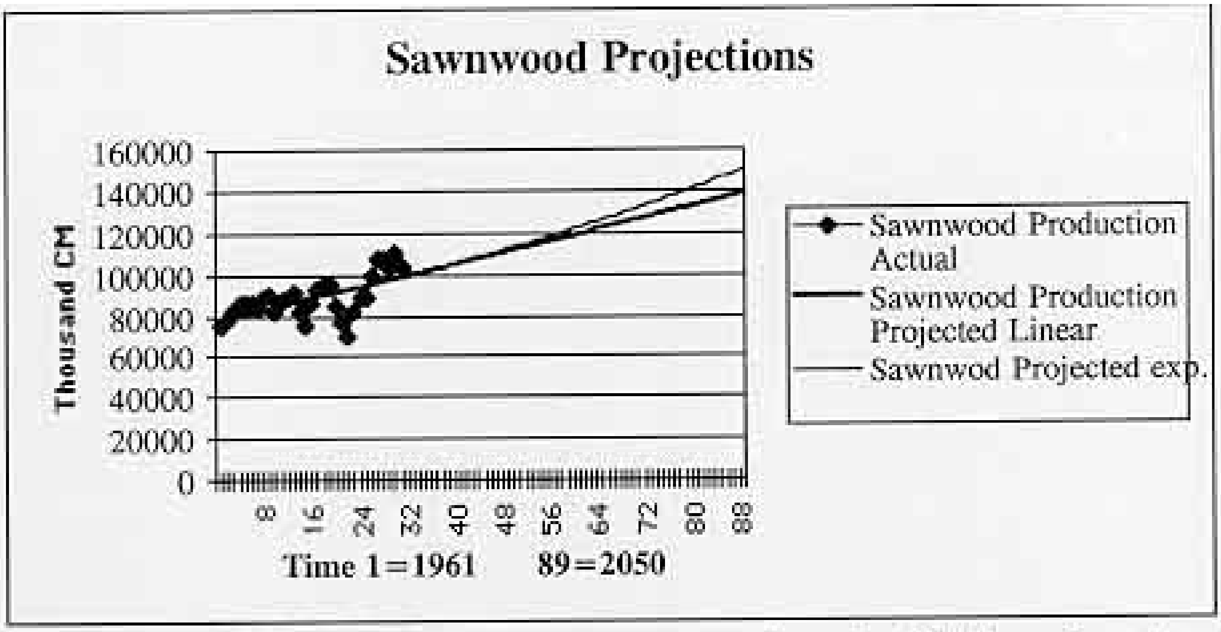
[2] Three 10-year models (1960-1970, 1970-1980, and 1980-1990) and two 20-year models (1960-1980 and 1970-1990) are developed and analyzed in this study.

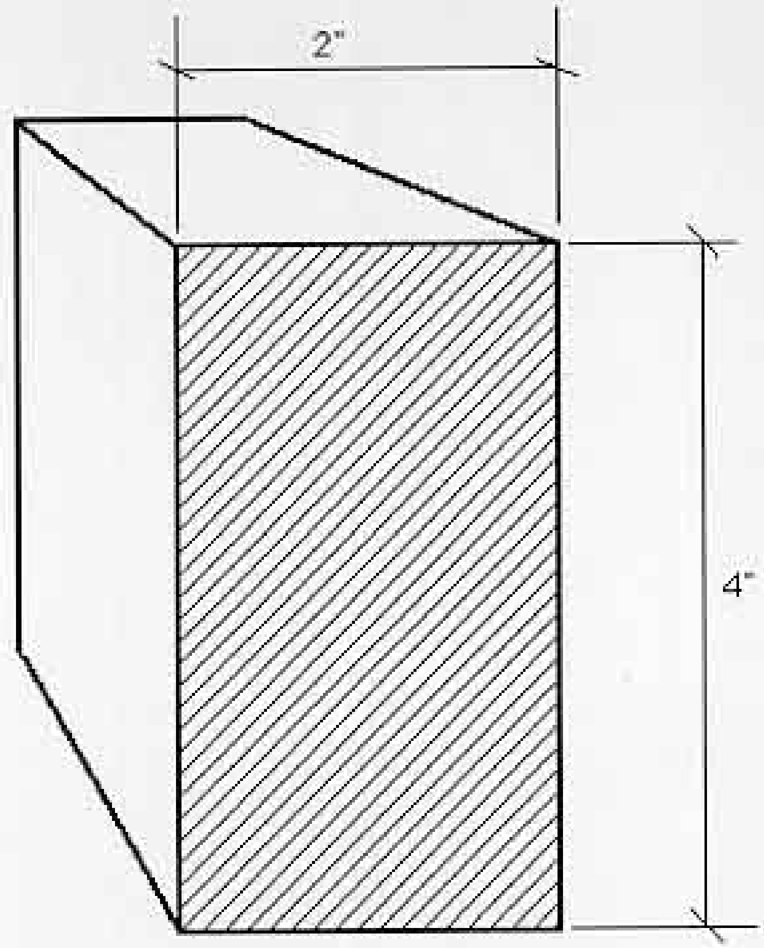
[3] Should one have a study area which is composed of 90% non-changed cells, one would have expected 90% accuracy rate simply by guessing NO CHANGE without any further information. In this case, very likely one would get 100% accuracy rate for predicting non-changed cells and 0% accuracy rate for predicting changed cells (total with 90% accuracy rate). Theoretically, the coefficients of independent variables should not be affected by the change of study area boundaries.

[4] These buffer widths are chosen subjectively with the consideration of the historical and expected growth trend. A sensitivity analysis, not yet included in this paper, would be very helpful to illustrate the influences of various buffer width choices on modeling results.

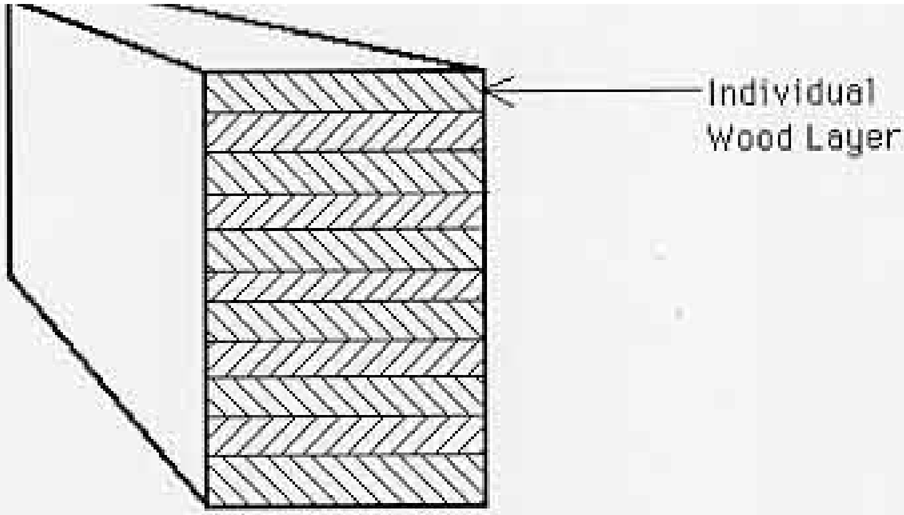
[5] For example, the growth of urbanized area between 1970 to 1980 might be highly related to the construction directions of highways which are well beyond 3 mile buffer of 1960 urbanized area. In order words, the study area defined as 3 mile buffer of 1960 urbanized area will fail to take those corridor type of growth pattern into account.


Steel Production Projections
150000
100000
50000
0
-50000
-100000
Thousand MT
1
4
7
10
13
16
19
22
Time 1=1977 5yr. periods
Steel Production Actual
Steel Production Linear Proj.
Steel Production exp. proj.

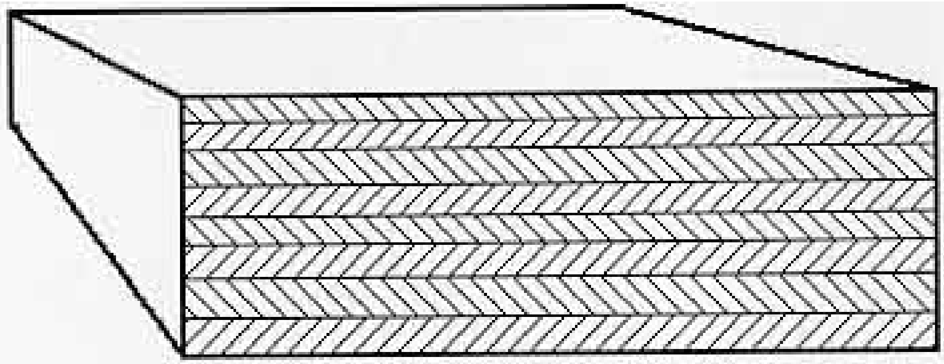

Sawnwood Projections
160000
140000
120000
100000
80000
60000
40000
20000
0
Thousand CM
8
16
24
32
40
48
56
64
72
80
88
Time 1=1961 89=2050
Sawnwood Production Actual
Sawnwood Production Projected Linear
Sawnwod Projected exp.



Two-By-Four Cross Section

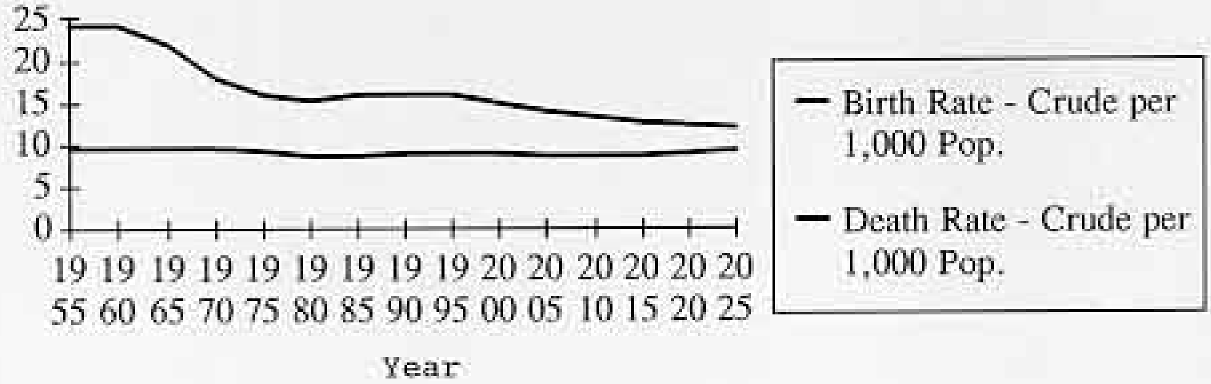


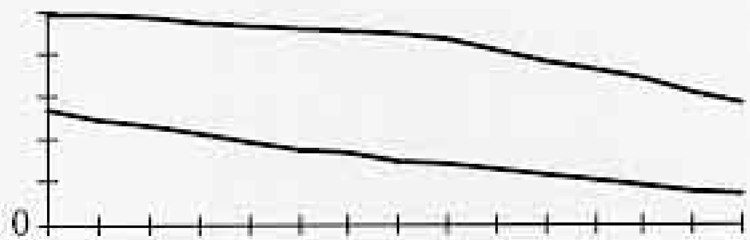
Glue Laminated Timber

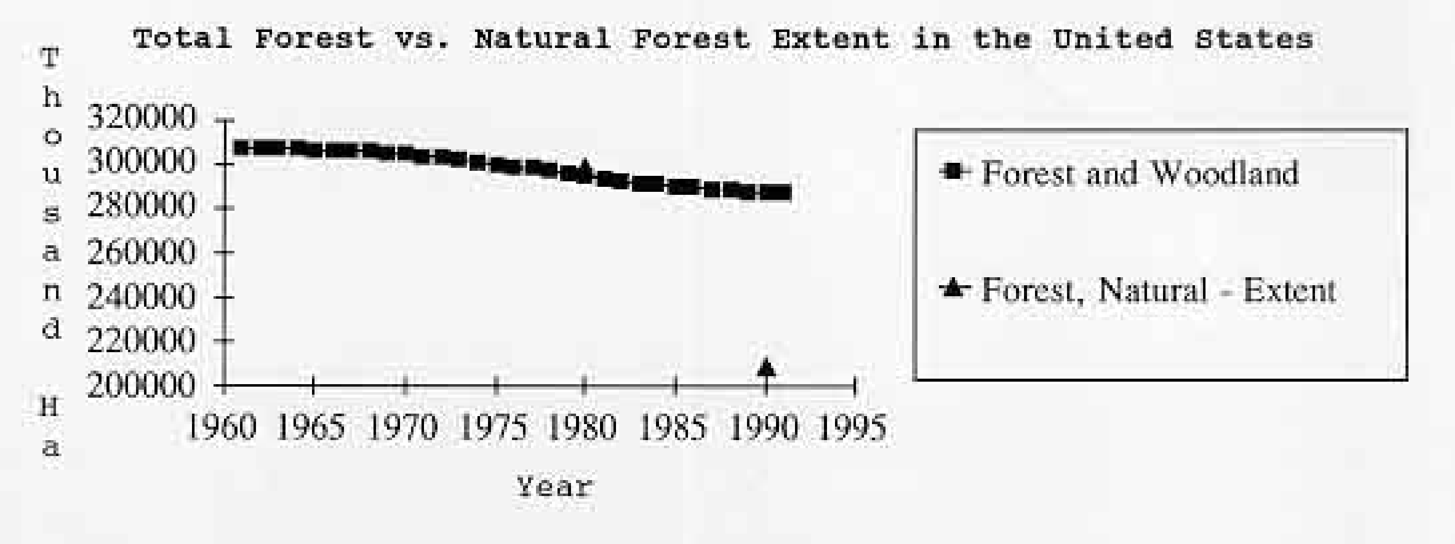


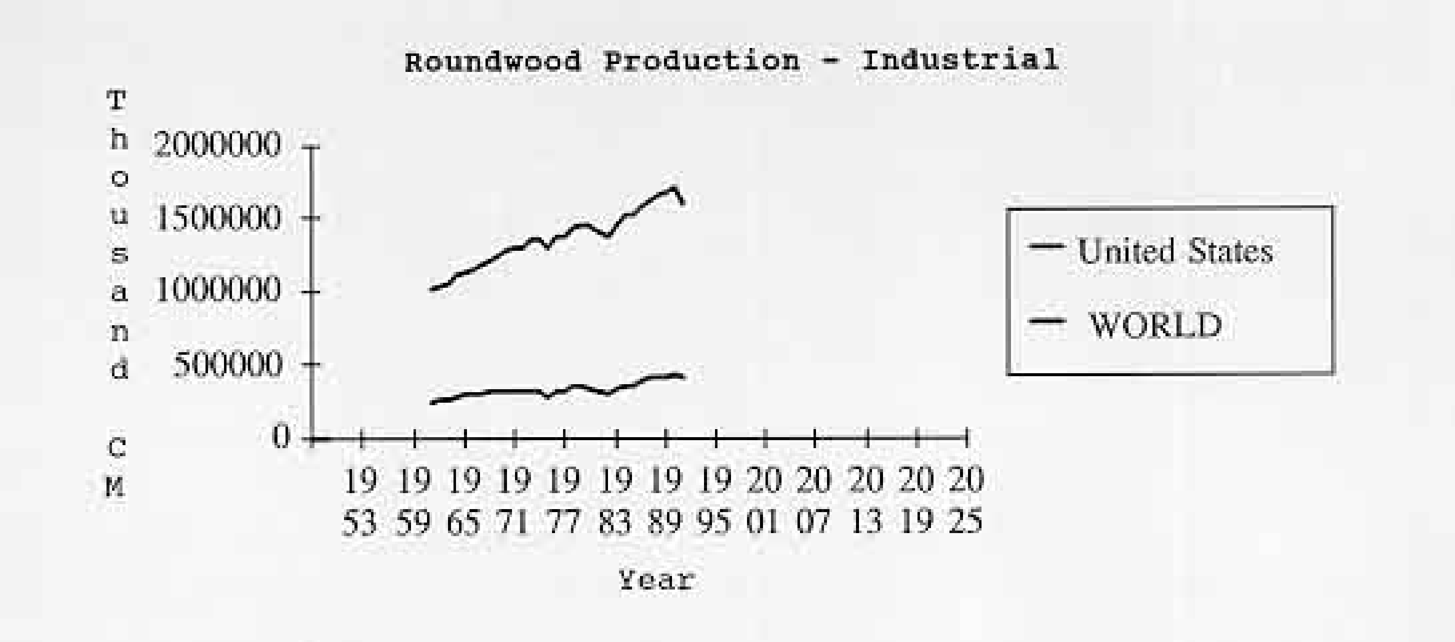
Laminated Veneer Lumber

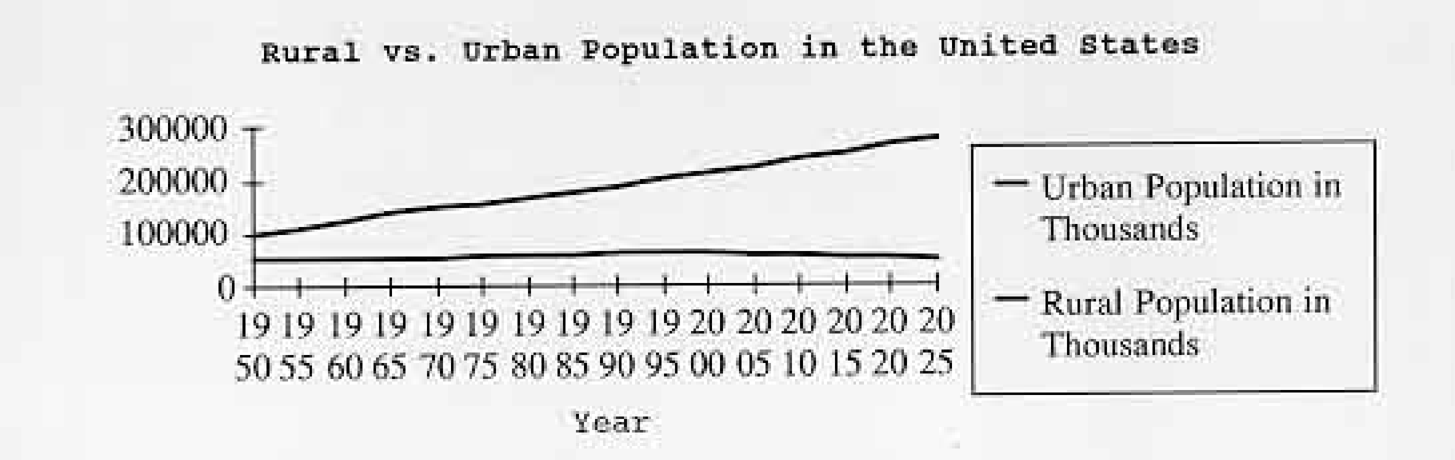
Crude Birth and Death Rate for the United States

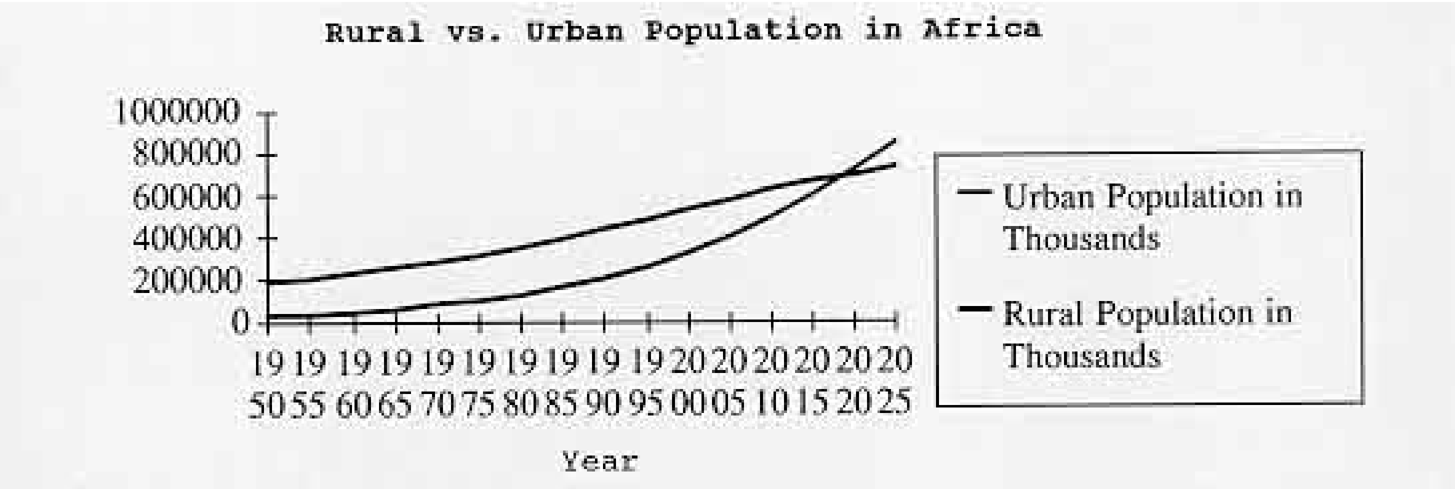


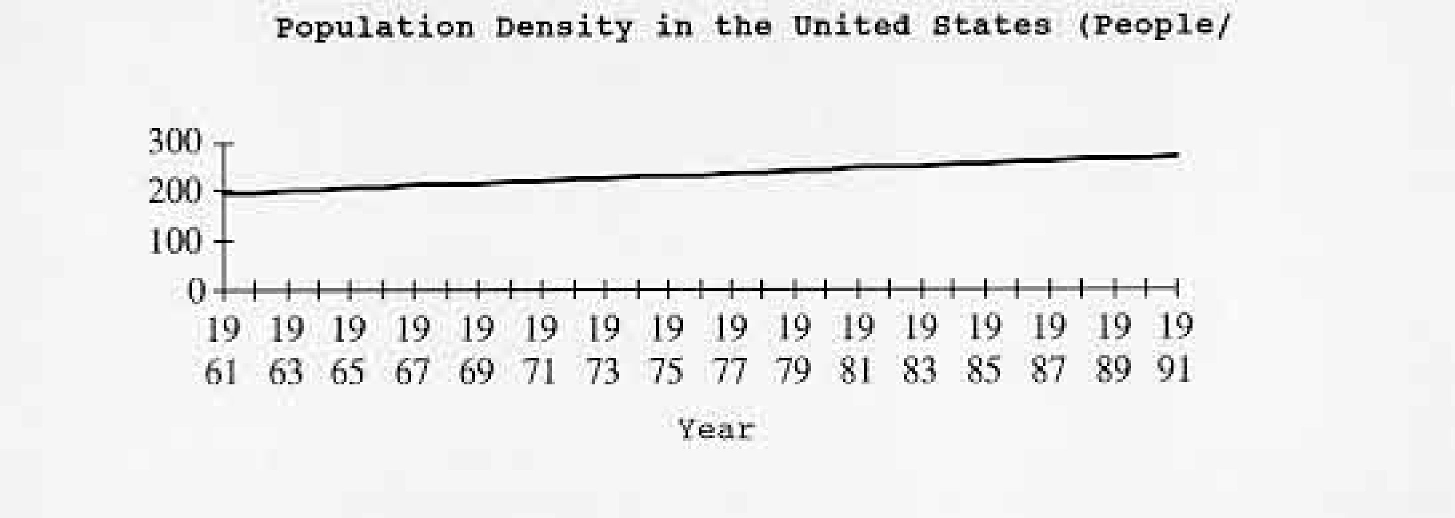



Total Forest vs. Natural Forest Extent in the United States
Thousand Ha
320000
300000
280000
260000
240000
220000
200000
1960 1965 1970 1975 1980 1985 1990 1995
Year
Forest and Woodland
Forest, Natural - Extent


Roundwood Production - Industrial
Thousand CM
2000000
1500000
1000000
500000
0
19 53
19 59
19 65
19 71
19 77
19 83
19 89
19 95
20 01
20 07
20 13
20 19
20 25
Year
United States
WORLD


Rural vs. Urban Population in the United States
300000
200000
100000
0
19 19 19 19 19 19 19 19 19 19 20 20 20 20 20 20
50 55 60 65 70 75 80 85 90 95 00 05 10 15 20 25
Year
Urban Population in Thousands
Rural Population in Thousands


Rural vs. Urban Population in Africa
1000000
800000
600000
400000
200000
0
19 19 19 19 19 19 19 19 19 19 20 20 20 20 20 20
50 55 60 65 70 75 80 85 90 95 00 05 10 15 20 25
Year
Urban Population in Thousands
Rural Population in Thousands


Population Density in the United States (People/
300
200
100
0
19 61
19 63
19 65
19 67
19 69
19 71
19 73
19 75
19 77
19 79
19 81
19 83
19 85
19 87
19 89
19 91
Year