Title:	Impact of Protected Areas on Poverty, Extreme Poverty and Inequality in Nepal
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Impact of Protected Areas on Poverty, Extreme Poverty and Inequality in Nepal

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Abstract:

Protected areas (PAs) are key for biodiversity conservation, but there are concerns that they can exacerbate poverty or unequal access to potential benefits, such as those arising from tourism. We assess how Nepalese PAs influence poverty, extreme poverty and inequality using a multidimensional poverty index, and a quasi-experimental design that controls for potential confounding factors in non-random treatment allocation. We specifically investigate

the role of tourism in contributing to PA impacts. Nepali PAs reduced overall poverty and extreme poverty, and crucially, did not exacerbate inequality. Benefits occurred in lowland and highland regions, and were often greater when a larger proportion of the area was protected. Spread of benefits to nearby areas outside PAs was negligible. Furthermore, older PAs performed better than more recently established ones, suggesting the existence of time-lags. Although tourism was a key driver of poverty alleviation, PAs also reduced extreme poverty in areas with fewer tourists.

Introduction:

Protected areas (PAs) are key conservation strategies but also have socioeconomic impacts on people living in and around them (Brockington and Wilkie 2015). PAs limiting anthropogenic activities can harm local economic development (Brockington and Wilkie 2015), but can also safeguard ecosystem services that local communities depend on, and generate additional sources of income, for example through tourism (Ferraro and Hanauer 2015). Some studies find that PAs are linked to high poverty levels (de Sherbinin 2008; Fisher and Christopher 2007), but such associations can be confounded because PAs are often located in areas with limited development potential (Joppa and Pfaff 2009). There are, therefore, growing efforts to assess PA outcomes using techniques that control for this non-random allocation of PAs. Such studies provide increasing evidence that PAs can reduce poverty, albeit with much heterogeneity in effect sizes (Andam *et al.* 2010; Hanauer and Canavire-Bacarreza 2015; Miranda *et al.* 2014; Sims and Alix-Garcia 2016; Yergeau *et al.* 2017).

Despite this progress, several topics remain understudied. First, PA assessments have focused primarily on mean poverty outcomes across entire communities (but see Sims 2010). However, PA's financial benefits may suffer from elite capture (Agrawal and Gupta 2005), leading to greater inequalities. Assessing the mechanisms through which PAs influence poverty is essential. PAs may increase tourism opportunities leading to improved local income and employment (Walpole and Leader-Williams 2001). Assessing tourism impacts across large spatial extents is often limited by data availability, and assessments have predominantly used binary proxies (presence or absence of tourism infrastructure, Ferraro *et al.* 2011). Yet to gain a better understanding of how tourism contributes to local poverty alleviation, it is important to move beyond binary assessments of tourism and consider variation in the intensity of tourism in PAs (Robalino and Villalobos 2015). Finally, there is substantial spatial variation in the proportion of land surrounding a community that is protected, the duration that it has been protected for, and livelihood opportunities that are constrained by a series of factors, such as slope and elevation that influence agricultural suitability (Gentle and Maraseni 2012). These factors can influence the magnitude, and possibly even the direction of PA effects on poverty.

Here, we assess how PAs in Nepal influence multiple measures of poverty. We combine national census derived poverty estimates for 2001 and 2011, and use statistical matching to construct a counterfactual group. We build upon previous research by i) quantifying how PA status influences measures of extreme poverty and inequality, in addition to overall measures of poverty, ii) using tourism indicators to assess if tourism is an important mechanism through which PAs influence poverty, and iii) testing whether effects of PAs on poverty are moderated by variations in the amount of protected land, time since establishment, and elevation.

Nepal provides a good case study to assess the effects of protected areas on multiple poverty outcomes. It is one of the poorest Asian countries (Alkire and Santos 2011) and has an extensive PA network, covering 20% of the country's land surface. Nepalese PA policies were first characterized by a strict "fences and fines" approach (Heinen and Shrestha 2006) that denied local people's user rights. However, during the nineties several important pieces of legislation were passed to promote social welfare including redistribution initiatives to minimize inequality by spending 30-50% of PA revenues on community development (Spiteri and Nepal 2008).

Methods:

1. Data:

We compiled a high spatial-resolution, national-level dataset using 3,845 of Nepal's 3,973 Village Development Committees (VDCs), the sub-district level administrative unit, as our unit of analysis.

i) Poverty metrics

We use household health, education and living standards data from the Nepali national censuses of 2001 and 2011 to develop three multi-dimensional poverty (MDP) measures based on the multi-dimensional poverty index developed by Alkire and Santos (2011): poverty (MDP>0.33 - following Alkire and Santos' (2011) cut-off for measuring poverty); extreme poverty (MDP>0.66 - this doubles the standard poverty threshold, following other studies (e.g. Lokshin and Ravallion, 2000) and indicates that at a minimum a household is completely deprived in one of the three poverty dimensions and partially deprived across the remaining two dimensions); and inequality - measured as the standard deviation of the incidence of household poverty (S1; Figure 1A). Using alternative thresholds for defining extreme poverty either generates too few VDCs that contain extreme poverty (70% threshold – 314 VDCs using 2001 baseline data compared to 1,153 with a 66% threshold) or generates qualitatively identical results and conclusions (60% threshold, Figure S2).

ii) Defining Protected Area treatments

We define protected treatments as VDCs that overlap Nepal's 32 PAs (IUCN categories II - VI, Nepal lacks category I PAs) using the World Database on Protected Areas (WDPA; IUCN & UNEP-WCMC, 2016; Figure 1B). The vast majority of these are multiple-use PAs. We conduct two separate analyses: one focusing on PAs established before 2001 (the baseline year of our poverty data), and one focusing on PAs established between 2001 and 2011. We conduct this second analysis as a robustness check because PAs established prior to 2001 could affect our baseline measures, although baseline poverty metrics were similar in VDCs that were protected before and after 2001 (see Fig. 2). We also defined protected VDCs using two separate definitions: those with i) at least 10% of their area overlapping with a PA (e.g. Andam *et al.* 2010; Hanauer and Canavire-Bacarreza, 2015) and ii) at least 70% of the VDC being protected (which is close to the mean percentage overlap for overlapping VDCs - PAs established before 2001 = 65.2%; PAs established after 2011 = 71.4%). VDCs with <1% of their area protected were defined as non-protected to ensure a clear distinction in the magnitude of protection between control and treatment VDCs.

iii) Tourism metrics

We assessed how PAs with different tourism intensities impacted our outcome variables, using data on official tourism numbers for each PA in 2011 (low < 10,000 visitors, intermediate 10,000-100,000, high > 100,000; Nepal Tourism Statistics, 2013). We also assessed how proximity to a PA entrance and trekking routes (categorised as major or minor; Table S9) contributed to heterogeneity in PA impacts using a mean travel time estimate (weighted by population density) from each VDC to the nearest PA entrance, and major and minor trekking routes (S3).

iv) Confounding factors

We selected a suite of biophysical and socioeconomic covariates based on their potential to influence the outcome or the relationship between treatment and outcomes. These covariates were baseline levels of our poverty measures, slope, elevation, precipitation, VDC area, forest cover, travel time from the VDC to population centres and district headquarters, proportion of the VDC under community forest management and the age of community forestry arrangement, population density, agricultural effort, international migration and district (Table S3).

2. Matching and post-matching analyses:

We used a combined matching and regression based approach to explore the causal link between PAs and poverty outcomes. We model poverty metrics in 2011 while controlling for baseline poverty in 2001 to avoid constructing models that can generate spurious correlations (Brett, 2004). This approach yields similar parameter estimates for our treatment variables as those generated when modelling absolute change (S2). The pre-processing of data using matching methods optimizes the balance of covariates across treated and control units, and is useful when imbalance between treatment and control is an issue for traditional causal inference techniques (Ho *et al.* 2007). We used genetic matching with replacement, which performs well when covariates have skewed distributions (Diamond and Sekhon 2013).

We performed all of our statistical analyses in *R* version 3.3.2 (2013) using the "Matchit" package (Ho *et al.* 2007). We used post-matching standardized mean differences of <0.25 as an acceptable balance between treatment and control groups for each covariate (Stuart 2010, see Figures S3-S5). We then performed an Ordinary Least Squares (OLS) regression to adjust for remaining imbalances in covariate distributions (Ho *et al.* 2007). When modelling extreme poverty, we implemented a two-step hurdle model (Cragg 1971) using matched binomial regressions to first model the incidence of extreme poverty, and then OLS regressions to model the magnitude of extreme poverty in those VDCs in which extreme poverty occurs. We first measured the average impact of our treatments (protection) on our response variables (poverty, extreme poverty and inequality in 2011). We then subset and separately matched PAs in each tourism intensity category (high, intermediate or low) to assess the impact of tourism intensity. PAs with high tourism levels were all designated before 2001, so we only performed this subgroup analysis on PAs established before 2001. We conducted robustness checks to test for spillover effects from unprotected VDCs adjacent to a PA (defined as the treatment) into unprotected control VDCs that are not adjacent to a PA (S4), and spatial autocorrelation (S5); results are robust to spillover and spatial autocorrelation unless stated otherwise.

3. Heterogeneity analysis:

We assessed if PA impacts were moderated by travel time to the nearest tourism hub (PA entrance, major and minor trekking route) and elevation, which affects livelihood choices (greater range of options in the lowlands, including commercial agriculture) and tourism options (safaris in the lowlands, trekking in the mountains). We used partial linear modelling (PLM - Yatchew 1998; Hanauer 2015) to assess heterogeneous impacts along the gradients of our moderating factors following methods described in Ferraro *et al.* (2011) and Hanauer and

Canavire-Bacarreza (2015). In a first step, we controlled for confounding factors using a linear regression. In the second stage, we employed a nonparametric locally weighted scatter plot smoothing (LOESS) to estimate the non-parametric relationship between moderator and outcome. This method allows us to estimate the impact of PAs on our outcome variables as a function of our moderator variables of interest (elevation and travel times to the nearest PA entrance, major and minor trekking routes) while holding other covariates constant.

Results:

i) Average impact on poverty, extreme poverty and inequality

We found no evidence that PAs exacerbated poverty in Nepal. In fact, matched protected VDCs (defined using the 10% threshold and established before 2001) had significantly lower poverty in 2011 than unprotected VDCs (coef. = -0.03, S.E. = 0.02, P = 0.027; Figure 2A). Poverty was not exacerbated when raising the protection threshold to 70% (coef. = -0.06, S.E. = 0.03, P = 0.060; Figure 2A). For PAs established after 2001 we found no evidence of positive or negative impacts of PAs on overall poverty (Figure 3A). Models without matching showed similar patterns (Table S7).

PAs established before and after 2001 reduced the incidence of extreme poverty. For PAs established before 2001, this result was significant for our 10% protection threshold (coef. = -0.95, S.E. = 0.38, P = 0.012; Figure 2B) and was accentuated by raising the threshold to 70% (coef. = -3.51, S.E. = 1.20, P = 0.003; Figure 2B). For PAs established after 2001, this result was not significant using a 10% protection threshold, but was significant after raising the protection threshold to 70% (coef. = -2.82, S.E. = 1.18, P = 0.018; Figure 2B). We found no significant impact of protection on the magnitude of extreme poverty (Table S8). Results from models without matching showed the same patterns for PAs established before and after 2001 (Table S7).

We found no consistent evidence that inequality was influenced by PAs established before or after 2001, using either 10% or 70% protection thresholds (Figure 2C). Models without matching indicate that PAs established before 2001 reduced inequality, while PAs established after 2001 increased inequality (Table S7), but these difference were not significant after controlling for spatial autocorrelation (Table S6).

ii) Tourism intensity

PAs with high tourism levels significantly reduced overall poverty (coef. = -0.05, S.E. = 0.02, P = 0.023; Figure 2A), while PAs with low tourism levels had no significant effect on poverty. However, PAs with low tourism levels significantly alleviated extreme poverty (coef. = -2.80, S.E. = 1.12, P = 0.013; Figure 2B) and decreased inequality (coef. = -1.01, S.E. = 0.43, P = 0.023; Figure 2C).

iii) Heterogeneity – travel time to PA entrance and trekking route

Travel time to a PA entrance had no impact on poverty (Figure S7) and inequality (Figure S6), while reductions in the incidence of extreme poverty were greater closer to a PA entrance (Figure 3D). Travel time to a minor and major trekking route moderated the influence of PAs on poverty, with significant reductions only occurring in VDCs close to the trekking route (Figures 3A and 3B). Incidence of extreme poverty was lower further away from a minor trekking routes (Figure 3D), but was not influenced by travel time to a major trekking route (Figure S7). Inequality was not influenced by proximity to major or minor trekking routes (Figure S6).

iv) Heterogeneity - elevation

Our PLM results do not show significant heterogeneous impacts of PAs on extreme poverty and inequality as a function of elevation (Figures 3F and S6). PAs established before 2001 reduced poverty to a greater extent at low elevations than high elevations (Figure 3E).

Discussion:

Nepali PAs typically reduced poverty, concurring with previous research elsewhere (Andam *et al.* 2010; Hanauer and Canavire-Bacarreza 2015). Crucially, PAs reduced extreme poverty without deepening inequalities. This finding is particularly important as creating pathways out of extreme poverty is more difficult than tackling less extreme poverty (Halder and Mosley 2004). Our findings suggest that PAs are able to provide pathways out of extreme poverty in remote areas, challenging previous evidence that PA policies only benefit community elites (Agrawal and Gupta 2005).

PAs with high tourism levels reduced poverty without exacerbating extreme poverty and inequality, while PAs with low tourism levels reduced extreme poverty and inequality but had no impact on overall poverty. These results suggest that the poorest receive the greatest benefits from small-scale tourism, contrasting with previous suggestions that tourism increases inequalities (West *et al.* 2006). We provide further evidence for beneficial impacts from tourism by showing that poverty reductions in PAs only occurred close to trekking routes. This suggests that redistribution policies (that 30-50% of PA revenue is spent on local community development; Heinen and Shrestha 2006) may not fully address spatial biases in which communities benefit from tourism in PAs. Notably, however, the impact of PAs on reducing extreme poverty increased with distance from minor trekking routes that are typically located in remote areas with little development potential that can benefit from park redistribution policies. Future studies should specifically assess if, where and how these policies influence PA poverty outcomes.

Distance from PA entrances had no impact on extreme poverty inside PAs, but increased extreme poverty outside PAs. This suggests localised negative spillovers, with PA residents living close to PA entrances receiving benefits that people living equally close to entrances outside of the PA miss out on. Other research on PA spillover effects show similar patterns of heterogeneity (Robalino *et al.*, 2017; Pfaff and Robalino, 2017), with tourism benefits only occurring close to PA entrances (Robalino and Villalobos 2015). Indeed, our analyses indicate that benefits of protection do not spread to neighbouring unprotected VDCs. Redistribution policies might thus need to target communities inside and outside protected area more equally.

Time since establishment moderated the effect of PAs on our measures of poverty. PAs established after 2001 did not show the same significant social benefits as PAs established before 2001, although in newer PAs we observe a trend towards lower extreme poverty and inequality. This pattern is expected if there are time lag effects that arise because communities need to adjust to new regulations imposed by PAs and the new opportunities provided by them, and for the tourism industry to develop. The reduced benefits of more recently established PAs are unlikely to be associated with changes in management regimes as these have been constant across all Nepali PAs since the 1990s (Bhattarai et al., 2017). Notably, an increase in the threshold used to define a protected VDC (from 10% to 70%) accentuated our main findings. This suggests that communities in VDCs that have restrictions placed on activities across a larger proportion of their land do not experience adverse impacts on poverty metrics, thus larger protected areas may deliver greater economic benefits. Finally, impacts of PAs were similar across a wide range of elevations indicating that PAs can deliver socio-economic impacts even in areas that typically support livelihoods that are less compatible with nature conservation, such as agriculture.

Our study makes a number of important contributions. First, we demonstrate not only that PAs in Nepal reduce poverty and extreme poverty, but that they do so without increasing inequality. These benefits occur even in lowland regions with high capacity for alternative land-uses, and when capacity for alternative livelihoods is reduced by protecting larger proportions of land. Second, we find that tourism is a key driver of PA benefits, but that reductions of extreme poverty are possible even in marginalised areas with limited tourism potential. Finally, we find no evidence that socio-economic benefits of PAs spread to people living outside, but close to, PAs. Addressing this by adjusting PA's revenue redistribution policies, could increase the benefits for these communities and reduce conflict between local communities and PA's conservation objectives (Oldekop *et al.* 2016). Nepal's PA management policy to promote social welfare via redistribution of PA revenues, gained through tourism and other activities, is similar to policies in other countries including Thailand (Sims 2000) and Kenya (Walpole and Leader-Williams, 2001) suggesting that our findings may also apply elsewhere.

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Figure legends:

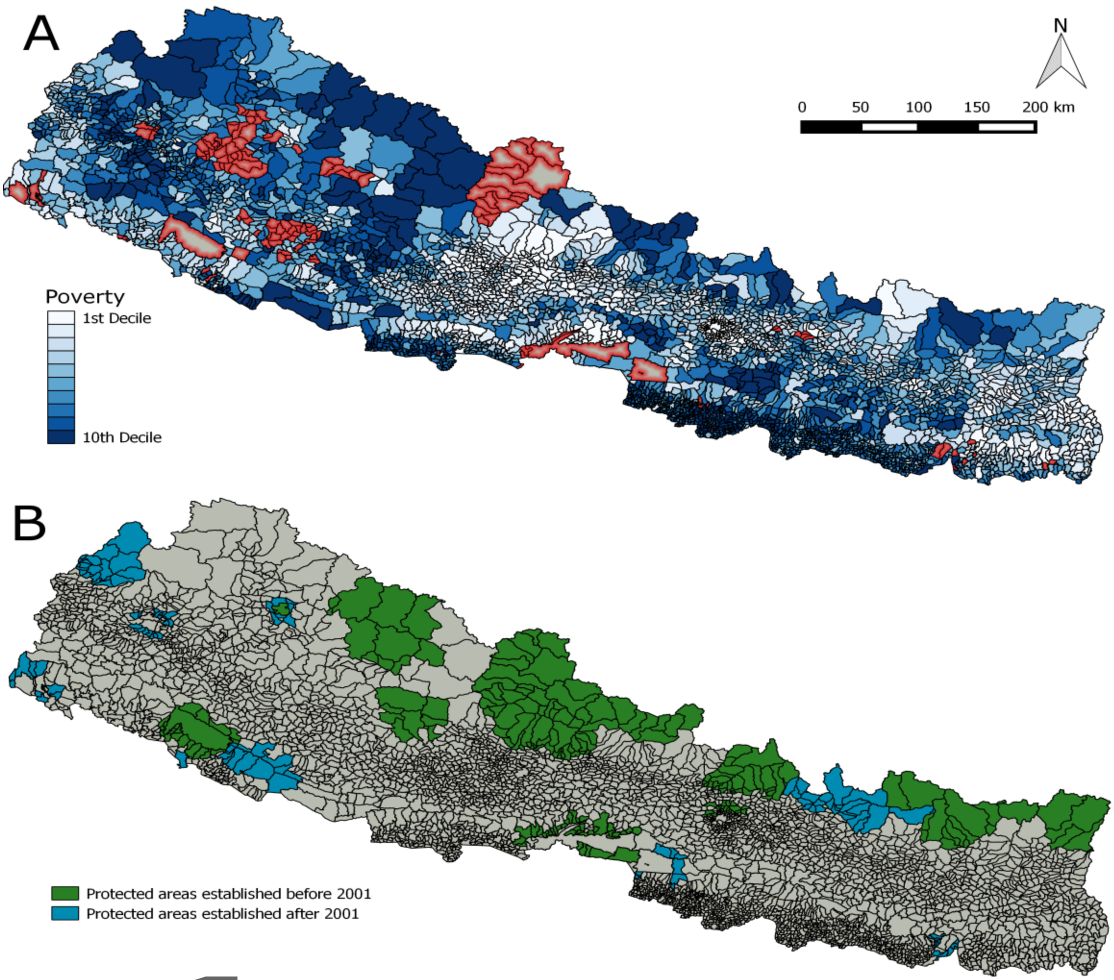

Figure 1: Poverty and protected areas. (A) Multidimensional Poverty in 2011. Each polygon represents a Village Development Committee (VDC). Data are presented as deciles. Grey areas with red contours represent excluded VDCs (reasons for exclusion include missing data due to armed conflict and instances of inconsistent data from the Nepali Department of Forests). **(B)** Schematic map of protected areas in Nepal. Data from the World Database of Protected Areas. In our analysis we included 192 VDCs that were protected before 2001 (of which 110 were protected using the 70% threshold definition), and 106 VDCs that were protected between 2001 and 2011 (of which 67 were protected using the 70% threshold).

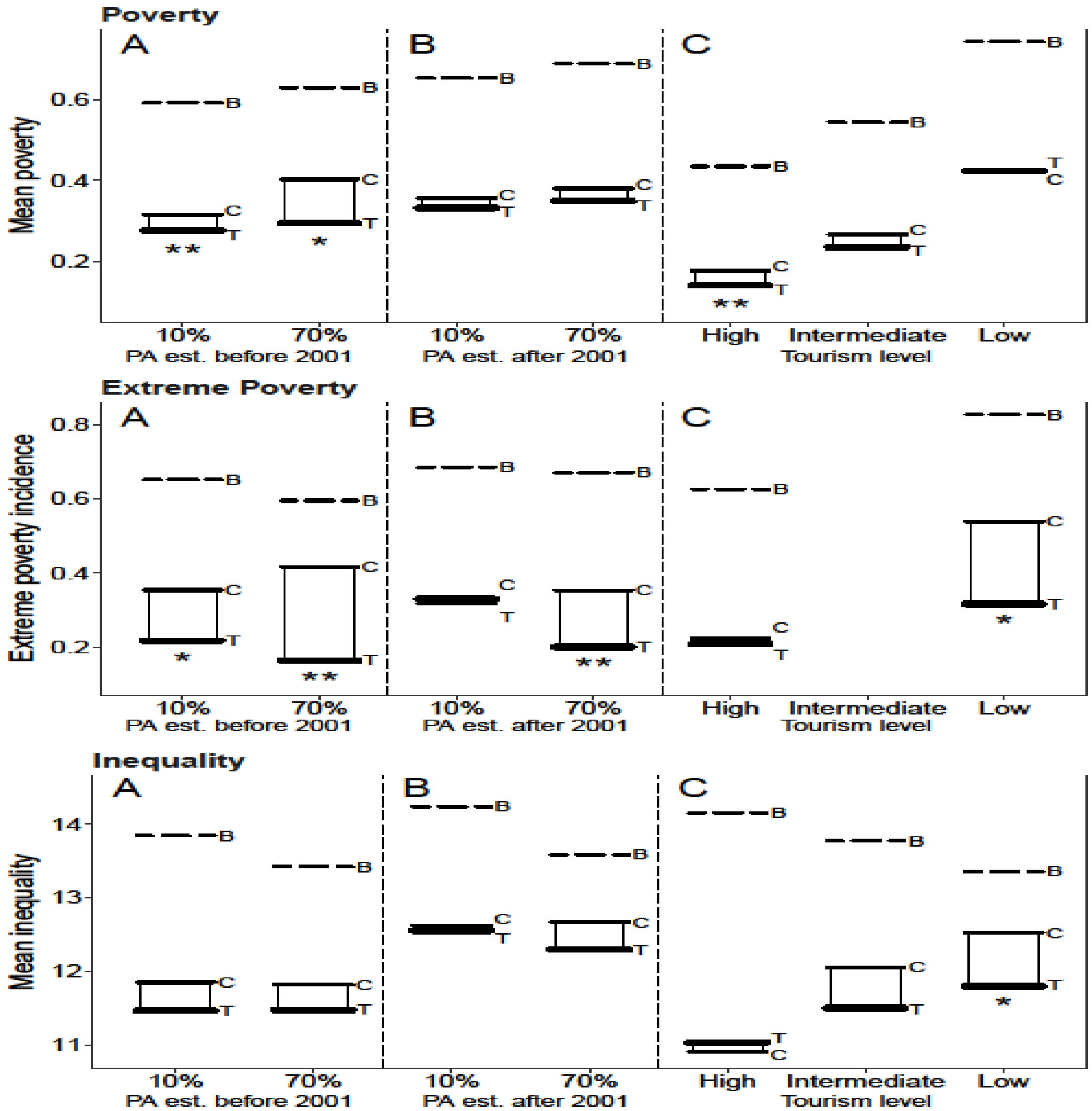

Figure 2: Estimated impacts of protected areas (PAs) on poverty, extreme poverty and inequality in Village Development Committees (VDCs) in Nepal for PAs established before 2001 (A), PAs established between 2001 and 2011 (B), and according to level of tourism (C). Poverty, extreme poverty and inequality measurements are based on a multidimensional poverty index. Dashed lines (B) represent mean baseline (2001) of VDCs, thick lines (T) represent treatment i.e. PAs, thin lines (C) represent counterfactual controls without protection. Significance: **** $P < 0.001$, *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$.

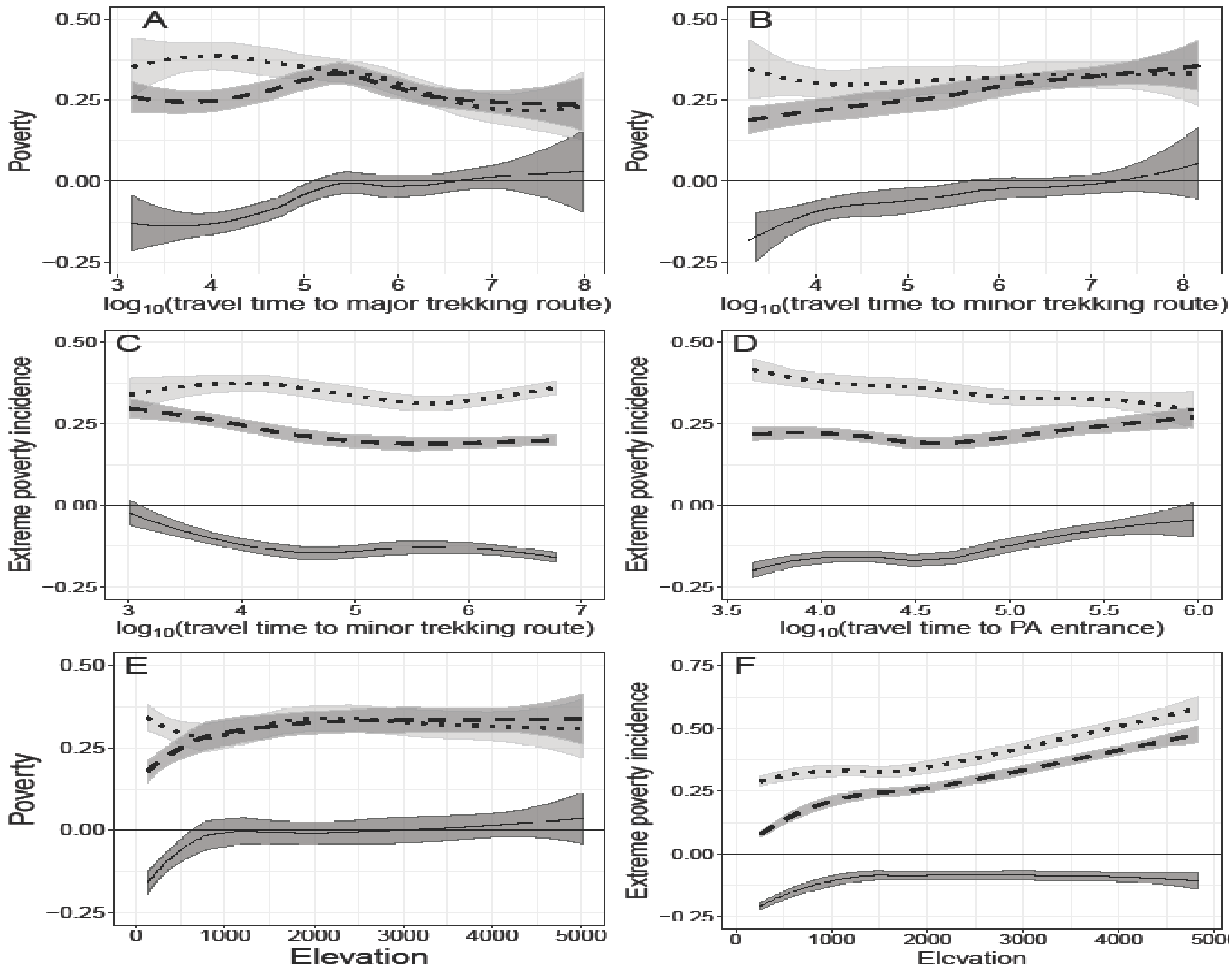

Figure 3: Partial linear models: Impact of protected areas (PA) on poverty (A-C) and extreme poverty (D-F) in Village Development Committees (VDCs) in Nepal for PAs established before 2001, conditional on travel time to major trekking route (A), minor trekking route (B-C) and PA entrance (D), and PA impacts conditional on elevation (E-F). Poverty measurements are based on a multidimensional poverty index. Dashed lines represent protected VDCs, dotted lines counterfactual controls without protection, and solid lines the difference between treatment and counterfactual estimates (negative values indicate reductions in poverty).