Specialty Coffee Farmers' Climate Change Concern and Perceived Ability to Adapt

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Client: CIMS Sustainable Markets Intelligence Center at INCAE Business School

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Executive Summary

Climate change studies predict that rising temperatures and water shortages will negatively impact coffee production suitability at lower elevations (Rivera et al., 2015). As climate change becomes increasingly severe, an assessment of coffee producers' ability and willingness to adapt would be especially valuable to those hoping to create adaptation strategies and policies. This had led to a significant growth of research surrounding the livelihood of farmers, as well as their perceptions of climate change and adaptation. However, research focused specifically on specialty coffee is still lacking. With higher quality considerations, different value chains, and lower price volatility, specialty coffee farmers are an especially interesting area of study (Vellucci, 2015). This study aims to fill this knowledge gap. To do this, a survey was conducted among Costa Rican specialty coffee producers in order to identify whether their concern about climate change and their perceived ability to adapt are affected by perceptions of climate change risk, financing, farmer demographics, coffee management practices, biophysical factors, access to information, or perceived adaptation methods. Survey responses were coded, quantified, and analyzed through statistical software using analysis of variance and linear regressions.

Previous studies show more concern about coffee price volatility than climate change (Tucker et al., 2009; Eakin et al., 2006; Gay et al. 2006). However, this study found greater concern about climate change than falling coffee prices among surveyed farmers, reinforcing that specialty coffee farmers may be better positioned than non-speciality growers to handle market volatility. Nevertheless, respondents felt less prepared to face the impacts of climate change. This study hypothesized that farmers with higher levels of climate change concern would have the lowest levels of perceived ability to adapt. However, it was found that farmer's concern about climate change did not correlate with their feelings of preparedness to address it. These few results among others detailed in the report signal a need to address the climate change concerns and adaptation capacity of speciality coffee growers. As Costa Rican policy makers, development organizations, and coffee importers and exporters build multi-stakeholder strategies to support this key segment of farmers, they should prioritize the implementation of tools that build adaptive capacity in addition to traditional market based mechanisms like promotion and trade policies. These results encourage the development of future studies to explore which specific tools at the farm, household, landscape, or political level would most enhance adaptive capacity of speciality coffee growers.

Sourcing this Project

As students interested in the intersection of policy, agroecosystems, business, Latin America, and climate change, our team contacted the Erb Institute's leadership for help in sourcing a suitable Master's Project with a viable partner organization. Soon after, the Institute introduced us to the Sustainable Markets Intelligence Center (CIMS) at INCAE Business School in Costa Rica as an organization with similar research and industry interests. From there we established a working collaboration to develop a set of pressing research questions that we could research between January 2015 through April 2016.

Subsequent video conferences and emails resulted in an interest in conducting research regarding climate change adaptation in the specialty coffee industry in Costa Rica, with the understanding that CIMS would provide logistical support throughout the process as needed. From this point forward, we led the process toward arriving at the final research questions, methods, and the direction of the study. CIMS provided extensive help in scheduling stakeholder interviews and conducting on-the-ground logistics while subsequent interviews were being conducted. In addition to CIMS, we received considerable guidance from our SNRE faculty advisor, Avik Basu, in pursuing the correct path forward toward a meaningful research project.

CIMS

CIMS Sustainable Markets Intelligence Center's mission is to improve the livelihoods of smallholder farmers throughout Latin America through evidence-based research and strategic advice to the private, public and NGO sectors working in agricultural supply chains. CIMS' clients include: Hanns R. Neumann Stiftung Foundation (HRNS), Fair Trade USA, Walmart, Rainforest Alliance, Nestlé, INCAE's Latin American Center for Competitiveness and Sustainable Development (CLACDS), Latin America Agribusiness Development Corporation S.A (LAAD), ICAFE,Central American Bank for Economic Integration (CABEI), among others. Its areas of focus are scientific, evidence-based research, agricultural-sector research and market intelligence, strategic advice on impact measurement, and training toolkits and frameworks.

Team Members Introduction

Micaela Battiste

Micaela is currently pursuing an MS in Environmental Justice and Conservation Ecology at the School of Natural Resources and Environment and an MBA at the Ross School of Business at the University of Michigan. . Her interest in social and environmental sustainability through business developed while writing her undergraduate thesis on fair-trade at the University of Michigan. She returned to Michigan after five years in Santiago, Chile, where she worked in fair-trade exports and education. Building on her interest in food systems and climate change, she recently interned with the Agribusiness Unit at the United Nations Industrial Development Organization in Vienna, Austria.

Matthew Gacioch

Matthew is currently pursuing an MS in Environmental Policy and Planning at the School of Natural Resources and Environment and an MBA at the Ross School of Business at the University of Michigan. His interests lie at the crossroads of the environment, public policy, and the private sector,

with particular focus on climate change mitigation/adaptation and natural resource conservation. He holds a BS in Environmental Science from the University of Michigan with a concentration in Global Systems and academic minors in Global Change and Peace & Social Justice. Before graduate school, Matt worked in the operational sustainability and marketing spaces in the American craft beer industry and spent a year on a Fulbright grant teaching high school English in Central Java, Indonesia. He has had a deep interest in the coffee production system since holding an internship as an undergraduate with Brewing Hope, an organization connecting smallholder coffee farmers in Chiapas, Mexico to the community in Ann Arbor, Michigan.

Michelle Gross

Michelle is currently pursuing an MS in Behavior, Education and Communication at the School of Natural Resources and Environment and an MBA at the Ross School of Business at the University of Michigan. She is interested in food and agricultural systems, and supply chain sustainability. Michelle is also interested in social enterprise, how to embed environmental sustainability into core business strategy, and how to to motivate behavioral change. Prior to enrolling in graduate school, Michelle worked in marketing in the healthcare industry in Spain for two multinational companies. In her spare time, she taught workshops to youth to raise awareness on environmental and social issues. Michelle received a BA in Political Science at McGill University.

Shoaib Rahman

Shoaib is currently pursuing an MS in Sustainable Systems and Conservation Ecology at the School of Natural Resources and Environment and an MBA at the Ross School of Business at the University of Michigan. His research interests include renewable energy, agroecosystems, and corporate sustainability. Professionally, Shoaib is especially interested in product strategy at emerging technology companies, and he hopes to use his future leadership positions within such companies to create a more sustainable world. Shoaib earned his Bachelor of Science degree from the University of Texas at Austin, where he studied computational biomedical engineering and undertook research in computer vision and biomedical informatics.

Faculty Advisor Introduction: Avik Basu, PhD

Avik Basu's research interests include understanding the differences between experts and laypeople in environmental decision-making, designing sustainable developments to be more acceptable to rural residents, promoting the adoption of sustainable transportation, and designing environments that simultaneously enhance individual and communal well-being. Over the last decade, he has been part of a collaborative effort to develop a framework, known as the Reasonable Person Model (RPM), to help practitioners from various disciplines become better at creating conditions that improve human well-being. Avik earned a Ph.D. in Environmental Psychology and a Master’s in Electrical Engineering both from the University of Michigan.

Introduction & Literature Review

Project Objective and Context

Climate change adaptation within the coffee industry is a growing area of research. An emerging subset of this research focuses on coffee farmers' perceptions of climate change as they relate to climate adaptation. However, research specifically focused on specialty coffee is still lacking. No studies currently exist that analyze farmer perceptions of climate change and adaptation specifically among specialty coffee farmers. Moreover, existing research about coffee farmers in general is not sufficient to address specialty coffee because the specialty coffee industry exhibits different qualities and specifications, including higher quality considerations, different value chains, and lower price volatility (Vellucci, 2015) than the commodity coffee industry exhibits.

To address this gap, this study aims to identify the drivers behind Costa Rican specialty coffee farmers' perceived ability to adapt to climate change, as well as the drivers behind their level of concern about climate change. In the context of this study, "ability to adapt" (i.e. adaptive capacity) is defined as "the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in both behaviour and in resources and technologies" (IPCC, 2007).

The results of this study could be used by future researchers, training programs, and government institutions to develop adaptation strategies, education programs, and support mechanisms that will be accepted and used by specialty coffee producers. Success of such programs could ensure that the specialty coffee industry continues to flourish in Costa Rica.

Background: Coffee

Coffee is a perennial, tropical crop grown both in humid lowlands and tropical humid/subhumid highlands. According to the International Coffee Association (2015), it requires very specific environmental conditions for successful production depending on the coffee variety grown. Ideal average temperatures range between 15-24ºC for Arabica and 24-30ºC for Robusta coffee varieties. Frost can easily damage coffee cherries in risk areas such as those at high elevations or in Southern Brazil. Likewise, extreme temperatures reaching and sustaining 30°C can limit growth. Seasonal rainy and dry periods are necessary for growth, but too much rain can be harmful. An annual rainfall of 1,500 to 3,000 mm is ideal for most Arabica varieties, but some varieties require less rain. Rainfall needs also change with soil type, level of humidity, cloud cover, and overall management practices. Application of fertilizer where necessary can help coffee to be grown on soils of different depths, pH, and mineral content. Finally, Arabica grows well in hilly areas and at higher altitudes while Robusta can be grown between sea-level and 800 meters above sea-level (International Coffee Association, 2015).

Background: Specialty Coffee

'Specialty' coffee is usually sold outside the general commodity coffee market as a premium quality product. Rather than a certification or single universal definition, it is an industry standard developed through coffee associations. The Specialty Coffee Association of America (SCAA) has standards for green and roasted coffee, water, and cupping coffee. For a coffee to be considered 'specialty' by the SCAA, it must meet several requirements: it is produced 'free of defects' in select altitudes and climates, is nursed for years before the first harvest, and has a distinct flavor. A coffee taster will determine the coffee's cupping score, based on a tasting session or 'cupping session,' which quantifies the quality based on the market and will in turn help determine the price of the coffee. These characteristics separate specialty coffee from coffees typically sold on the commodity market. As it surpasses the traditional coffee product, the price of specialty coffee can be set at a premium. The SCAA Green Grading Handbook (2009) has more information on coffee scoring and defects.

Background: Global Climate Change and Coffee

Since coffee plants are highly sensitive to climate and weather patterns, the coffee industry is especially vulnerable to climate change. Some general predictions for the coffee industry anticipate that traditional areas will no longer be suitable for coffee, other areas may be able to adapt, and some will gain climatic suitability for coffee production (Fischersworring et al., 2015). According to a study by Davis et al. (2012), climate change could reduce the suitable localities for coffee farming by 65-100% by 2080. Fortunately, coffee producers have already begun to adapt. Overall, coffee farmers are growing more coffee with less land according to reference FAO trends on yields and total land area dedicated to coffee cultivation. More specifically, there has been a reduction in the worldwide harvested area for coffee of approximately 2%, while yields per hectare have increased by approximately 25% since 2003. While this is true at a global level, it is not the case for all coffee-growing regions.

Background: Climate Change and Coffee in Costa Rica

In Costa Rica, between 2003-2013, the coffee sector saw a 17.3% decrease in area harvested and a 29.8% decrease in yield per hectare from 11,664 Hg/Ha to roughly the currently global average of 8,900 Hg/Ha, according to FAO data. This analysis is strikingly different from the worldwide harvest and yield data from the same FAO report, and it paints an alarming picture for the Costa Rican coffee industry. It also highlights the need for climate adaptation among Costa Rican coffee farmers.

Because Costa Rica has high mountains, some predictions estimate that the country will continue to have suitable coffee-growing land in the 2050s as farms move to higher altitudes. However, even if Costa Rica continues to have suitable land for coffee production, Costa Rican coffee producers may still find themselves unable to take advantage of suitable coffee growing land in the future due to restrictions on farming in high-altitude protected areas (Ovalle-Rivera et al., 2015).

Coffee has a long history in Costa Rica. In the early 1800s, Costa Rica became the first Central American country to establish a thriving coffee industry, and coffee remained Costa Rica's sole export until 1890. Since coffee had become such an integral component of Costa Rica's culture and economy, the government passed a law in 1933 to establish the Costa Rica National Coffee Institute (ICAFE), which would promote the production of coffee in Costa Rica. Today, as climate change has increasingly become a concern for coffee farmers, ICAFE has started to influence coffee farmers in their climate adaptation efforts. As a result of ICAFE's work, two new coffee varieties were recently

introduced that produce higher yields and are more resistant to climate change: Caturra and Catuaí (ICAFE, 2016). As Costa Rican coffee farmers continue to face climate change and an evolving market, agencies such as ICAFE will likely be an important source of information and support during the adaptation process. For ICAFE's programs to be truly successful, they have to induce changes in farmer behavior. As behavior is highly influenced by perception and motivation, understanding these will be paramount in furthering real behavior change.

The Role of Farmer Perceptions in Climate Change Adaptation

As mentioned earlier, a number of recent studies have investigated climate adaptation through the lens of farmer perceptions. While none of the studies focused solely on specialty coffee farmers as their sample populations, these studies still provide valuable context for how to conduct a perceptions-oriented study of coffee farmers, and for how to interpret the results of this study. Of particular interest will be how the results from a survey of specialty coffee farmers differs from the results of existing research with a less selective sample population.

Quiroga et al. (2014) and Tucker et al. (2010) have both conducted studies specifically focused on Latin America, and hence they are relevant in the context of Costa Rica. Quiroga et al. assessed Nicaraguan smallholder coffee farmers' perceptions of climate change and their ability to adapt. Their key finding is that "experience and technical capacity are relevant to the adaptive capacity although smallholders do not always show high concern and their expectations with regard to external support are very low" (Quiroga et al., 2014). Likewise, Tucker et al. studied Central American and Mexican coffee farmers' perception of risk and adaptive capacity. They found that "farmers who associated events with high risk were not more likely to engage in specific adaptations. Adaptive responses were more clearly associated with access to land than perception of risk, suggesting that adaptation is more a function of exogenous constraints on decision making than perception" (Tucker et al., 2010). Hence, when analyzing results among specialty coffee farmers in Costa Rica, it would be interesting to see what links, if any, exist between experience, land ownership, perceived risk, and adaptive capacity. A comparison with these existing results may highlight differences in perception and adaptive capacity that are specific to specialty coffee farmers.

Frank et al. (2011) also conducted a study of perceptions and their association with climate adaptation. This study paid special attention to social identity and motivations. They found that farmers' perceptions of their own social identities, as well as where they fall in relation to others, influences their perceived level of climate change risk. This is especially interesting for our study because, if specialty coffee farmers associate with an identity that's distinct from the broader coffee-growing population, then Frank et al.'s research implies that their perceived risk from climate change may also be different from the rest of the coffee-growing population. Additionally, Frank et al. (2011) found that farmers are more likely to believe information sources that they believe to be of higher status than their own social identity.

Furthermore, Mertz et al. (2009), Okonya et al. (2013), and Maddison (2007) have each conducted studies on perceptions and adaptive capacity among African farmers. While these results may be less relevant to the Costa Rican context, they nevertheless provide valuable context on perceptions-specific adaptation research among farmers. Similarly to Tucker et al., Okonya et al. also found that availability of owned land significantly affected adaptive capacity (Okonya et al., 2013). Mertz et al. found that when African farmers were asked about the main drivers for their modifications in farm management practices, they would attribute the changes to climate change if the questions were asked in the context of climate change, but if the questions were asked without context, the farmers would attribute those changes to economic, political, and social factors. This study highlights

the need to consider not just climatic factors in surveys about perceptions and motivations, but also economic, social, and political factors (Mertz et al., 2009). Finally, Maddison's study found that African farmers with the most experience were more likely to perceive changes in climate, but educated farmers were the most likely to actually follow through with adaptive actions (Maddison, 2007). Hence, it may also be interesting to explore the links between Costa Rican farmers' experience, education, and perceptions of climate change and adaptive capacity.

Factors Explored in this Paper

Climate change is a spatially differentiated process where vulnerability is based on both biophysical and social factors (Liverman, 1994). The FAO and OECD (Fellmann, 2012) also stress that any attempt to measure vulnerability only has meaning within its specific context based on the assessment of multiple variables: physical, environmental, social, cultural, and economic. In order to understand how specialty coffee farmers perceive climate change to be impacting them, the team looked at the following factors, as defined in the following ways:

Table 1

Factor	Definition
Access to Information	Hearing, listening, or reading literature or news related to climate change (future weather and climatic scenarios) and local climate (current weather and climatic conditions), as well as participation in coffee management training programs.
Coffee Management (includes business and farm management)	Includes financial record-keeping, number of employes and cost of labour, etc. along with agroforestry strategies such as coffee plant varieties grown, shade management and crop diversification, management of inputs (fertilizer, pesticide, fungicide), climate and weather record-keeping. Agroforestry is a technique whereby farmers plant trees alongside crops, hoping to take advantage of physical and chemical synergies for better crop outcomes (USDA National Agroforestry Center, 2016).
Financing	Source of capital used to invest in the farm including personal finances or bank credits/loans, as well as past and predicted credit access.
Adaptation Methods	Methods for generating income as a complement to coffee production and as a substitute in the case that coffee production is no longer possible.
Perception of Risk	Self-assessment or personal assessment of the vulnerability to climate change.
Biophysical Factors	Factors such as soil quality, weather, and disease which fall outside of the farmer's control
Farmer Demographics	General demographics such as age, income, location, etc.

Access to Information

Access to information was explored in order to understand whether increased access, including frequency, variety and quality of sources of information (organizations, training, news, etc.) might have an effect on perceived risk and adaptation strategies taken. There seems to be a consensus, especially among development organizations, that increased access to information could help farmers adapt, as timely climatic data could help growers make informed judgements. According to the Coffee and Climate Initiative, a consortium of European coffee companies and the German Ministry for Economic Cooperation and Development (2015), "If the farmer receives expert advice, increases knowledge and has sufficient funding with which to make a decision, he can be said to have a good adaptive capacity." This suggests that access to information could be beneficial to adaptability, and that level of access to information could be a factor that relates to perceptions of preparedness, risk or vulnerability towards climate change. For example, information on localized temperature changes and climate events could be useful tools to communicate predictions that encourage farmers to adapt autonomously to build adaptive capacity by reducing climate vulnerability and increasing resilience.

Coffee Management

Coffee Management practices were explored to understand how both business and farm management relate to perceived risk and adaptation ability. Survey questions evaluated financial recordkeeping, in order to understand whether farmers who keep accounts of how much they are spending on different inputs, labor, and other costs, whether this affects concern about climate change. Survey questions also evaluated farm management strategies such as integrated agroforestry systems and intensity of inputs. These questions were informed by a range of empirical studies on farming methods that could be used to adapt to climate change.

Designing a high-yielding coffee production system is an important and valid concern for strictly commercial farmers. Certification schemes often require farmers to keep financial records, which could be an indicator for less perceived risk or more perceived ability to adapt.

Farm management practices could also indicate different levels of perceived risk or perceived ability to adapt. For example, Haggar et al. (2011) suggest that coffee yields can be stabilized under agroforestry systems over time avoiding the "boom and bust" yields of sun coffee plantations in Costa Rica and Nicaragua. Moreover, secondary products from trees including fruit, fodder, firewood, and timber can supplement farmers' income incentivizing them to make long-term investments in their farms by planting different types of trees (Muschler, 2000). Another study based in Costa Rica measured the perception of farmers of shaded systems. It found that farmers considered the systems "necessary for the protection of coffee plants during the extended dry season, which can last up to six months. The shade tree systems used by farmers in the Peninsula of Nicoya could be beneficial in areas under similar environmental and socioeconomic conditions, such low-elevation zones with a distinct dry season and areas where farmers cannot afford the high costs of maintaining non shaded coffee plantations" (Albertin and Nair, 2004). However, increased biodiversity can lead to tradeoffs such as lower coffee yields due to competition, pests, and disease. Sun grown coffee systems often control for these variables through the application of pesticides and fertilizers. This tradeoff pushes researchers to investigate how to improve this and to work with farmers to design optimum shaded systems. Staver et al. (2001) suggest that varied amounts of shade over seasons may be the best approach to limit risk. More studies are needed to better evaluate specific coffee-tree-pest interactions. However, our study could shed light on which practices are currently being adopted within our sample, and how these relate more specifically to concern for and perceived risk of climate change.

Financing

The source of capital could also be an interesting factor pool to look at in order to understand whether there might be a relationship with this and the research questions. Whether farmers have personal credit in order to invest in their farm, or whether they have access to financial institutions that can provide a viable source of financing could relate to a low level of perceived risk of climate change, since they may feel that they have the means to mitigate vulnerability that they might otherwise feel. Financing may also be important for a farmer's willingness and ability to invest in climate adaptation.

Adaptation Methods

Survey questions on adaptation methods were included in order to better understand whether farmers would complement or substitute coffee production for another income generating activity in the case that coffee production is no longer possible. This is one of several types of climate change adaptation strategies mentioned in "Climate Change Adaptation in Coffee Production Guide" (Fischersworring et al., 2015). Complements or substitutes in the case of Costa Rica are of interest due to the reality, described above, that coffee production is becoming increasingly less profitable for farmers. Understanding this reality, and understanding farmers stance could be interesting as a first step in informing policy makers, government, or other supporting organizations or institutions of how they can best support those in the industry. The relevance of measuring this was found based on many conversations with different stakeholders including the farmers themselves, during initial interviews and focus groups.

Perception of Risk

Perceived risk was also explored to better understand how it relates climate change concern and perceived adaptive capacity. However, a proper assessment of perceived risk would require an investigation through the lens of other factors. The FAO and OECD stress that any attempt to measure vulnerability only has meaning within its specific context based on the assessment of multiple variables: physical, environmental, social, cultural, and economic (Fellmann, 2012). Therefore, perceived risk was measured in the context of factor pools, such as market price fluctuations, coffee production, technical assistance, and climate change.

Biophysical Factors

This study explores biophysical factors such as variability in precipitation, invasion of pests, and incidence of disease. How these areas intersect to influence a farm's suitability for coffee production is a pressing question for growers and the industry as a whole (Ovalle-Rivera et al, 2015). The IPCC (2007) states that the climate-related drivers of key risks within food security include a warming and drying trend, extreme temperature, extreme precipitation, carbon dioxide fertilization, and ocean acidification. These same drivers are also of concern in the coffee sector. This study offers the opportunity to obtain an initial understanding of specialty coffee producers' perceptions on how biophysical factors affect their coffee production.

Farmer Demographics

This study incorporated farmer demographics as a factor pool in order to better understand whether there is a relationship between level of perceived risk and ability to adapt with certain factors including farm location and farmer experience, education, etc. Some studies that discuss perceptions about climate change and climate related information suggest that perceptions remain constant among coffee producers in Mexico, but at the same time that "social identity influences perceived credibility and legitimacy of information" (Frank et al. 2011). Therefore, our study collected demographic data about the surveyed farmers. This was seen as an important step to either find notable differences in perceptions between different demographic groups or to document whether farmers were generally of the same demographic characteristics. The group believes that this will be helpful for other researchers who would like to develop follow up studies to better understand and make other inferences about the particular sample group that this study explores.

Research Questions

This research was conducted along seven key factors: perception of climate change risk, financing, farmer demographics, coffee management practices, biophysical factors, access to information, and perceived adaptation methods. These factors were analyzed along each of the following dimensions: concern about climate change and perceived ability to adapt to climate change. The following research questions were addressed in the context of Costa Rican specialty coffee farmers:

1. How concerned are specialty coffee farmers about climate change?
2. How prepared do specialty coffee farmers feel for climate change?
3. How is perception of climate change preparedness related to concern about climate change?
4. Which factors influence climate change concern and perception of climate change preparedness?

The factors explored in this paper were further defined by subfactors and topics listed in the table below.

Table 2

Factor	Subfactors	Survey Question Topics
Access to Information	● Farming ● Local climate ● Climate change	● Participation and frequency of participation in training programs ● Frequency of hearing and/or reading about rain and climate change ● Sourcing of information about climate, temperature, rain, etc.
Adaptation Methods	● Complement or substitute coffee production	● Methods for generating income in the case that coffee production is no longer possible ● Number of years coffee production would not be profitable before stopping

		production altogether
Biophysical Factors	• Coffee disease • Climate variability	• Frequency of disease • Impact of disease (coffee rust and ojo de gallo) on coffee production • Frequency and amount of rain • Quality of harvest
Coffee Management	• Coffee varieties • Shade trees • Certification • Business model • Record keeping • Sustainability • Labor • General management practices	• Coffee varieties grown (and change in which varieties) • Types of trees used for shade management, density and height of trees • Inputs used • Certifications • Frequency of soil analysis • Reuse/recycling of materials • How profitable is the farm? • Sources of income (coffee production, other agricultural, other sources) • Profitability of coffee (price and quantity of coffee sold/produced) • Costs of labor, maintenance and inputs (fertilizer, pesticide, fungicide) • Financial recordkeeping • Weather recordkeeping (frequency of noting/logging temperature, rain level, humidity)
Farmer Demographics	• Farm location, size, ownership, processing facility • Farmer experience, income, education, age, family, gender	• Farm and land ownership • Generations of coffee production • Education level • Age • Marital Status • Supporting children • Gender (observed, not asked)
Financing	• Access to Credit • Perception of Financial Resources • Willingness to Invest	• Farm investment • Support from bank/financial institution credits or other loans • Needing, requesting and obtaining credits (to understand whether there might be barriers in obtaining loans, if they are requested) • Sources of investment (loan or personal) • Plan to request credit
Perception of Risk/Vulnerability	• Market Price Fluctuations	• Concern for price fluctuations and changes in climate/weather and climate

	• Coffee Production • Technical Assistance • Climate Change	change • Frequency of unexpected climate events • Feeling of preparedness for climate change • Feeling that unexpected events, rust, ojo de gallo or other diseases have affected coffee production • Belief that current rain level is sufficient/not for coffee production • Number of years you would sustain losses before switching to another source of income • Support from technical assistance from different sources (governmental, buyers, etc.)

Methods

Initial Survey Development: Stakeholder Meetings and Farmer Interviews

Survey questions addressing the study's research questions were developed through an iterative process based on reviewing current literature, qualitative telephone interviews prior to travel to Costa Rica, stakeholder interviews in Costa Rica, and semi-structured farmer interviews and focus groups. A survey pilot was then conducted, and subsequently, the finalized survey was administered. The collected responses were coded and analyzed.

An initial literature review was conducted in order to understand the current knowledge, interest and limitations in research in the nexus of agricultural products, farming methods, commodity and specialty coffee, climate change, perceptions and adaptation.

Meanwhile, unstructured and semi-structured, exploratory interviews were conducted with coffee farmers in Costa Rica over the phone in Spanish. The purpose of these initial qualitative interviews was to have an open ended discussion to gain a deeper understanding of and appreciation for the experience of a coffee farmer first hand, and to pay attention to what common issues are being raised by the farmers. These interviews also allowed the team to develop a comfort with the language used and with the interview process for data collection. The interview transcripts were coded and analytic memos were taken which helped to inform the question development process moving forward to develop semi-structured interview questions and finally the survey questions.

Then, factors were identified, explained in more detail in the table above. The team traveled to Costa Rica where multiple stakeholders were engaged, including CIMS, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Exclusive Coffees, Coopedota, Instituto de Café de Costa Rica (ICAFE), and the Programa Institucional de Gestión del Riesgo de Desastres at the Universidad Nacional de Costa Rica (UNA). The team visited several farms, cooperatives, and processing plants. Through interactions with many farmers, the group continued refining the interview questions. Through a semi-structured interview approach and input, consisting of both pre-written and ad-hoc questions by the interviewers, the team performed three farmer interviews and a focus group with three producers. This allowed the team to develop and continually iterate on the survey questions, and to ensure that the content and language were accurate and appropriate in the regional context.

Finally, the team refined the questions and chose a survey style approach with close-ended questions rather than a structured interview. The survey was then piloted five times to ensure that the questions were properly understood, that the choices were collectively exhaustive and mutually exclusive, and that the language was optimized and appropriate. The original survey and English translation can be found in Appendix A.

Sample Population

The Costa Rican association for specialty coffee, called the Asociación de Cafés Finos de Costa Rica (SCACR), provided the team a list of all Cup of Excellence winners from 2011-2015. This list was determined to be an appropriate proxy for the Costa Rican specialty coffee industry overall, given that participants are selected from a pool of the highest quality cups of coffee in the country and sold in global online auctions at premium prices. The significant public recognition that comes with being awarded a Cup of Excellence serves as a major incentive for farmers to submit to this competition. Participation in this competition was considered to be both attractive and accessible to most farmers, ensuring that the sample should be representative of the general specialty coffee farmer population.

Survey Administration

The two local survey administrators chose a sample of famers from the list of winners based on geographic distribution and farmer availability. Preference was given to geographic clusters of farmers to reduce the amount of travel time and visit as many producers as possible within the study's timeframe. In total, 34 of the 47 winners from 2011-15 were surveyed (72.3% completion rate). With a relatively small sample size, it is worth noting that there could be limitations to using this proxy to generalize to all specialty coffee farmers.

The survey was administered between October 25, 2015 and February 2, 2016. CIMS recommended people with whom the team could work, and the team interviewed and employed two surveyors who met with farmers face-to-face and recorded all responses directly into the Qualtrics application. There was no written component for survey respondents. Surveyors were selected based on their prior experience working with coffee producers, interviewing, collecting data, and building rapport with farmers. The team supported and managed the surveyors remotely, and collected audio files recorded during the surveys to ensure data accuracy.

Data Organization and Survey Questions

Questions were categorized into factors to meaningfully answer the research questions. The group considered farmers' level of concern about climate change and farmers' perceived ability to adapt to climate change as the main factors under consideration. The other factors considered are categorized into the following dimensions: financing, coffee management practices, biophysical factors, access to information, and farmer demographics.

Data Analysis

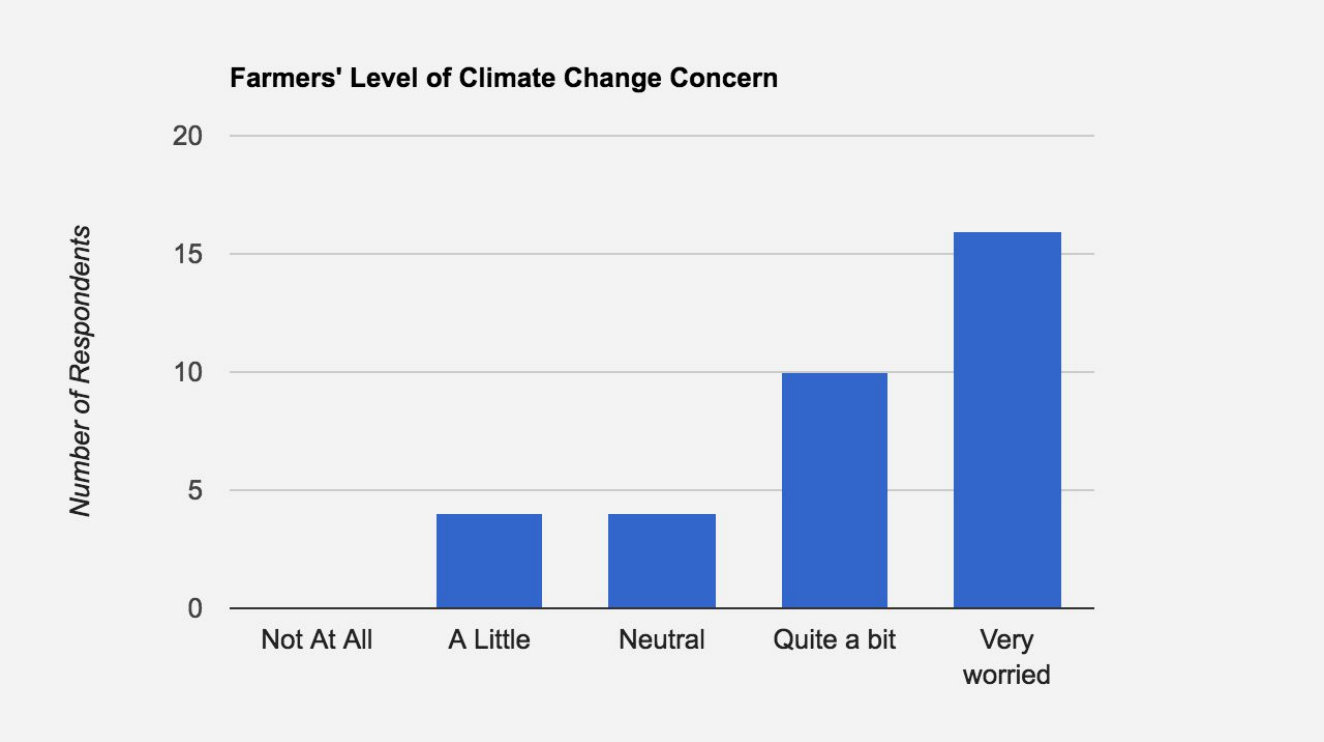
An Excel file was downloaded from Qualtrics with the survey results. For each dimension mentioned within Table 2, survey results were analyzed through pie charts, histograms, and general statistics (e.g. means, modes, etc.) within Excel to develop an overall picture of how farmers responded to the questions. Subsequently, the data was normalized and converted into a format suitable for SPSS, and the data was then imported into SPSS for further analysis. For each question, a one-way-ANOVA was performed via SPSS to identify if survey respondents' answers to the question was related to their concern for climate change or their perceived ability to adapt to climate change. In questions with continuous numerical variables, highly granular likert-scales, or uneven spread in answer choices, the respondents' answer choices were grouped such that the answers would be more suitable to analysis with ANOVA. For example, in a question with responses on a 10-point scale, the responses could be grouped such that response 1-5 = Group 1, and response 6-10 = Group 2, effectively turning the question into a binary variable, which could give a more useful result with ANOVA. In the event that the groupings produced 3 or more options (i.e. not a binary variable), Tukey post-hoc analysis was performed to identify which specific pairwise comparisons among the available options showed a statistically significant difference of means. In cases where groupings and Tukey post-hoc analyses have been performed, the details are noted within the Results section.

Results

Climate Change Concern

Among the sample population of specialty coffee farmers in Costa Rica, there is an uneven distribution of concern about climate change, as portrayed in the graph below. While no respondents reported feeling "no concern"about climate change, 76% expressed being "quite" or "very" concerned. Furthermore, nearly 50% of farmers surveyed reported being "very concerned." Used as a proxy for Cup of Excellence winners, this sample population indicates a higher than moderate collective level of concern.

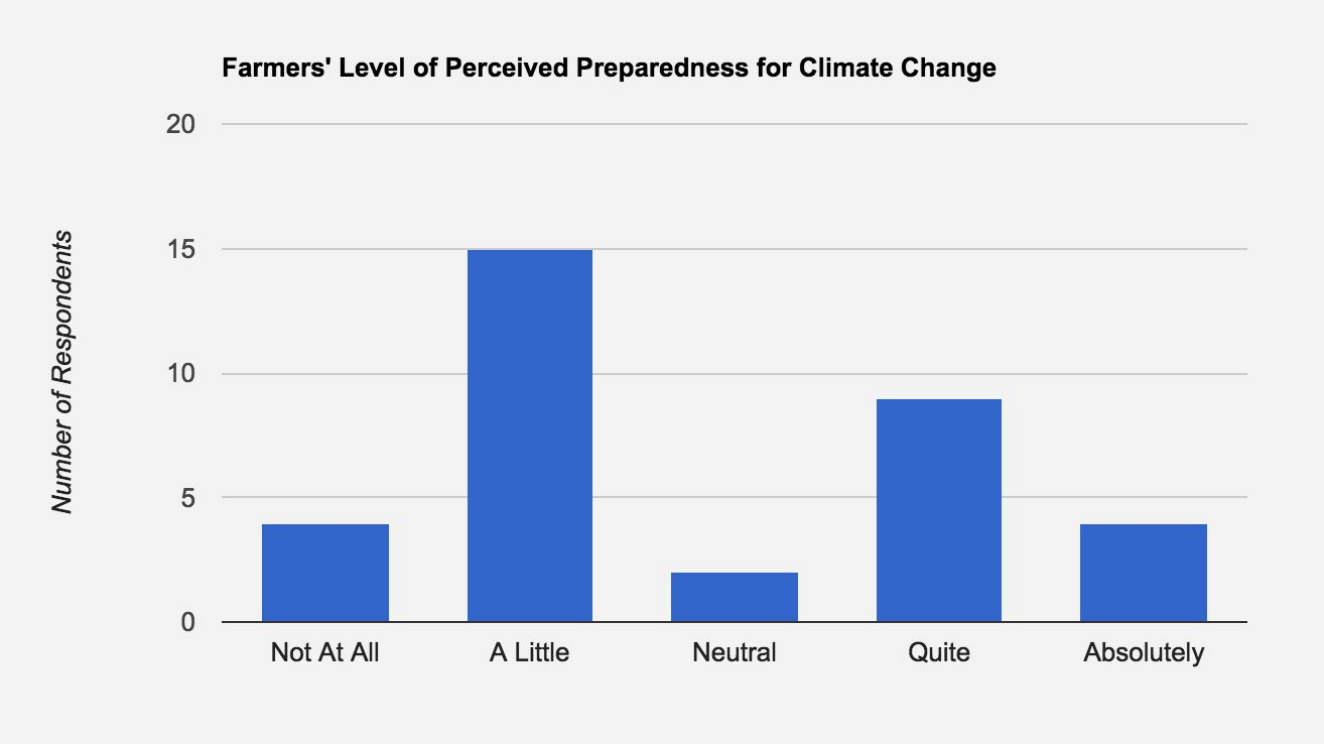
Figure 1



Perceived Preparedness for Climate Change

Unlike the distribution of climate change concern, farmer perceptions of preparedness to climate change are less directional from one extreme to the other. 62% of respondents reported feeling moderately prepared, including "not at all," "a little," or "neutral," while the remainder expressed feeling "quite" or "absolutely" prepared for the effects of a changing climate. Additionally, while the distribution is split quite evenly between low or high levels of preparedness, the majority of farmers surveyed did not report levels on either end of the spectrum. Only 12% reported feeling either "not at all" or "absolutely" prepared, while 44% expressed being "a little bit" prepared and 26% feeling "quite" prepared. This range of responses allowed the research team to test differences in means between perceived preparedness and a number of factors of interest.

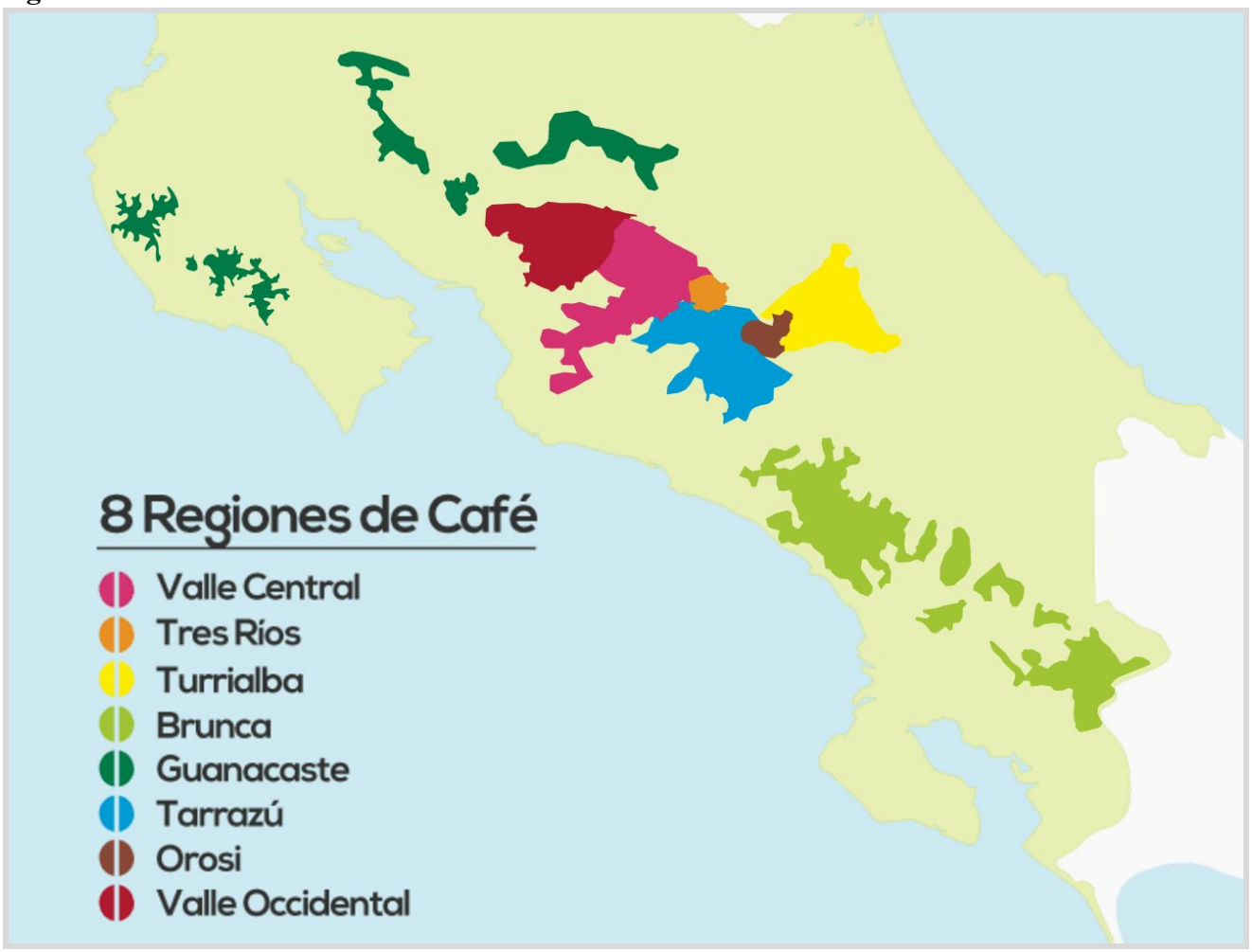
Figure 2



Farmer Demographics

A range of demographic questions explored how location, income, age, education, and experience are related to farmers' concern about climate change and perceived ability to adapt. Surveyed farmers come from five out of the eight principal coffee growing regions in Costa Rica: West Valley (Valle Occidental), Central Valley (Valle Central), Tarrazú, Brunca, and Tres Ríos (see map below from ICAFE, 2016 of all regions). Farmers from the West Valley and Tarrazú regions made up 85% of survey respondents. These regions are known for Costa Rica's finest coffees grown at high altitudes between 1,200 and 1,900 meters. According to ICAFE (2015), these regions also produce the most coffee out of all regions combined, accounting for 52% of harvested coffee over the 2014-2015 season.

Figure 3

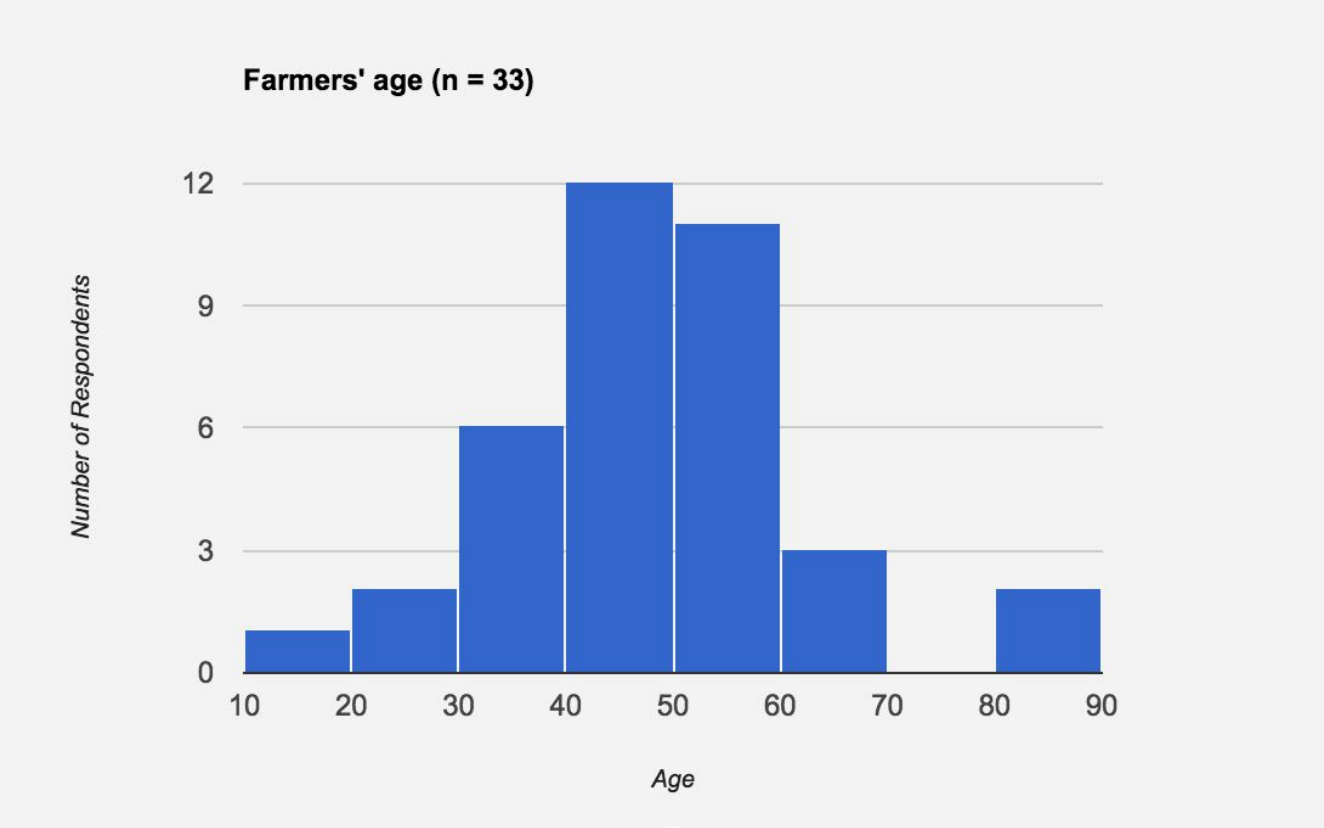


Map of Costa Rica's eight coffee growing regions (ICAFE, 2016)

Farmers' revenue across all regions averaged $180,000 USD (95,000,000 CRC) with 42% of respondents earning above this amount. In order to maintain or increase revenues, farmers will continue to look for markets that offer high prices for specialty coffee. The average price that surveyed farmers received per fanega grew by 6% from $211.75 to $224.87 USD (113,000 to 120,000 CRC) between the 2013-14 and 2014-15 harvest seasons.[1] Interestingly, farmers were noticeably split between age, education, and farm productivity. The average age of the coffee farmer was 50 years old with 10 respondents between 25-40 and another 10 between 40-50 years old. A one way ANOVA showed that the differences in climate change concern between 26-45 years old ($n = 12$, $M = 4.75$, $SD = 0.45$) and 46-84 years old ($n = 21$, $M = 3.76$, $SD = 1.14$) were statistically significant, $F(1,31) = 8.237$, $p = 0.007$, $\eta^2 = 7.486$.

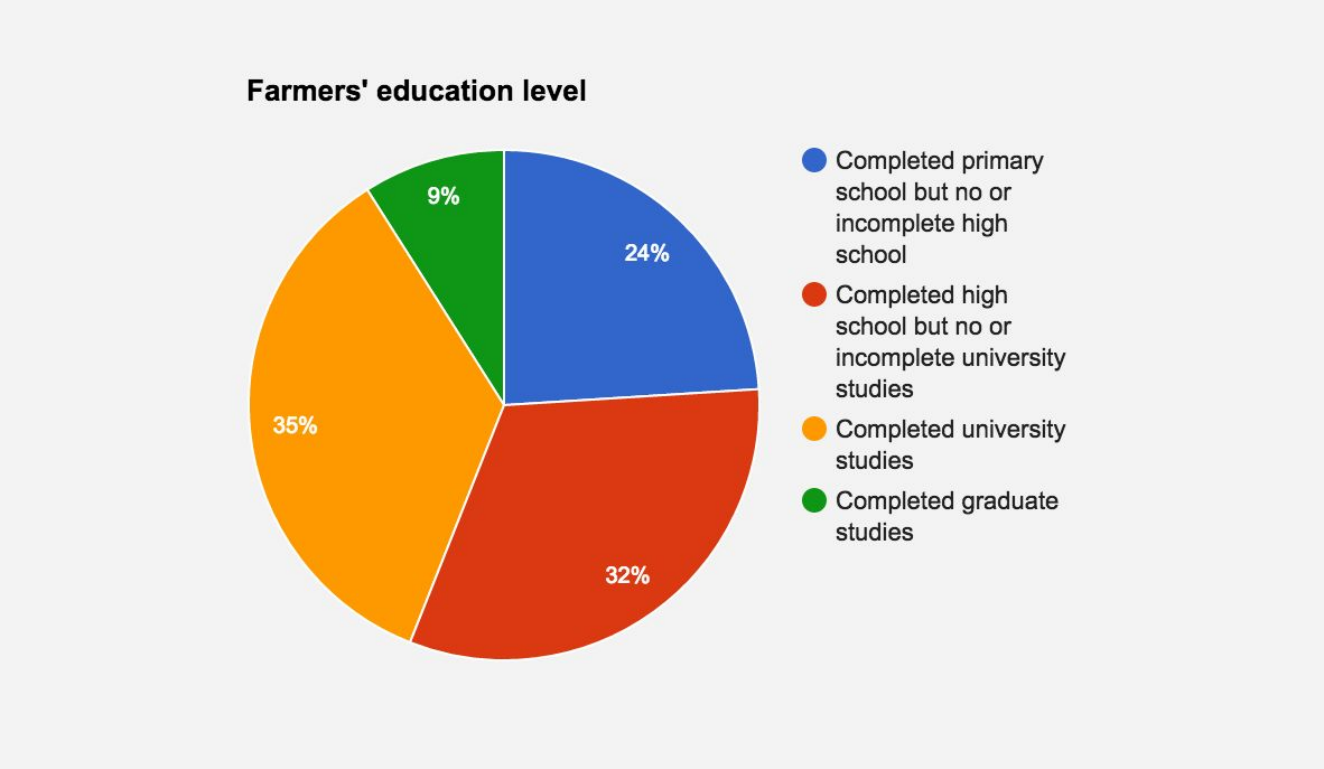
[1] A fanega is equivalent to 248 kg of fresh coffee cherries or 46 kg of green coffee beans (Villanueva et al., 2011)

Figure 4



Nearly 44% of respondents had completed post-secondary education. Specifically, 35% completed primary school but no or incomplete high school, 21% completed high school but no or incomplete university studies, 35% completed university studies, and 9% attained graduate degrees. A one way ANOVA showed that the differences in perceived preparedness between farmers who had completed primary school but no or incomplete high school (n = 8, M = 3.00, SD = 1.41), completed high school but no or incomplete university studies (n = 11, M = 2.90, SD = 1.37), and completed university studies and/or graduate degrees (n = 15, M = 2.67, SD = 1.23) were not statistically significant, $F(2,31) = 0.200$, $p = 0.820$, $\eta^2 = 0.349$. Another one way ANOVA showed that the differences in climate change concern between farmers who had completed primary school but no or incomplete high school (n = 8, M = 4.38, SD = 0.51), completed high school but no or incomplete university studies (n = 11, M = 3.73, SD = 1.19), and completed university studies and/or graduate degrees (n = 15, M = 4.27, SD = 1.04) were not statistically significant, $F(2,31) = 1.193$, $p = 0.317$, $\eta^2 = 1.270$.

Figure 5



In order to cope with increasing costs, farmers may adapt by attempting to increase productivity. One might expect specialty coffee farmers to be the most knowledgeable and driven to maximize crop yield. However, further survey analysis shows three different tiers of farm productivity within this producer market. ICAFE classifies low yielding farms producing between 20 to 26 fanegas, medium yielding farms between 26 to 34 fanegas, and high yielding farms between 34 to 40 fanegas (ICAFE, 2014). Survey respondents were distributed almost equally between all three ICAFE classification groups with 38% classified as low yielding, 35% as medium yielding, and 27% as high yielding. A one way ANOVA showed that the differences in perceived preparedness between the low yielding group (n = 13, M = 2.31, SD = 1.03) and the medium yielding group (n = 12, M = 3.67, SD = 1.37) were statistically significant, $F(2,31) = 4.942$, $p = 0.014$, $\eta^2 = 6.642$. Overall, low yielding farmers felt less prepared to face climate change than medium yielding plantations. No significant difference was detected between low and high yielding farmers. Both groups felt relatively ill-prepared to face climate change when compared to the medium yielding group, but the difference in means was only statistically significant between low and medium yielding groups.

Regarding landholding, the 34 farmers had a mean total area in hectares of 38.4 (SD = 54.8). Nearly 50% dedicate the entire plantation to coffee production. A one way ANOVA showed that the differences in perceived preparedness between farmers with 1-10 ha (n = 13, M = 2.69, SD = 1.37) and more than 10 ha (n = 21, M = 2.90, SD = 1.26) were not statistically significant, $F(1,32) = 0.212$, $p = 0.648$, $\eta^2 = 0.362$. Moreover, another one way ANOVA showed that the differences in climate change concern between farmers with 1-10 ha (n = 13, M = 3.92, SD = 1.12) and more than 10 ha (n = 21, M = 4.24, SD = 1.04) were also not statistically significant, $F(1,32) = 0.734$, $p = 0.398$, $\eta^2 = 0.797$.

Table 3

Farmer demographics (n=34)	
Region	
West Valley	9%
Central Valley	50%
Tarrazú	35%
Brunca	3%
Tres Ríos	3%
Area of land held in hectares	
1-10 ha	30%
More than 10 ha	70%
Plantation dedicated to coffee production	
35-74%	24%
75-99%	29%
100%	47%
Yield	
Low (Less than 26 fanegas/ha)	38%
Medium (26-34 fanegas/ha)	35%
High (34 to 40 fanegas/ha)	27%
Change in yield 2013-14 to 2014-15	
Positive or no change	38%
Negative	62%
Mean change in yield 2013-14 to 2014-15 harvest seasons (%)	2.91 (SD = 80.47)
Mean Age	49 (SD = 11.8)
Level of Education	
Primary school complete	24%
Secondary school incomplete	12%
Secondary complete	15%
Universities incomplete	6%
University complete	35%
Postgraduate studies	9%

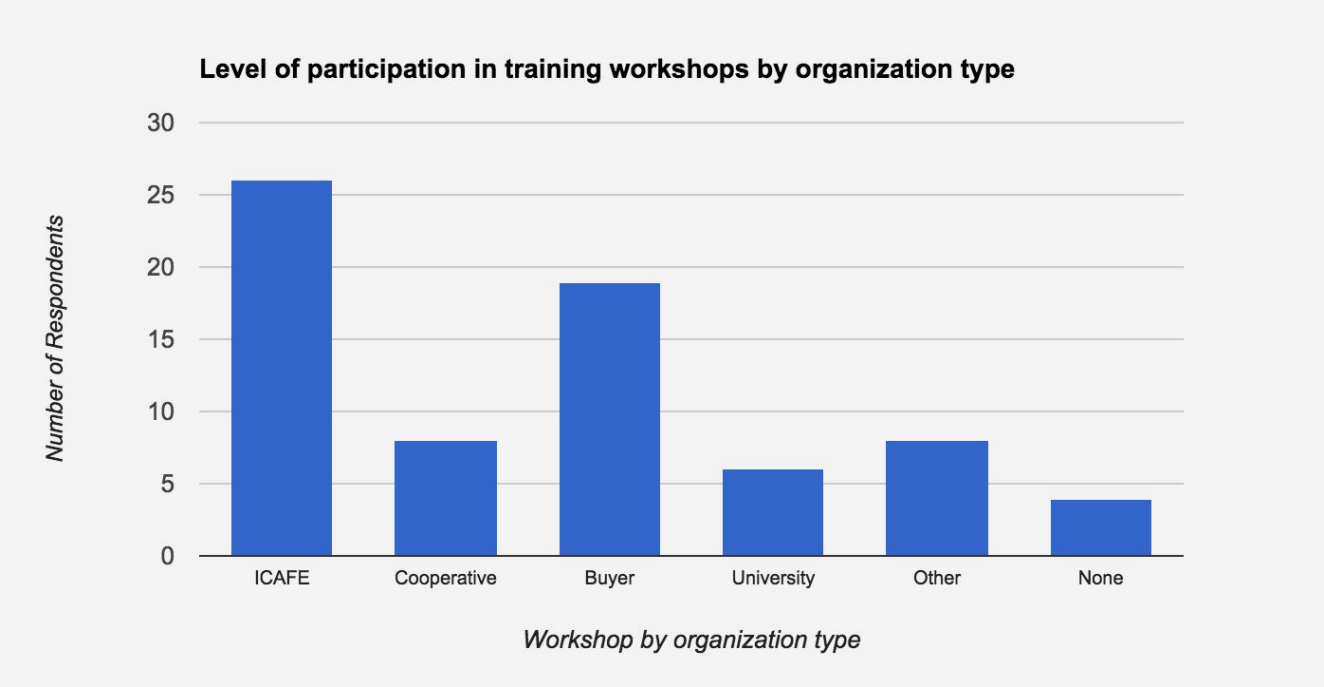
Access to Information

The purpose of exploring perceived access to information is to understand the channels and connectedness of Cup of Excellence farmers with regard to farming practices, local climate, and climate change information. Distinct from the demographic understanding of level of formal schooling achieved, this group of questions dealt instead with the continuous flow of information that may or

may not be available to farmers to make decisions that impact the management of their farms and, ultimately, the concern about climate change and their perceived abilities to adapt.

The majority of farmers (88%) reported attending at least one type of farming training session throughout the year. Most commonly, farmers attended trainings from ICAFE (76% of respondents) and from their buyers (56%). Although the trainings that the farmers attended most often were with ICAFE and from their buyers, there were no types of trainings that showed a significant impact on concern about climate change or perceived preparedness. Of the 30 respondents who offered their frequency of training attendance, 80% reported attending between 2-4 trainings annually, with one outlier who reported attending 12. The number of trainings that the farmers attended annually also did not show a significant difference on either climate change concern or perception of preparedness.

Figure 6



Farmers were at least somewhat tuned in to the current local climate as well as projections of a changing climate, with 100% reporting reading or hearing about climate and climate change at least infrequently (therefore not never). However, the focus tips towards local climate when assessing reported frequencies. 68% of respondents reported always being informed about local climate, while only 47% reported that same frequency with regard to climate change information. Even so, 79% reported being exposed to information about climate change at least often. Frequency of information absorption with regard to both local climate and climate change did not yield significant results and neither did the channel for accessing this information. Among both local climate and climate change, there is no discernable difference in the channels by which farmers are receiving that information. In both cases, more than 75% of respondents received this information from the television and Internet, with no other channel offering more than 45% of those surveyed that same information.

Coffee Management

Questions related to coffee management practices were meant to explore the elements of coffee production that fall under the farmer's control. Information gathered for this pool was comprised of coffee varieties, shade tree characteristics, sustainability, certifications pursued, record-keeping, farm business model, labor, and general management practices.

There were only three coffee varieties that at least 50% of survey respondents reported using: Catuaí Rojo, Caturra, and Geisha. At the same time, among the 34 farmers surveyed, 21 coffee varieties were mentioned as being used in production. Among the coffee varieties represented in survey responses, most did not exhibit a significant relationship with climate change concern or perception of preparedness. The exception however was *Tipica*, which 26% of farmers reported using. Those farmers who do use *Tipica* ($n = 9$, $M = 3.56$, $SD = 1.01$) reported a statistically significant ($F(1,32) = 4.338$, $p = 0.045$, $\eta^2 = 6.559$) higher perceived preparedness than the remainder who did not ($n = 25$, $M = 2.56$, $SD = 1.29$). Nearly 90% of respondents reported incorporating new varieties to increase the quality of the cup, far more than the next most common reason given: productivity. As could be expected, there was a significant connection between respondents feelings of preparedness about climate change and those who introduced new varieties of coffee for the sake of climate change preparation. In this instance, the respondents who did introduce new varieties for this reason ($n = 11$, $M = 1.82$, $SD = 0.40$) felt less prepared to deal with climate change ($F(1,32) = 13.658$, $p = 0.001$, $\eta^2 = 16.435$) than those who did not ($n = 23$, $M = 3.30$, $SD = 1.29$).

Types of shade trees used in coffee plantations also varied widely. Although 82% of farmers reported using *poro* trees, the next most commonly reported was *guaba* with only 38% of respondents (and only 6% reported using no shade trees at all). Further, among the sample population, a full 46 varieties of shade tree were reported being used. While there were few patterns in types of shade trees employed, tree height and density revealed more consistent patterns. Nearly 80% of respondents who employed shade trees reported tree height of 2-5 meters. At the same time, tree density was mostly evenly distributed with the most common ranges being between 1-35 trees per hectare and over 100 trees per hectare. When considering characteristics of shade trees, there was no significant relationship between shade tree height or density and either climate change concern or perception of preparedness. As for "sustainability" practices (defined here as methods that repurpose or recycle material from the coffee production process), there was a clear divide between types of farm materials that are repurposed or recycled by survey respondents. While 100% reported reusing plant organic material and 91% reused coffee pulp, only 6% reused chemical containers or paper/cardboard. However, 85% reported recycling containers and 35% recycled paper, while no respondents reported recycling organic material or coffee pulp.

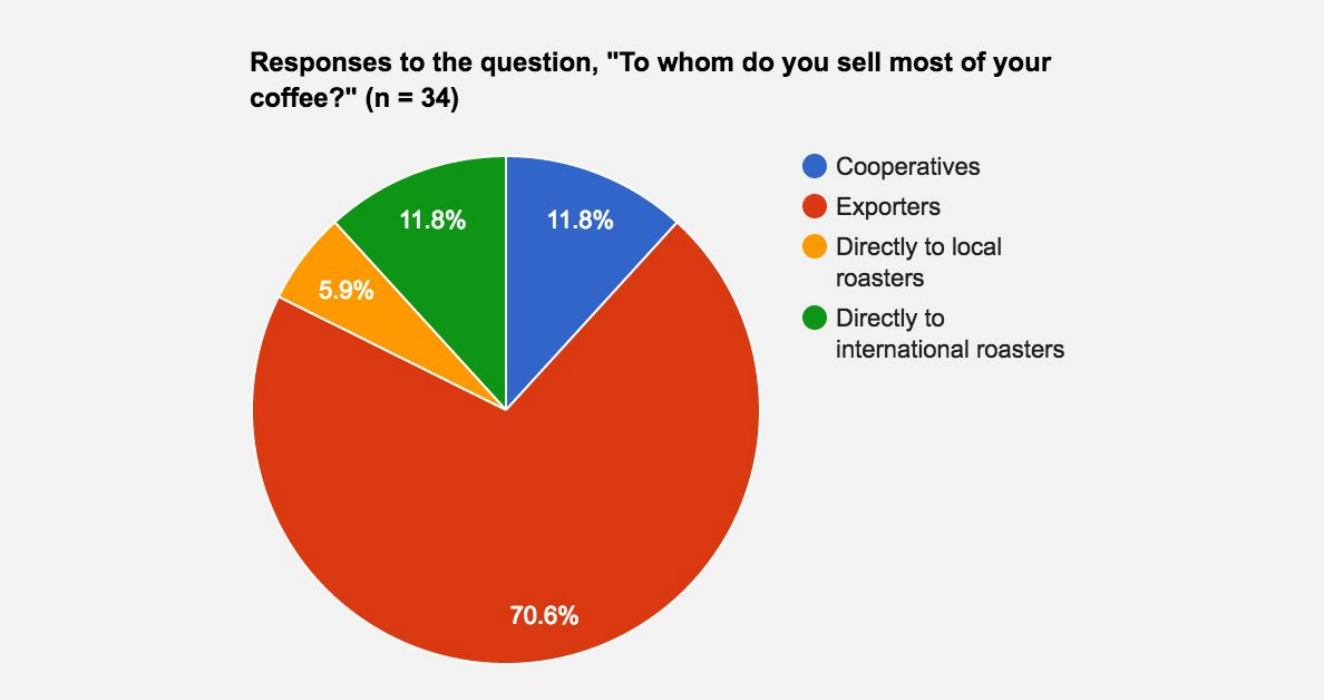
Survey results from Cup of Excellence participants showed that coffee certifications are not as common as the research team hypothesized. Fewer than 45% of respondents reported participating in any certification at all. Although some farmers had multiple certifications, the most common was Rainforest Alliance, with 26% of respondents participating. Survey respondents who participated in at least one certification program did not report having a significantly different perceived preparedness than those who had not participated in certification programs. Moreover, there was no significant relationship that indicated, beyond the binary consideration of certification use or not, a larger number of certifications is connected to any more or less concern or perceived preparedness.

Record-keeping among the sample set showed more of a tendency toward financial rather than biophysical information gathering. 85% of respondents reported keeping financial records at least "sometimes" (74% "always"), but fewer than 30% reported keeping information on temperature, rainfall, or humidity. Additionally, less than 15% reported conducting soil analysis on their farms more

than once each year. In terms of record-keeping, those survey respondents who reported always maintaining financial records (n = 9, M = 3.44, SD = 1.24) had a significantly higher level of concern about climate change (F (1,32) = 5.921, p = 0.021, $\eta^2 = 5.547$) than those who kept less frequent or no financial records (n = 25, M = 4.36, SD = 0.86). While no significant relationship was shown between the key research variables and any kind of biophysical record-keeping (i.e. temperature, rain, and humidity), there was a positive correlation between concern about climate change and the number of times that soil is sampled annually.

There is a noticeable trend amongst the sample set around selling to exporters. Over 70% of respondents reported this business model compared to the next most common methods of selling to a cooperative or selling direct to an international coffee roaster, both reported by 12% of respondents. To whom farmers choose to sell their coffee was revealed to have a significant relationship with perceived preparedness to deal with climate change. Those who sell directly to international coffee roasters (n = 4, M = 4.5, SD = 0.58) feel significantly higher levels of climate change preparedness (F (3,30) = 3.909, p = 0.018, $\eta^2 = 5.147$) than those who sell to cooperatives (n = 4, M = 2, SD = 0.82) and those who sell to exporters (n = 24, M = 2.75, SD = 1.26).

Figure 7



General coffee management practices included questions of labor, fertilizer application, and other farming activities. For labor, 62% of respondents reported employing both permanent and temporary laborers, with 26% employing only permanent *or* temporary workers. Responses also showed that all farmers (100%) choose to fertilize their crops at least three times annually and implement the practice of *renovación*, whereby coffee plants are replaced after a certain amount of time. While over 90% of respondents incorporate organic material, new varieties of coffee, and shade trees, only 12% currently use irrigation. This lack of irrigation is likely currently the reality due to sufficient and predictable rainfall. However, there is indication that this number increases slightly to 18% when prompted about planning for irrigation in the coming two years. Another result that stands out from the predicted farming practices deals with agrochemical application. While 9% of

respondents predict using more agrochemicals in the coming years, 79% anticipate actually using less. This may be connected to the fact that 91% of survey respondents predict using higher quality inputs within two years. When considering general coffee management practices, little showed up as having a significant relationship with either climate change concern or perceived preparedness. The lone exception was that there is a lower feeling of preparedness ($F(1,32) = 7.261$, $p = 0.011$, $\eta^2 = 10.161$) about climate change among those who plan to increase fertilizers on their plantations over the next two years ($n = 12$, $M = 2.08$, $SD = 1.24$) than those who do not ($n = 22$, $M = 3.23$, $SD = 1.15$).

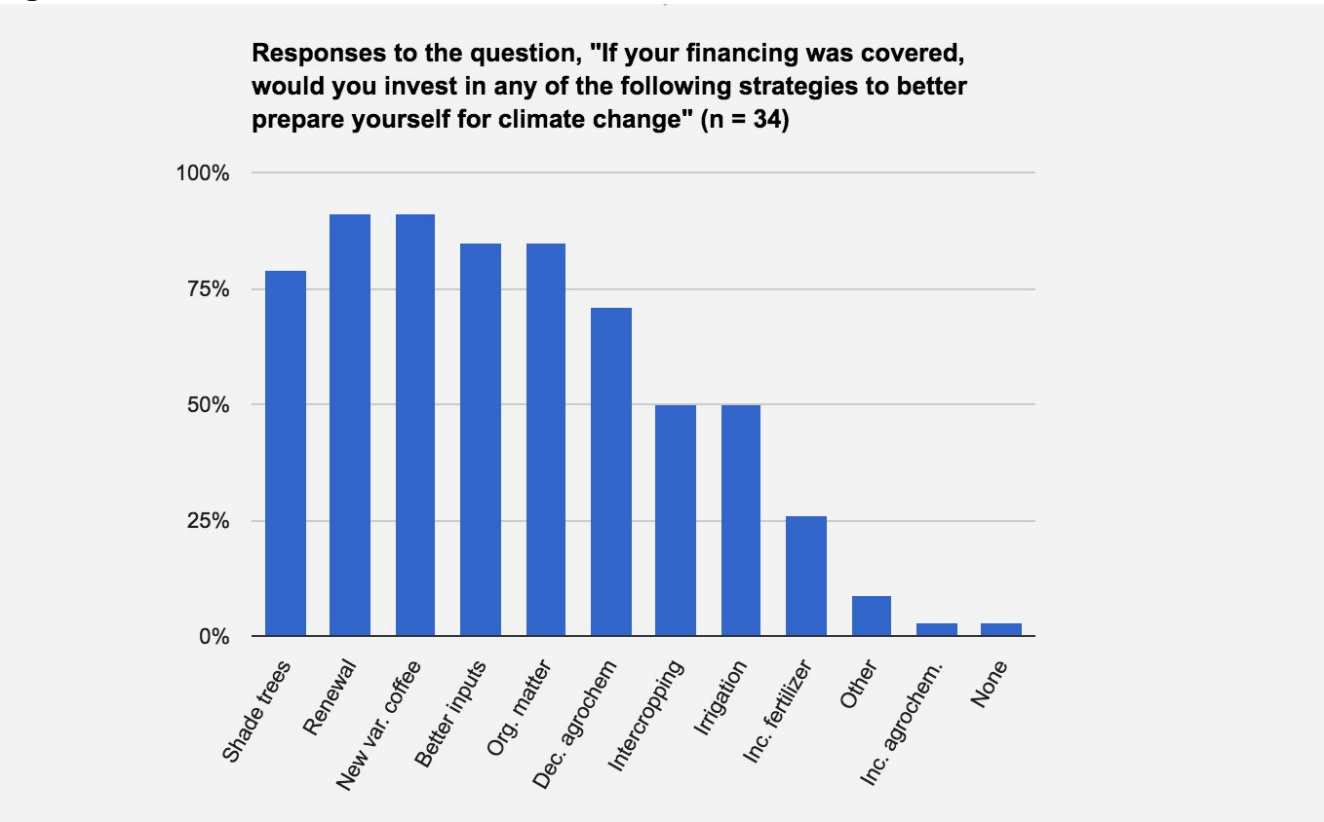
Financing

The survey included a number of questions regarding financing. The goal of these questions was to gain clarity on the extent to which farmers require credit or financial support, and the extent to which they are able to attain the support they need. These questions are especially important in an adaptation context because adaptation may be expensive, and farmers with better access to financing may be in a better position to afford to take adaptive measures.

Based on these questions, a number of interesting results arise. Most farmers do have access to credit, and most farmers take advantage of this financial support. About 5% of farms felt that they need credit but are unable to obtain it. Despite whether or not the farmer requested credit or received it, no significant relationship was exhibited with either climate change concern or perceived preparedness. The vast majority (71%) of farmers who choose to request financing receive it from banks. A smaller portion receive financing from cooperatives (9%) or from buyers (12%). Other sources, including government support (3%), are rare or absent. An interesting trend emerges among the level of support needed among farmers, with two peaks in the curve. Whereas most farmers self-fund between 80 to 100% of their operations, a very sizeable group self-funds only about half of their operations. The trend shows two tiers among farms, but there is no significant difference of means shown between these groups and either climate change concern or perceived preparedness. The overwhelming majority of farmers (94%) are either "quite interested" or "very interested" in investing in their farms to prepare for climate change. Farmers who expressed a desire or willingness to invest in their farm to prepare for climate change ($n = 32$, $M = 4.22$, $SD = 0.97$) were statistically more worried about climate change ($F(1,32) = 5.938$, $p = 0.021$, $\eta^2 = 5.561$) than farmers' who were not willing to invest ($n = 2$, $M = 2.5$, $SD = 0.71$). Interestingly, these same farmers were not statistically more likely to feel prepared for climate change than those uninterested in investing for climate change.

A pattern emerges in the methods through which farmers hope to adapt. Notably, farmers are much less interested in methods involving agrochemicals (3%) and enhanced fertilizers (26%), and much more interested in techniques such as intercropping (50%), renewal (91%), incorporation of new varieties (91%), better supplies (85%), and agroforestry (79%).

Figure 8



Biophysical Factors

The survey included questions about biophysical factors that aimed to assess the level to which farmers are affected by environmental factors such as crop diseases and precipitation patterns. In contrast to the questions posed in the coffee management section, these questions specifically looked at the factors that are influential in the coffee production process, but fall outside of the farmer's control.

The majority of specialty coffee farmers are "not at all," or "not significantly" affected by coffee rust (65%). However, a high percentage (relative to another disease explored) actually are affected by coffee rust, with 12% going so far as to say that they are "very much" affected by coffee rust. Ojo de gallo is much less of a concern than coffee rust, with 90% of farmers saying that ojo de gallo affects them either "not at all" or "very little." While the coffee rust and ojo de gallo diseases are affecting a number of specialty coffee farmers in the sample population, those who experienced the diseases on their farms reported no significant difference in concern or preparedness for climate change than those who did not experience those diseases on their farms.

Farmers overwhelmingly agree that unusual changes to the local climate have been occurring. In fact, 97% of farmers surveyed reported either "very much" or "absolutely" agreeing that there have been unusual changes in the local climate in the past five years. Since there was such consensus on this topic, the factor was treated as a constant and was not tested against concern or perceived preparedness to climate change.

Perception of Risk

The survey also asked farmers about their perception of risk. In particular, these questions were asked in order to understand the level to which producers view climate change as a legitimate risk to their livelihoods. These questions ask farmers about their concern about climate change, their observations on the effects of climate change, and their perceived level of technical support from other entities in the event of climate change.

The majority (almost 60%) of farmers are "absolutely" or "very much" concerned about drops in coffee prices. 41% of farmers were either "not concerned," "very little" concern or "neutral," whereas 59% were "concerned" or "very concerned." Interestingly, when grouped into low concern about coffee price drops (those who aren't concerned, are little concerned, and neutral) compared to those with high concern (those who are quite or very concerned) there is no statistically significant relationship ($F(1,32) = 0.201$, $p = 0.657$, $\eta^2 = 0.222$) between the low group ($n = 14$, $M = 4.21$, $SD = 1.05$) and the high group ($n = 20$, $M = 4.05$, $SD = 1.05$) with regard to farmers' concern about climate change. Overall, an equal proportion of farmers (29%) claim that their coffee production has grown as opposed to decreased, with the rest (41%) claiming that it has stayed the same. Of those who claim their production has decreased, farmers assign near-equal weights to climate (70%) and crop diseases (60%).

Approximately 68% of farmers believe that unexpected climate events affect their coffee production either "always" or "quite a bit," with only 6% stating that they are unaffected. Over a third of farmers believe that current rain levels are insufficient for coffee production, which is notable, given that supplemental irrigation is relatively uncommon among coffee farmers. Farmers who perceived that the current quantity of rain is not sufficient (grouped as those who feel it is "not at all," "not sufficient," or "neutral") ($n = 15$, $M = 2.27$, $SD = 0.80$) for coffee production felt significantly less prepared for climate change ($F(1,32) = 5.714$, $p = 0.023$, $\eta^2 = 8.324$) than those who perceive there to be sufficient rain ($n = 19$, $M = 3.26$, $SD = 1.45$). The majority (nearly 80%) of farmers believe that the government does not provide technical assistance for farmers in adapting to climate change. The availability of and farmers' opinions about technical assistance programs for farmers demonstrated no statistically significant relationship with farmers' concern about climate change or their perceived ability to adapt.

Adaptation Methods

The survey included a number of questions regarding adaptation methods. These questions aim to assess how farmers intend to respond to climate change. By gaining an understanding of this at a broad scale, it may be possible to assess systemic effects on the coffee industry in Costa Rica in the event of a severe climate change scenario. While the descriptive statistics about adaptation methods are valuable for understanding farmer perceptions, these variables demonstrated no statistically significant relationship with or effect on farmers' concern for climate change or their perceived ability to adapt to climate change.

Farmers were equally split between those who answered "probable" or "very probable" when asked about potentially complementing coffee production with other activities (50%), versus those who would be "less likely" to do so (50%). On the other hand, only 15% of farmers answered "probable" or "very probable" when asked about their willingness to replace their coffee production with another activity entirely in a future climate change scenario. Farmers' willingness to sustain financial losses seems very limited, with the majority indicating that they would stop coffee production entirely if it were to be unprofitable for one to three years. With the exception of one outlier, the most

farmers most tolerant to financial losses are willing to sustain losses for up to five years before giving up production. While this result is interesting, it is even more interesting in light of farmers' preferences on how they would pivot in the event that they could no longer sell coffee. Of the respondents, 26.5% would sell or rent their land, and over half the respondents would move into another type of agricultural activity (either as an employed farmer, a poultry or cattle farmer, or a plant farmer for crops other than coffee). The remaining farmers (17.6%) would pivot in directions other than the options given in the survey.

Influence of Climate Change Concern on Perceived Preparedness for Climate Change

Despite the expectation of a significant relationship, running a regression on the perception of preparedness in specialty coffee farmers against their concern about climate change yields a weak, insignificant result. The standardized regression coefficient of -0.256 has a t-statistic of -1.496 and a p-value of 0.145. The R-squared of the regression is low (0.065). A one-way ANOVA test of difference in means between those who have varying levels of concern about climate change turned up insignificant results. Those respondents who reported low levels of climate change concern (grouped as those who expressed "no concern," "little concern," and "neutral concern") ($n = 8$, $M = 3.5$, $SD = 1.41$) reported an insignificantly higher level of preparedness ($F(1,32) = 3.054$, $p = 0.090$, $\eta^2 = 4.79$) than those with higher climate change concern (grouped as those who are "quite" or "very concerned") ($n = 26$, $M = 2.61$, $SD = 1.20$). This result does not allow us to reject the null hypothesis that there is no difference between the means of perceived climate change preparedness between those farmers with either low or high levels of climate change concern.

Discussion

Comparison with Existing Research

The initial literature review mentioned several key findings in existing literature. Given that our research aimed at a much more specific sample population, a comparison of our results with those of existing literature could yield interesting insights regarding specialty coffee farmers in Costa Rica as compared to the general coffee-growing community.

Tucker et al. (2010) found that "farmers who associated events with high risk were not more likely to engage in specific adaptations. Adaptive responses were more clearly associated with access to land than perception of risk, suggesting that adaptation is more a function of exogenous constraints on decision making than perception." While our study did not address specific adaptation practices, we can use our metric of perceived preparedness for climate change as a parallel topic of interest. The lack of significant relationship between climate change preparedness and climate change concern in our study suggests, similarly to Tucker et al.'s argument, that perceived risk did not correlate with adaptation. However, our survey also found that farmers with more land (or who owned their land) were more likely to feel prepared for climate change (but not with statistical significance). As such, we have no significant finding to suggest that those farmers in our sample perceived being any more prepared for climate change if they had had more land than if they felt higher risk about climate change and were consequently concerned. This could be an effect of our small sample size or, alternatively, be telling of a difference between Costa Rican specialty coffee growers and Tucker et al.'s (2010) sample of various coffee farmers in Guatemala, Honduras, and Mexico.

As one of the prior studies that primarily informed our own, Quiroga et al. (2014) pointed to the effect of education or level of experience by reporting that "experience and technical capacity are

relevant to the adaptive capacity although smallholders do not always show high concern and their expectations with regard to external support are very low." Although experience may be linked to adaptive capacity, in our survey sample, there was no significant relationship between years growing coffee and perceived preparedness for climate change. This could be attributed to the fact that the environment may have changed so dramatically over recent years that those who have been growing coffee for longer periods still land along a continuum of perceived preparedness. A similar phenomenon may also be at play when considering that there was no significant relationship between the level of education achieved by farmers or number or frequency of trainings (by any organization) they partook in and how prepared they felt for climate change.

While our survey did not show some of the correlational relationships expressed by Quiroga et al. (2014), there was support of their assertion about low expectations of external support. In fact, 82% of farmers fall into the "low expectations" group (those who feel support is "impossible," "improbable," or "neutral") feel that they do not have sufficient technical assistance from the government. At the same time, only 30% who are grouped the same way feel "low expectations" with regard to technical assistance from their buyers. This finding indicates that there may be more nuance to how farmers perceive access to technical assistance. A deeper understanding of expectations regarding technical assistance and from whom it should originate would be helpful than only referring to "external support." Looking more specifically at our finding about government technical assistance, a number of potential explanations emerge. On one hand, one might hypothesize that the government actually does not provide technical assistance to farmers. However, given the government support of ICAFE and the development of new varieties, we know that this is not true. On the other hand, this perception could be a result of ineffectiveness and/or low visibility of government assistance programs. Regardless, this has considerable implications for the future government involvement in climate adaptation, and it points toward the government institutions needing to take additional steps toward optimizing the effectiveness and visibility of their assistance programs.

In Frank et al.'s 2011 study, it was determined that farmers' view of their own social identities influences their perceived risk, and in fact, farmers are more likely to trust information sources that they view to be of higher status than their own social identities. However, in our own study, no significant link was found between the source of information and climate change concern or perceived preparedness. This might imply that the pattern Frank et al. discovered was not detectable among our population. However, this is not necessarily true. This result may also imply that the information sources that the survey covers, and which farmers have used in the past, are all of similar status in the eyes of specialty coffee farmers. In fact, specialty coffee farmers are generally of a high social status, given their prestigious product and potentially higher incomes. It is possible that the information sources they have used have all been perceived as being of lower social status than specialty coffee. This could be due to the nature and marketing of these information sources. If, for example, the sources are targeting commodity coffee producers, then if the specialty coffee producers see themselves as being of higher social status, they may not feel that the information provided is beneficial or relevant to them. If this were the case, it would suggest that information should strategically target each specific audience, a potentially useful recommendation for training program developers. This pattern could be clarified further if farmers would be interviewed about their perceived social status and their perception of the credibility of their information sources.

One consistent theme in the literature around coffee farmers' perceptions is that coffee farmers are more concerned about coffee price volatility than they are about climate change (Tucker et al., 2009; Eakin et al., 2006; Gay et al. 2006). In our own results, we found the opposite result. Whereas 76% of farmers were "quite" or "very" concerned about climate change, only 60% of specialty coffee farmers were "concerned" or "very concerned" about drops in coffee prices. As mentioned earlier,

specialty coffee is distinct from regular coffee because it operates outside the commodity market, and hence has less price volatility, and has a premium over the prevailing coffee prices. Our results corroborate what one may expect as a result of this: specialty coffee farmers are less concerned about drops in coffee prices (and, by proxy, volatility) than they are about climate change. This is likely because specialty coffee farmers have grown accustomed to setting their own prices based on the quality of coffee rather than being beholden to commodity market fluctuations. If this is indeed the case, then it also makes sense that they would be more concerned about the climate because the climate would affect the taste of their coffee, and hence their cupping score, and hence the eventual premium they are able to charge for their coffee in any given year.

Additional Insights - Sample Population Perceptions

Beyond existing literature, our survey and data analysis also uncovered original insights that do not appear to have been covered by existing literature about climate change adaptation in coffee.

An interesting picture emerges when analyzing the coffee varieties grown among specialty coffee farmers in Costa Rica. Although farms grow 21 different varieties of coffee, the varieties Catuaí Rojo, Caturra, and Geisha are the most prevalent and were each used by at least 50% of farmers. This is interesting for two reasons. On one hand, the wide variety of coffees grown highlights the need for distinction within the specialty coffee industry and may be indicative of farmer efforts to find niche flavors that will be appreciated among specialty coffee buyers. On the other hand, the wide prevalence of Catuaí and Caturra point to a significant success for government programs aimed at climate adaptation. As mentioned earlier, Catuaí and Caturra were the varieties developed and introduced by ICAFE to be more resilient to climate change than existing varieties. Hence, the wide prevalence of these varieties indicates that ICAFE's program to enhance adaptation among the coffee industry is showing significant success. Even more interesting, however, is the fact that neither of these varieties were associated with an increase in perceived ability to adapt to climate change. The disconnect between farmer willingness to adopt ICAFE's varietals, while not actually feeling more adapted should be investigated, as it could have implications on policy, and as understanding this could improve promotion, messaging and overall effectiveness of programs like that of ICAFE. Additionally, the perception among farmers that the government does not provide technical assistance should also be further investigated, given the success of this particular government intervention.

In a future climate change scenario, farmers showed significant hesitation to stop coffee production altogether, or substitute it completely with another income generating activity, although they were willing to complement it with other types of farming. This highlights the importance of coffee culture in Costa Rica, and it underscores the lengths to which farmers would go to preserve coffee production there. However, although farmers seem less likely to give up coffee for climate reasons, they are much more risk-averse when it comes to finances. As discussed earlier in the results, even the least risk-averse farmers would only be willing to sustain financial hardships for five years before stopping coffee production altogether, and most farmers would stop production within only one to three years of financial hardship. This underscores the importance of financing mechanisms for preserving the specialty coffee industry in the future. It is also interesting to consider that farmers are more concerned about finances than climate change in this particular scenario, but our research also uncovered that they are less concerned about price drops than climate change. This further highlights that commodity markets are less influential on specialty coffee farmers' revenues, and specialty coffee farmers derive their revenue and financing through other means. A further study to more granularly highlight these differences may be valuable in clarifying the particulars of this value chain.

Among farmers attempting to adapt, it is notable that farmers generally shy away from agrochemicals, which could be seen as a less sustainable adaptation method. They instead focus on techniques such as intercropping, renewal, incorporation of new varieties, better supplies, and agroforestry. This could be the case for a number of reasons. On one hand, farmers may simply prefer to stay away from chemical inputs into their soil out of personal preference. However, several other factors could also come into play, such as concern about sustainability and finances. As a next step, it may be worthwhile to investigate if farmer adaptation actions are influenced by the level of concern farmers have about sustainability. If this were to be the case, then future adaptation programs and interventions would have to be tailored around these farmer preferences to have a good chance at succeeding. Alternatively, cost could be a driver to reducing chemical inputs. Agrochemical inputs are expensive, and it may be the case, or even likely, that specialty coffee farmers would choose to adapt through means other than chemical inputs because of a desire to be cost effective in achieving their desired results. This is consistent with existing literature. According to Tucker et al. (2009), farmers during the coffee crisis used a reduction in agrochemical inputs as a mechanism to cut costs.

Additional Insights - Factors Associated with Concern for Climate Change

Those farmers who reported "always" keeping financial records showed a significantly higher concern for climate change than those who did not keep such records, or who kept records less frequently. Interestingly, no such statistically significant relationship was found among those who kept records of biophysical factors such as temperature, rain, or humidity (although a positive correlation did exist without statistical significance). This could be the case for a number of reasons. It's possible that the lack of statistical significance in the relationship between biophysical record-keeping and climate change concern is simply a case of the sample size being too small to identify a statistical relationship with high confidence. Additionally, the statistically significant relationship between financial record-keeping and climate change concern could indicate a higher propensity to notice gradual changes in climate among record-keepers, a higher propensity to think about future planning and challenges, or simply a certain personality type. While the exact reasons are difficult to ascertain without additional studies, it is still a notable relationship, and it should be taken into account when designing adaptation programs for farmers who do and do not keep financial records.

In the survey, those farmers who are more willing to invest as a climate change adaptation strategy also exhibit a significantly higher concern about climate change. This correlation makes sense, and there is evidence to suggest that investment for dealing with future impacts of climate change may be possible. Between the 2013-14 and 2014-15 harvest season, farmers faced an average increase in production costs of approximately 2% (ICAFE, 2014). In the same period, farmers in our survey reported receiving a much larger increase of 9.4% in price per fanega of coffee produced. This signals that specialty coffee farmers' margins could continue to increase if they are able to secure a higher price for their coffee and/or improve yields. With this trend, farmers may be more willing to invest in the future of their farms as an adaptation strategy to reduce vulnerability to climate change.

One of the most significant relationships demonstrated in this survey dealt with the age of farmers and their levels of concern about climate change. The group of farmers 26-45 years old had significantly higher levels of climate change concern than did the group of farmers who were 46-84 years old. This result suggests that certain other factors might impact the younger generation of farmers perceptions that older farmers may not be exposed to. These factors could range from social media to the contemporary social discourse on climate change to greater concern due to a longer prospective career of dealing with the effects of climate change before retirement. Exploring further

the motivations and differences in perceptions between age groups could be a worthwhile topic of investigation for future researchers.

Additional Insights - Factors Associated with Perceived Preparedness

Of the 21 varieties of coffee that are grown by farmers in the sample set, only the use of one (*Tipica*) showed any significant relationship with perception of preparedness. In the case of *Tipica*, farmers using that variety felt more prepared for climate change than those who did not. First, it is telling that it is rare for the use of certain coffee varieties to lead to any significantly different feelings of preparedness. This may indicate that decisions surrounding coffee variety choice are not made primarily on the basis of having a crop that is tolerant to a changing climate. The other big takeaway is the fact that even in the small sample size of this survey, *Tipica*, one of the oldest coffee varieties, stood out as having this significant relationship with preparedness perception. This begs the question: why? Further work should be done to assess whether this perception derives from intrinsic (e.g. personal experience with the variety) or extrinsic (e.g. marketing) factors. If the former is the driver, then it could make sense to focus on promoting this particular coffee variety to farmers who are particularly vulnerable to climate change.

Another significant relationship was presented between those who plan on increasing fertilizer use over the next two years and perception of preparedness. Those who do plan on increasing their use of fertilizer have a lower perceived preparedness than those who do not plan on increasing fertilizer use. This makes sense as a farmer who is concerned about climate change (76% of our survey population), but does not feel prepared to address it would plan to increase the inputs into the soil in order to maintain production and quality levels. This increase in fertilizer to deal with the effects of climate change unfortunately has negative effects on the more localized environment. Increased farming inputs means there are more inputs in the farm system overall, which can lead to runoff and increased levels in surrounding waterways, which could then lead to eutrophication. The systemic nature of the natural system means that an overcompensation to address one problem at one moment in time could lead immediately to another in the future. It is also worth noting that this emphasis on agrochemical inputs is very different from the specialty coffee population overall, which, as mentioned earlier, was found to emphasize adaptation methods that do not use agrochemical inputs. Given the increased perception of preparedness among the other specialty coffee farmers, it may be worth investigating if the other adaptation techniques are more effective than additional fertilizer use, and if so, methods to re-educate farmers who emphasize agrochemical inputs should be considered.

The most significant relationship uncovered by the survey of our sample population revealed that those farmers who introduce new varieties of coffee for the purpose of climate change preparation have significantly less perceived preparedness than those who do not. While this result is quite intuitive since those who do not feel prepared seem like they would be more likely to make choices that lead to preparedness, there is another more important implication from this result. The strength of this relationship offers a certain level of validity to this study in the sense that farmers were consistent in their responses. If this relationship had not shown to be significant, there would have been concern from the research team that individual farmers were responding with answers that varied in fundamentally inconsistent ways.

With regard to where farmers are selling most of their coffee, there was a significant difference in perceived preparedness between some of the buyer channels. Those farmers who sold directly to an international roaster have significantly higher feelings of preparedness than those who sell to either cooperatives or exporters. This finding has a number of potential implications. For one, this may be telling of the strength of business relationships between specialty farmers and international roasters. A

personal relationship and a solid contract may make farmers feel like there will be an income stream from this channel despite changes in climate in coming years. Alternatively, those farmers working with cooperatives or exporters may feel less prepared due to the conversations they are having with individuals who have a number of grower contacts regionally or even nationally. If farmers selling direct to international roasters feel a higher level of preparedness due to ignorance, there is opportunity there for more exposure to context to close that knowledge gap.

Another result that confirmed consistency among farmers more than it provided insight into unexpected relationships was that those farmers who did not feel like current quantities of rain are sufficient for coffee production felt significantly less prepared for climate change. It stands to reason that those who already are experiencing environmental impacts having negative effects on their coffee production would also be the ones who feel less prepared for future impacts (particularly if they link rain patterns to climate change). While perhaps not a surprising result, it may offer some insight into the way the conversation of climate change is framed to farmers. Rather than discussing climate change in terms such as the more abstract "rain levels," it may make sense to explicitly link climate change to effects such as the "sufficient rain for coffee production" (as it was demonstrated in this question).

The difference in perceived preparedness between yield groups was only significant between farmers with medium yields and those with low yields. In this case, the medium yield group had higher perceived preparedness than those in the low yield group. While those with medium yields also felt more prepared than those with high yields, that relationship was insignificant. The implication of this result may be that the farmers with low coffee yields per hectare are already feeling vulnerable to external factors and so may not feel they are prepared to handle additional changes to climate. If this is the case, it may be these farmers who should be the target of support programs in order to provide some sort of a safety net for the coffee producers who are most vulnerable to climate change.

Conclusion

This exploratory study has investigated a wide variety of factor pools including access to information, coffee management, financing, adaptation methods, perception of risk and vulnerability, biophysical factors, and farmer demographics in order to understand the perceived risk and perceived ability to adapt to climate change for specialty coffee producers in Costa Rica.

As a study with such a large scope and wide range of variables, it serves as a good starting point for future research to be done, to understand in more detail how these factor pools relate to each other. While this study has exposed some significant relationships between independent factors and concern about and perceived preparedness to climate change, the results were limited by the size of the survey sample. The sample that was comprised of 72% of all Cup of Excellence winners between 2011-2015 offered very telling insight into that particular population. However, in order for the results to be more translatable across other populations of specialty coffee growers in Costa Rica who have not applied for or been accepted into the Cup of Excellence competition, the survey should be administered across a larger sample population with a higher response rate. This additional data would offer increased granularity in our results in terms of being able to assess other significant relationships that may not have been apparent with so few respondents in different groups. That said, the benefit of a small sample size has been that the relationships exposed as significant in this sample suggest a level of strength in that relationship.

From the farmer perceptions and associated factors identified in this study, a few key findings and tentative recommendations have emerged:

- Coffee farmers are less concerned about price drops in coffee than they are climate change, which is contrary to the prevailing literature about the coffee industry, and highlights a distinct difference in the priorities of specialty coffee farmers as compared to other coffee farmers.
- Coffee farmers are more likely to quit coffee production due to finances than due to climate change. Hence, the development of financing mechanisms, paired with encouragement to invest in climate change adaptation, could be an impactful method to foster adaptation among specialty coffee farmers and ensure the survival of the specialty coffee industry long-term.
- Farmers with more land feel more prepared for climate change than those with less. To optimize effectiveness of climate adaptation programs, the government may want to consider targeting smallholders first, since they may be the least prepared of all.
- Literature and our findings consistently show that farmers do not believe that they receive sufficient external support for climate adaptation, especially from the government. Hence, not only should adaptation programs be developed, but they should also be aggressively marketed to specialty coffee farmers so that they know of and are able to take advantage of them.
- Farmers who sell directly to international roasters feel a much stronger sense of security, which is demonstrated through their increased perceived preparation for climate change. This has implications for the ideal value chain of coffee, indicating that the existing exporter and cooperative model may not be ideal for specialty coffee farmers as they face increased uncertainty in the face of climate change. It may be worthwhile to investigate this link further, and if confirmed, incentives for an industry shift should be considered.

While the above points should be considered, the main usefulness of this study is in its exploratory and introductory nature. Several studies could be developed as a follow up to this one, which could each look at one of the pools of factors to get an in-depth understanding of their relationship to perceived climate change preparedness and perceived adaptation ability. Another interesting follow-on study could be to develop a metric of actual climate change preparedness, analyze the distribution of preparedness among specialty coffee growers in Costa Rica, and then compare those results against reported (i.e. perceived) preparedness. Such a study could enable researchers to offer valuable insight into the connection (or disconnect) between perception and reality in this space. Certainly, the challenge therein would be developing a reliable metric that is useful in such an assessment. A suggested approach would be a longitudinal one, where researchers would observe practices over a long enough timeframe to understand the implications of farmer practices on the long-term viability of those farmers' coffee plantations.

Finally, a next step would be to apply the results of this study to both the development and improvement of current programs and policies relevant to specialty coffee growers in Costa Rica. While the group has provided some guidance on this in the above bullets, providing specific recommendations on improvements of those programs and policies falls outside the scope of the work done in this study. The study team feels it would be valuable for the readers of this report in positions to make changes to use these results as a useful lens in making decisions that influence the way the public- and private-sector stakeholders are engaging with each other on these important topics. We hope that many of the partners we have benefited from working with throughout the process will find the results telling of the state of the industry, and can be integrated strategically into the programs and policies that will guide the direction of specialty coffee in Costa Rica into the future.

References

Albertin, A., & Nair, P. K. (2004). Farmers' perspectives on the role of shade trees in coffee production systems: An assessment from the nicoya peninsula, costa rica. Human Ecology, 32(4), 443-463.

Davis, A. P., Gole, T. W., Baena, S., & Moat, J. (2012). The Impact of Climate Change on Indigenous Arabica Coffee (*Coffea arabica*): Predicting Future Trends and Identifying Priorities. *PLoS ONE*, *7*(11), e47981. doi:10.1371/journal.pone.0047981

Fischersworring, B., Schmidt, G., Linne, K., Line, G., Pringle, P., Baker, P., Lonsdale, K., Ochoa, M., Opitz, M., Walton, P., Ruiz, P., Grunze, S., Albrecht, S., Voigt, T., Fischersworring, V. Climate Change Adaptation in Coffee Production Guide. (2015). *Coffee & Climate*.

Food and Agriculture Organization of the United Nations (2003-2013). FAOSTAT database: Coffee, green bean production.

Frank, E., Eakin, H., & López-Carr, D. (2011). Social identity, perception and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. *Global Environmental Change Part A: Human & Policy Dimensions, 21*(1), 66-76.

Fellmann, T. (2012). The assessment of climate change related vulnerability in the agricultural sector: Reviewing conceptual frameworks. FAO/OECD Workshop Building Resilience for Adaptation to Climate Change in the Agriculture sector, 23-24 April 2012 Red Room, FAO. Available at: http://www.fao.org/fileadmin/templates/agphome/documents/faooecd/Frameworks.pdf

Gay, C., Estrada, F., Conde, C., Eakin, H. & Villers, L. (2006) Potential impacts of climate change on agriculture: a case study of coffee production in Veracruz, Mexico. Climatic Change 79, 259–288.

Haggar, J. & Shepp, K. (2011). Coffee and climate change, desk study: Impact of climate change in four pilot countries of the coffee and climate initiative. Available from: http://www.coffeeandclimate.org/reports_studies.html?file=tl_files/CoffeeAndClimate/Science/Haggar%20%26%20Schepp_Impacts%20of%20Climate%20Change%20Synthesis%20Report_ENG.pdf

Haggar, J., Barrios, M., Bolaños, M., Merlo, M., Moraga, P., Munguia, R., et al. (2011). Coffee agroecosystem performance under full sun, shade, conventional and organic management regimes in central america. Agroforestry Systems, 82(3), 285.

ICAFE. (2014). Costo de la Actividad Cafetalera. Available at: http://www.icafe.cr/sector-cafetalero/informacion-de-mercado/costo-de-la-actividad-cafetalera/

ICAFE. (2015). Inicio de cosecha de café en zonas de maduración temprana (región sur). Available at: http://www.icafe.cr/sector-cafetalero/informacion-de-mercado/costo-de-la-actividad-cafetalera/

ICAFE. (2016). Historia del Café de Costa Rica. Available at: http://www.icafe.cr/nuestro-cafe/historia/

ICAFE. (2016). Regiones Cafetaleras de Costa Rica. Available at: http://www.icafe.cr/nuestro-cafe/regiones-cafetaleras/

International Coffee Association. (2015). Ecology. Available at: http://www.ico.org/ecology.asp?section=About_Coffee

Intergovernmental Panel on Climate Change (IPCC). (2007) IPCC Fourth Assessment Report. Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability. Available at: www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-p-z.html

Maddison, D. (2007). The Perception of and Adaptation to Climate Change in Africa. *The World Bank*.

Mertz, O., Mbow, C., Reenberg, A. (2009). Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. *Environmental Management, 43,* 804–816.

Muschler, R. G. (2000). Arboles en Cafetales. Modulo de Ensenanza Agroforestal No. 5., Proyecto Agroforestal CATIE/GTZ, CATIE, Turrialba, Costa Rica.

Okonya, J., Syndikus, K., Kroschel, J. (2013). Farmers' Perceptions of and Coping Strategies to Climate Change: Evidence From Six Agro-Ecological Zones of Uganda. *Journal of Agricultural Science, 5(8)*, 252-263.

Quiroga, S., Suárez, C., & Solís, J. D. (2015). Exploring coffee farmers' awareness about climate change and water needs: Smallholders' perceptions of adaptive capacity. *Environmental Science & Policy, 45*, 53-66.

Specialty Coffee Association of America. (2015). Coffee Terms and Definitions. Available at: http://www.scaaevent.org/PDF/Press%20Kit/2015/SCAA-Media-Kit_2015-Coffee-Terms-and-Definitions.pdf

Specialty Coffee Association of America. (2009) SCAA Protocols: Grading Green Coffee. Available at: http://www.scaa.org/PDF/resources/grading-green-coffee.pdf

Specialty Coffee Association of America. Specialty Coffee Price Index. Available at: http://www.scaa.org/?page=resources&d=specialty-coffee-price-index

Specialty Coffee Association of America.What is Specialty Coffee? Available at: http://www.scaa.org/?page=resources&d=what-is-specialty-coffee

Staver, C., Guharay, F., Monterroso, D., & Muschler, R. G. (2001). Designing pest-suppressive multistrata perennial crop systems: shade-grown coffee in Central America. *Agroforestry Systems*, *53*(2), 151-170.

Tucker, C. M., Eakin, H., & Castellanos, E. J. (2010). Perceptions of risk and adaptation: Coffee producers, market shocks, and extreme weather in central america and mexico. *Global Environmental Change Part A: Human & Policy Dimensions, 20*(1), 23-32.

USDA National Agroforestry Center. (2016). Agroforestry Practices. Available at: http://nac.unl.edu/practices/index.htm

Vellucci, Michael. (2015). The Continued Rise of Premium Coffee in the U.S.: Will It De-Commoditize Coffee?. *Brown Brothers Harriman Commodity Markets Update.* Available at: https://www.bbh.com/en-us/insights/the-continued-rise-of-premium-coffee-in-the-u-s---will-it-de-commoditize-coffee-/10966

Villanueva, C., Sepulveda, C., Ibrahim, M. (2011). Manejo agroecológico como ruta para lograr la sostenibilidad de fincas con café y ganadería. CATIE.

World Bank Global Facility for Disaster Reduction and Recovery. (2011). Vulnerability, Risk Reduction, and Adaptation to Climate Change: Costa Rica. Available at: http://countryadaptationprofiles.gfdrr.org

Appendix A. Survey Translated from Spanish to English

Q#	Spanish Survey Questions	English Survey Question Translation
7	¿Cuál es el área total de su terreno? (Indicar en hectáreas o manzanas)	What is the area of your plantation (in hectares or manzanas)?
8	¿Cuál es el área total de café en producción? (Indicar en hectáreas o manzanas)	What is the total area of your plantation dedicated to growing coffee?
9	El terreno es:'	The property is owned, rented...
10	¿Tiene beneficio en su terreno?'	Do you own a coffee processing facility?
12	¿Hace cuántos años está produciendo el café? (Número de años)'	How long have you been growing coffee (years)?
13	¿Hace cuántas generaciones su familia produce café? (Número de generaciones)'	How many generations has your family produced coffee?
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Catuaí Rojo'	What varieties of coffee to you grow? Give percentage of each type. Catuaí Rojo
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Catuaí Amarillo '	Catuaí Amarillo
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Caturra '	Caturra
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Obatá'	Obatá
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Borbon'	Borbon
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Villasarchi'	Villasarchi
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Catimor'	Catimor
14	¿Qué variedad o variedades de café produce en su finca? En qué proporciones? DEBE SUMAR A 100%.-Otros (Indica en la siguiente pregunta)'	Other

16	¿Cúales de las siguientes prácticas ya están incorporadas en su plantación? PUEDE SELECIONAR VARI...	Which of the following practices are already incorporated in your coffee plantation?
17	¿Por qué incorpora nuevas variedades de café? PUEDE SELECIONAR VARIAS RESPUESTAS.	For which reason do you incorporate new coffee varieties?
18	¿ En los próximos dos años, planea incorporar una de las siguientes prácticas en su plantación co...	In the next two years, do you plan on incorporating any of the following practices in your coffee platation?
19	¿Qué tipos de árboles utiliza para el manejo de sombra?	Which types of trees do you use for shade management?
20	¿Cúal es la densidad de árboles de sombra por hectárea?'	What is the density of shade trees per hectare?
21	¿Qué altura de sombra dan la mayoría de los árboles?'	What is the average height of shade of the trees?
22	¿Qué certificaciones tiene usted para su producción del café? PUEDE SELECIONAR VARIAS RESPUESTAS	Which certifications do you have for your coffee production? / For which certifications is your coffee plantation certified?
23	¿A quién vende usted el café principalmente? SELECIONA UNA RESPUESTA. '	Who do you sell most of your coffee to?
24	¿En cuáles programas de capacitación participa? PUEDE SELECIONAR VARIAS RESPUESTAS.	In which training programs do you participate in?
25	¿Cuántas veces al año participa usted en esos programas de capacitación?'	How many times per year have you participated in these training workshops?
26	¿Cuántas veces al año hace análisis de suelo?'	How many times per year do you conduct soil analysis?
27	¿Cuántas veces al año hace la fertilización con base al análisis del suelo?'	How many times per year do you fertilize based on soil analysis?
29	¿La finca reutiliza las siguientes materiales?-La pulpa de café?'	Does the farm reuse the following materials? Coffee Pulp
29	¿La finca reutiliza las siguientes materiales?-Materia orgánica vegetal (hojarasca, podas, etc.)?'	Organic material (leaves, prunings, etc.)
29	¿La finca reutiliza las siguientes materiales?-Envases de agroquímicos?'	Agrochemical containers/bottles
29	¿La finca reutiliza las siguientes materiales?-Aguas mieles y lixiviados de la finca?'	Honey water and leachates

29	¿La finca reutiliza las siguientes materiales?-Papel y cartón de la finca?'	Paper and cardboard
30	¿La finca manda las siguentes materiales a ser reciclados?-La pulpa de café?'	Does the farm send the following materials to be recycled? Coffee Pulp
30	¿La finca manda las siguentes materiales a ser reciclados?-Materia orgánica vegetal (hojarasca, podas, etc.)?'	Organic material (leaves, prunings, etc.)
30	¿La finca manda las siguentes materiales a ser reciclados?-Envases de agroquímicos?'	Agrochemical containers/bottles
30	¿La finca manda las siguentes materiales a ser reciclados?-Aguas mieles y lixiviados de la finca?'	Honey water and leachates
30	¿La finca manda las siguentes materiales a ser reciclados?-Papel y cartón de la finca?'	Paper and cardboard
32	¿Está siendo rentable la producción del café para usted?'	Is coffee continuing to be profitable for you?
33	¿Tiene usted otras fuentes de ingresos que no sean del café?'	Do you have other sources of income that are not coffee-related?
34	¿Si es que sí, cuáles son? PUEDE SELECIONAR VARIAS RESPUESTAS.'	If you do have non-coffee related income, what is the source of income? (Choose all that are applicable)
35	¿Qué porcentaje de su ingreso total viene de la producción de café?'	What percentage of your total income comes from coffee production?
36	Su mano de obra se compone de:'	Your labor is composed of:
37	¿Cuál es el costo anual de mano de obra para la recolecta por cajuela? (Colones)'	What is the yearly cost of labor for harvesting per cajuela (trunk)?
38	¿Cuál es el costo anual de mano de obra para el manejo o mantenimiento del cafetal? (Colones)'	What is the yearly cost of labor for management and maintenance of the coffee plantation?
39	¿Cuál es el costo anual de insumos por hectárea (por ejemplo fertilizantes, pesticidas, fungicida...'	What is the yearly cost of inputs per hectare (e.g. fertilizer, pesticide, fungicide)?
40	¿Cuál fue la producción total en fanegas de la plantación en la última cosecha de 2014-2015?'	What was your total production in fanegas for the most recent harvest, 2014-2015?
41	¿Cuál fue el precio promedio que recibió por fanega en 2014-2015? (Colones)'	What was your average price that you received in fanegas in 2014-2015?
42	¿Cuál fue la producción total en fanegas de la plantación en 2013-2014?'	What was your total production in fanegas for the 2013-2014 harvest?

43	¿Cuál fue el precio promedio que recibió por fanega en 2013-2014? (Colones)'	What was your average price that you received in fanegas in 2013-2014?
44	¿Hasta qué punto está usted preocupado de que baje mucho el precio del café?'	How worried are you that the price of coffee will fall considerably?
45	¿Se lleva una contabilidad en la finca?'	Do you keep financial records of the plantation?
47	¿Cree que tiene acceso a los bancos u otras instituciones financieras cuando necesita crédito par...'	Do you believe you have support to credit from banks and other financial institutions when you need it?
48	¿Ha necesitado un crédito en los últimos cinco años para la producción de café?'	Have you needed credit in the last five years to help with coffee production?
49	¿Ha solicitado un crédito en los últimos cinco años para la producción de café?'	Did you request credit in the last five years to help with coffee production?
50	¿Ha recibido un crédito en los últimos cinco años para la producción de café?'	Did you receive credit in the last five years to help with coffee production?
51	¿Cuáles de las siguientes instituciones recibe usted financiamiento? PUEDE SELECIONAR VARIAS RESP..	From which of the following institutions do you receive financing/financial support?
52	¿De la inversión total en su plantación (para la asistencia, mano de obra, maquinaria, etc.) que...-De fondos personales'	What sources do you uses to invest in your farm: Personal savings?
52	¿De la inversión total en su plantación (para la asistencia, mano de obra, maquinaria, etc.) que...-De crédito'	Credit
53	¿Piensa solicitar un crédito en el siguiente año?'	Are you thinking of requesting credit next year?
55	En los últimos cinco años usted se siente que su producción ha:'	In the last five years, do you believe your coffee production has...
56	¿Porque? PUEDE SELECIONAR VARIAS RESPUESTAS.	What is the cause of this?
57	¿Hasta qué punto han sido un problema los eventos imprevistos del clima en la producción del café...'	To what degree have unexpected climate events affected your coffee production?
58	¿Cuánto ha afectado la roya su plantación?'	How much has coffee rust affected your plantation? / your harvest? (but we did say “plantation” here)
59	¿Cuánto ha afectado ojo de gallo su plantación?'	How much has ojo de gallo affected your plantation? / your harvest?
60	¿Cree que la cantidad de lluvia actual es suficiente para la producción del café?'	Do you believe that the current quantity of rain is sufficient for coffee production?

62	¿Que tan a menudo lee o escucha sobre el clima (temperatura o lluvia) en su región?'	How often do you hear or read about climate in your region (temperature or rain)?
63	¿Cúales fuentes de información del clima (temperatura o lluvia) que lee o vea más? PUEDE SELECIO...	What are the sources of information about climate (temperature and rain) do you read or see most?
64	¿Que tan a menudo lee o escucha sobre los efectos del cambio climático?'	How often do you hear or read about climate change?
65	¿Cómo se informa sobre el cambio climático? PUEDE SELECIONAR VARIAS RESPUESTAS.	How do you inform yourself about climate change?
66	¿Apunta usted en algún lugar los registros de...-Temperatura?'	Do you note/log temperature?
66	¿Apunta usted en algún lugar los registros de...-Lluvia?'	Do you note/log rain level?
66	¿Apunta usted en algún lugar los registros de...-Humedad?'	Do you note/log humidity?
67	¿La información sobre el estado del clima le hace sentir más preparado para enfrentar el cambio c...'	Does information about the state of climate make your feel more prepared to face climate change?
68	¿Le parece que han habido cambios fuera de lo normal en el clima en los últimos cinco años?'	Do you see unusual changes to climate in the last five years?
69	¿Usted se siente preparado para el cambio climático?'	Do you feel prepared for climate change?
71	¿Si no pudiera producir café, que haría? SELECIONA UNA RESPUESTA.'	If you could no longer produce coffee, what would you do?
72	¿Qué probabilidad existe de que usted complemente la actividad cafetalera con una de las activida...'	How probable is it that you complement your coffee production with one or more of the following activities?
73	¿Qué probabilidad existe de que usted sustituya la actividad cafetalera con una de las actividade...'	How probable is it that you substitute your coffee production with one or more of the following activities?
74	¿Cuántos años tendría que tener pérdidas el café para que usted ya no quiera producir café?'	How many years would you need to have profit losses from coffee production to decide to terminate production?
76	¿Hasta qué punto siente que tendrá asistencia técnica del gobierno para enfrentar el cambio climático...'	To what degree do you feel that you have technical assistance from the government to face climate change?
77	¿Hasta qué punto siente que tendrá asistencia técnica de los compradores (cooperativas, exportado...'	To what degree do you feel that you have technical assistance from your buyers

		(cooperatives and exporters) to face climate change?
78	¿Cuál organización cree que debería brindar asistencia técnica a los productores de café principa...'	From which organization do you believe that technical assistance should be given to coffee producers?
80	¿Cree en el cambio climático?'	Do you believe in climate change? / Do you believe that climate change exists?
81	¿Qué tan preocupado/a está usted sobre el cambio climático?'	How worried are you about climate change?
82	¿Piensa que el cambio climático afectará…-Patrones de la lluvia?'	Do you think that climate change will affect….. Rain patterns
82	¿Piensa que el cambio climático afectará…-El lavado del suelo/erosión?'	Soil washing/soil remediation or erosion
82	¿Piensa que el cambio climático afectará…-La presencia de la roya?'	Presence of rust disease
82	¿Piensa que el cambio climático afectará…-La presencia de otras enfermedades?'	Presence of other diseases
82	¿Piensa que el cambio climático afectará…-La calidad de la cosecha?'	Quality of the harvest
82	¿Piensa que el cambio climático afectará…-La producción total de la plantación?'	The quantity of coffee produced on the plantation
83	¿Está interesado/a en invertir en su finca para prepararse para el cambio climático?'	Are you interested in investing in your plantation as a means to prepare yourself for climate change? / Would you like to invest in your plantation as a means to prepare yourself for climate change?
84	¿Piensa que invertir en su finca le ayudaría a prepararse para el cambio climático?'	Do you believe that investing in your plantation will allow you to be better prepared for climate change?
85	¿Si tuviera financiamiento asegurado invertiría en alguna de las siguientes estrategias para prep...	If your financing was covered, would you invest in any of the following strategies to better prepare yourself for climate change
86	¿Qué situación tendría que pasar para hacerle invertir más en proyectos para enfrentar el cambio...	What circumstances would have to be happen for you to invest more in actions to face climate change?
88	¿Cúal es su nivel más alto de educación? '	What is your highest level of education?
89	¿Cúal es su edad?'	What is your age?
90	¿Cúal es su estado civil?'	What is your marital status?

91	¿Cuántos hijos tiene?'	Do you have children, and if so, how many do you have?
92	¿Cuántos hijos cuentan con su apoyo económico?'	How many children do you currently support financially?
93	Género(s) (Observar, no preguntar)'	Gender (observe)

Appendix B. Selected ANOVA results

Concern About Climate Change	n	Mean	SD	F	p-value	η^2	Tukey's HSD
Frequency of financial record-keeping:				5.921	0.021*	5.547	
- Always	9	3.44	1.24				
- Sometimes or Never	25	4.36	0.86				
Willing to invest for climate change?				5.938	0.021*	5.561	
- Yes	32	4.22	0.97				
- No	2	2.50	0.71				
Level of concern about coffee price drops				0.201	0.657	0.222	
- Low concern	14	4.21	1.05				
- High concern	20	4.05	1.05				
Change in yield				2.480	0.125	2.555	
- Positive or no change	13	3.77	1.17				
- Negative	21	4.33	0.91				
Age				8.237	0.007**	7.456	
- 26-45 years old	12	4.75	0.45				
- 46- 84 years old	21	3.76	1.14				
Area of land held in hectares				0.734	0.398	0.797	
1-10 ha	13	3.92	1.11				
More than 10 ha	21	4.23	0.99				
Education				1.193	0.317	1.270	
- Completed primary school but no or incomplete high school	8	4.38	0.51				
- Completed high school but no or incomplete university studies	11	3.73	1.19				
- Completed university studies and/or graduate degrees	15	4.27	1.04				
Perceived Preparedness to Climate Change	n	Mean	SD	F	p-value	η^2	Tukey's HSD

What varieties of coffee do you produce? - Tipica				4.338	0.045*	6.559	
- Yes	9	3.56	1.01				
- No	25	2.56	1.29				
Plan to increase fertilizer use over next two years?				7.261	0.011*	10.161	
- Yes	12	2.08	1.24				
- No	22	3.23	1.15				
Introduce new varieties for climate change preparation?				13.658	0.001**	16.435	
- Yes	11	1.82	0.40				
- No	23	3.30	1.29				
Sell most coffee to:				3.909	0.018*	5.147	1, 2 < 4
- 1. Cooperative	4	2.00	0.82				
- 2. Exporter	24	2.75	1.26				
- 3. Direct to local roaster	2	2.00	0.00				
- 4. Direct to international roaster	4	4.50	0.58				
Current quantity of rain is:				5.714	0.023*	8.324	
- Insufficient	15	2.27	0.80				
- Sufficient	19	3.26	1.45				
Level of climate change concern:				3.054	0.090	4.787	
- Low	8	3.50	1.41				
- High	26	2.61	1.20				
Yield				4.942	0.014*	6.642	1 < 2
- 1.Low	13	2.31	1.03				
- 2. Medium	12	3.67	1.37				
- 3. High	9	2.44	1.01				
Area of land held in hectares				0.212	0.398	0.362	
1-10 ha	13	2.69	1.38				
More than 10 ha	21	2.90	1.26				
Education				0.200	0.820	0.349	
- Completed primary school but no or incomplete high school	8	3.00	1.41				
- Completed high school but no or	11	2.90	1.37				

incomplete university studies				
- Completed university studies and/or graduate degrees	12	2.67	1.23	

NOTE: One asterisk (*) represents significance at the 95% level and two asterisks (**) indicates significance at the 99% level.

Appendix C. Survey questions and results: Continuous data

Factor	Survey question	Mean	Median	SD	Min	Max
Access to Information	How many times per year have you participated in training workshops?	3.13	3.00	2.24	0.00	12.00
Adaptation Methods	How many years would you need to have profit losses from coffee production to decide to terminate production?	2.78	2.00	2.87	0.00	15.00
Coffee Management	Give percentage of each type of coffee you grow.					
	Catuaí Rojo	36.32	30.00	32.13	0.00	90.00
	Catuaí Amarillo	2.06	0.00	6.14	0.00	30.00
	Caturra	30.15	30.00	27.6	0.00	90.00
	Obatá	0.09	0.00	0.51	0.00	3.00
	Borbon	0.38	0.00	1.35	0.00	6.00
	Villasarchi	16.47	0.00	27.3	0.00	80.00
	Catimor	2.26	0.00	12.86	0.00	75.00
	Others	13.15	10.00	8.85	0.00	35.00
	How many times per year do you conduct soil analysis?	1.12	1	0.54	0	3
	How many times per year do you fertilize based on soil analysis?	3.21	3	0.48	3	5
	Does the farm reuse the following materials?					
Farmer Demographics	What is the area of your plantation (hectares)?	38.36	19.50	54.83	1.05	250.00
	What is the total area of your plantation dedicated to growing coffee?	30.36	14.50	46.62	1.05	250.00
	The property is…?					
	How long have you been growing coffee (years)?	35.44	35.50	18.33	8.00	70.00
	How many generations has your family produced coffee?	3.00	3.00	1.30	0.00	6.00

	What is the yearly cost (CRC) of labor for harvesting per cajuela? [2]	1364.71	1300.00	300.39	1000.00	2000.00
	What was your total production in fanegas for the most recent harvest, 2014-2015?[3]	887.85	380.00	1298.28	20.00	7000.00
	What was your average price (CRC) that you received in fanegas in 2014-2015?	131,259	125,000	33,395	80,000	210,000
	What was your total production in fanegas for the 2013-2014 harvest?	966.76	475.00	1389.68	15.00	7261.00
	What was your average price (CRC) that you received in fanegas in 2013-2014?	124,913	120,000	38,428	60,000	200,000
	What is your age?	48.66	49.00	11.75	26.00	84.00
	Do you have children, and if so, how many do you have?	2.41	2.50	1.67	0.00	8.00
	How many children do you currently support financially?	1.56	2.00	1.35	0.00	4.00
Financing	What percentage of total investment in the farm comes from personal savings versus credit?	68.68	80.00	33.40	0.00	100.00

[2] In Costa Rica, a cajuela measures approximately 12.9 kg of harvested cherries.
[3] A fanega measures approximately 258 kg of harvested cherries.

Appendix D. Survey questions and results: Categorical data

Factor	Survey question	Option	Percent
Access to Information	In which training programs do you participate?		
		ICAFE	76%
		Buyer	56%
		Co-op	24%
		Other	24%
		University	18%
		None	12%
	How often do you hear or read about climate (temperature and rain) in your region?		
		Never	0%
		A few times	9%
		Sometimes	3%
		A lot	21%
		Always	68%
	What are the sources of information about climate (temperature and rain) do you read or see most?		
		Television	79%
		Radio	26%
		Internet	76%
		Presentations	41%
		University	9%
		Other	12%
	How often do you hear or read about climate change?		
		Never	0%
		A few times	9%
		Sometimes	12%
		A lot	32%
		Always	47%
	How do you inform yourself about climate change?		
		Television	82%
		Radio	24%
		Internet	76%

		Presentations	29%
		University	12%
		Other	9%
Adaptation Methods	If you could no longer produce coffee, what would you do?		
		Other agricultural production	21%
		Cattle for beef or dairy production	12%
		Poultry production	9%
		Employment outside agriculture sector	18%
		Sale/rent land	26%
		Other	15%
	How probable is it that you *complement* your coffee production with one or more of the stated activities?		
		Impossible	3%
		Unlikely	44%
		Neutral	3%
		Probable	15%
		Very probable	35%
	How probable is it that you *substitute* your coffee production with one or more of the stated activities?		
		Impossible	59%
		Unlikely	24%
		Neutral	3%
		Probable	3%
		Very probable	12%
Biophysical Factors	How much has coffee rust affected your plantation?		
		Not at all	21%
		Very little	44%
		A few times	3%
		Quite a bit	21%
		Very much	12%
	How much has ojo de gallo affected your plantation?		
		Not at all	35%

		Very little	56%
		A few times	3%
		Quite a bit	6%
		Always	0%
	In the last five years, have you seen unusual climate changes?		
		Not at all	0%
		Very little	0%
		Neutral	3%
		Very much	29%
		Absolutely	68%
Climate Change Concern	How worried are you about climate change?		
		Not at all	0%
		A little	12%
		Neutral	12%
		Quite a bit	29%
		Absolutely	47%
Climate Change Preparedness	Do you feel prepared for climate change?		
		Not at all	12%
		A little	44%
		Neutral	6%
		Quite a bit	26%
		Absolutely	12%
Coffee Management	Which of the following practices are already incorporated in your coffee plantation?		
		Shade trees	94%
		Intercropping	50%
		Irrigation	12%
		Renewal	100%
		Incorporation of organic matter	94%
		Incorporation of new varieties of coffee	94%
	For which reason do you incorporate new coffee varieties?		
		Improve quality	88%
		Resist rust disease	44%

	Reduce amount of inputs	21%
	By recommendation	41%
	Preparation for climate change	32%
	Improve yield	56%
	Other	3%
In the next two years, do you plan on incorporating any of the following practices in your coffee plantation?		
	Shade trees	82%
	Intercropping	44%
	Irrigation	18%
	Renewal	94%
	Incorporation of organic matter	88%
	Incorporation of new varieties of coffee	91%
	Use better inputs	91%
	Increase agrochemicals	9%
	Decrease agrochemicals	79%
	Increase fertilizer use	35%
	Other	3%
Which types of trees do you use for shade management? (Top 6)		
	Poro	82%
	Guaba	38%
	Musas	26%
	Cedro	15%
	Aguacate	15%
	Eucaplito	15%
What is the density of shade trees per hectare?		
	1-35	31%
	36-70	19%
	71-100	16%
	100+	34%
What is the average height of shade of the trees (meters)?		
	<2	3%
	2-3	41%

	4-5	38%
	6+	19%
Which coffee certifications do you have?		
	Rainforest Alliance	26%
	UTZ	3%
	Organic	3%
	Fair Trade	0%
	Café Practices – Starbucks	24%
	Bird Friendly	0%
	Nespresso AAA	9%
	Others	12%
	None	56%
Who do you sell most of your coffee to?		
	Cooperative	12%
	Exporter	71%
	National roaster	6%
	International roaster	12%
Does the farm reuse the following materials?		
	Coffee pulp	91%
	Organic material (leaf litter, prunings, etc.)	100%
	Agrochemical bags	6%
	Waste water	77%
	Paper and cardboard	6%
Does the farm send the following materials to be recycled?		
	Coffee pulp	0%
	Organic material (leaf litter, prunings, etc.)	0%
	Agrochemical bags	85%
	Waste water	3%
	Paper and cardboard	35%
Your labor is composed of:		
	Temporary employees	24%
	Permanent employees	3%
	Both temporary and permanent	62%

		Relatives	12%
	Do you keep an accounting system?		
		Yes, always	74%
		Yes, sometimes	12%
		No	15%
	Do you keep the following records…?		
		Temperature	24%
		Rain	29%
		Humidity	21%
Farmer Demographics	Canton?		
		Naranjo	32%
		Dota	21%
		Tarrazú	9%
		Zarcero	9%
		Grecia	3%
		León Cortez	3%
		San Ramon	3%
		San Isidro	3%
		Tres Ríos	3%
		Poas	3%
		Acosta	3%
		Perez Zeledon	3%
	The property is…?		
		Owned	91%
		Rented	0%
		Joint association	6%
		Other	3%
	Do you own a coffee processing facility? (Yes)		76%
	Do you have other sources of income that are not coffee-related? (Yes)		71%
	If you do have non-coffee related income, what is the source of income? (Choose all that are applicable)		
		Other agricultural production	29%
		Cattle for beef or dairy production	15%
		Poultry production	3%

	Employment outside agriculture sector	18%
	Sell/rent land	0%
	Other	6%
What percentage of your total income comes from coffee production?		
	<20%	6%
	20-40%	6%
	40-60%	12%
	60-80%	18%
	80-100%	59%
What is the yearly cost (CRC) of labor for management and maintenance of the coffee plantation?		
	0-300,000	9%
	300,000-500,000	26%
	500,000+	59%
What is the yearly cost (CRC) of inputs per hectare (e.g. fertilizer, pesticide, fungicide)?		
	0-300,000	0%
	300,000-500,000	35%
	500,000+	59%
What is your highest level of education?		
	Primary school complete	24%
	Secondary school incomplete	12%
	Secondary complete	15%
	University incomplete	6%
	University complete	35%
	Postgraduate studies	9%
What is your marital status?		
	Single	6%
	Married	85%
	Divorced	6%
	Widowed	0%
Gender (observe)		
	Male	91%
	Female	9%

Financing	Do you believe you have support to credit from banks and other financial institutions when you need it?		
		Not at all	12%
		Little	15%
		Neutral	6%
		Quite a bit	21%
		Very much	47%
	Have you needed credit in the last five years to help with coffee production? (Yes)		77%
	Did you request credit in the last five years to help with coffee production? (Yes)		77%
	Did you receive credit in the last five years to help with coffee production? (Yes)		71%
	From which of the following institutions do you receive financing/financial support?		
		Banks	71%
		Co-ops	9%
		Micro financing institutions	3%
		Buyers	12%
		Lenders	0%
		Government	3%
		None	9%
		Other	3%
	Are you thinking of requesting credit next year? (Yes)		
		Not at all	29%
		Unlikely	24%
		Neutral	0%
		Probably	12%
		Absolutely	35%
	Are you interested in investing in your plantation as a means to prepare yourself for climate change?		
		Not at all	6%
		A little	0%
		Neutral	0%

		Interested	32%
		Very interested	62%
	If your financing was covered, would you invest in any of the following strategies to better prepare yourself for climate change?		
		Shade trees	79%
		Intercropping	50%
		Irrigation	50%
		Renewal	91%
		Incorporation of organic matter	85%
		Incorporation of new varieties of coffee	91%
		Use better inputs	85%
		Increase agrochemicals	3%
		Decrease agrochemicals	71%
		Increase fertilizer use	26%
		Other	9%
Perception of Risk/Vulnerability	How worried are you about climate change?		
		Not at all	12%
		Little	26%
		Neutral	3%
		Fairly worried	26%
		Very worried	32%
	In the last five years, do you believe your coffee production has…?		
		Decreased	29%
		Increased	29%
		Stayed the same	41%
		What is the cause of this?	
		Management	53%
		Climate	26%
		Renovation	59%
		Disease	24%
		Other	21%
	To what degree have unexpected climate events affected your coffee production?		

	Never	6%
	Few times	9%
	Sometimes	18%
	Often	26%
	All the time	41%
Do you believe that the current quantity of rain is sufficient for coffee production?		
	Not at all	9%
	Not much	26%
	Neutral	9%
	More or less	32%
	Absolutely	24%
Is coffee continuing to be profitable for you?		
	Not at all	0%
	Very little	21%
	Neutral	9%
	Profitable	41%
	Very profitable	29%
To what degree do you feel that you have technical assistance from the government to face climate change?		
	Impossible	36%
	Unlikely	42%
	Neutral	3%
	Probable	12%
	Very probable	6%
To what degree do you feel that you have technical assistance from your buyers (cooperatives and exporters) to face climate change?		
	Impossible	15%
	Unlikely	12%
	Neutral	3%
	Probable	41%
	Very probable	29%
Which organization do you believe should give technical assistance to coffee producers?		

	MAG	32%
	ICAFE	53%
	Co-ops	0%
	Other	15%
Do you think that climate change will affect…? (Percentage worried or very worried)		
	Rain patterns	91%
	Erosion	76%
	Prevalence of rust disease	85%
	Prevalence of other diseases	85%
	Quality of yield	88%
	Total production	91%