"Consequences of Protected Areas for Forest Extraction and Human Well-being: Evidence from Nepal"

Aparna Howlader*, Amy W. Ando**

* PhD Candidate (corresponding author), Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, email: howlade2@illinois.edu

** Professor, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, email: amyando@illinois.edu

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Abstract

Forest protected areas are mostly located in developing countries, where forests are a main source of the traditional rural livelihood. This creates potential for conflict between local communities and biodiversity conservation. To explore this issue, we examine the case of forest protected areas (PAs) in Nepal. In the period of 1995-2003, the Nepalese government established several new protected areas (PAs) throughout the country. Using Nepal Living Standard Survey collected in 1995/1996 and 2003/2004, we evaluate the effects of these new PAs on household consumption and wood-collection effort by combining differences across regions with differences across time. The estimates suggest that the PA establishment has reduced average forest-good consumption by almost 30% to 70% compared to the pre-establishment period and this decrease has not translated into a larger market participation in fuel purchase. However, as described in previous literature, the estimates on welfare variable (in terms of per-capita consumption expenditure) does not suggest spillover impacts on the households from PA-based ecotourism industry in the study period. The paper also explores whether protected areas could be affecting households in other ways, such as by migration or inducing changes in labor supply.

Keywords: Protected Area, Land Conservation, Impact Evaluation, Nepal.
JEL Codes: Q560, Q570, Q580.

Protected areas (PAs) – places with legal restriction on resource extraction – play a pivotal role in biodiversity conservation. According to the World Database of Protected Areas, about fifteen percent of the world's land is currently under some level of "protection".[2] Because tropical developing countries are the habitat of many endangered and threatened species, most protected areas are located in poor regions of the world. However, households living around forests traditionally extract and depend on resources from the landscape (e.g., firewood, honey and herbal medicines). An important unintended consequence of PAs in developing countries

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Any comments are welcome. Contact: howlade2@illinois.edu. Mailing address: Department of Agricultural and Consumer Economics, 402 Mumford Hall, 1301 W. Gregory, Urbana, IL 61801.
[2] See also: http://www.protectedplanet.net/

may be welfare loss to these households if people need to reallocate effort and consumption choices after a sudden ban on the resource access. This paper asks the question: how does a protected area affect the actions and well-being of surrounding people?

The question of whether establishment of forest protected areas causes any adverse impact on welfare or reduces poverty by generating ecotourism activities has recently become a concern to environmental economists and policymakers (Baylis et al., 2015; Miteva et al., 2012; Pullin et al., 2012). A growing body of literature exists on the analysis of regional level poverty data over several decades to see the impacts of PAs. However, almost no effort has been made to estimate the impacts of PAs using household level forest-dependency information. Thus, we do not understand the mechanism of behavior that drives the results of these studies. Understanding the impacts of PAs with a shorter study period and household level information, is needed to design better policy instruments for future conservation and follow-up compensation tools. Tackling such micro-level issues is the primary goal of this paper.

In this paper, I analyze changes in household activities and corresponding welfare changes from the ban on resource extraction and empirically investigate the channels through which households react to the ban. The predictions derived from economic theory is ambiguous: at one side, resource restriction based on PAs would hamper daily livelihood of forest-dependent local communities; alternatively, ecotourism industry based on PAs could change the local labor market by introducing new income sources. The ideal experiment to estimate the impacts on households would be to randomly assign PAs to some communities and not to others, and then to compare activities across the communities. However, the principal methodological problem with research on protected areas is that PAs are not randomly allocated. Forest landscapes with more biodiversity richness are likely to be more protected. Also, the government may try to invest in protecting those landscapes which have better prospects as a popular tourist spot. This selection procedure complicates the empirical strategy because outcomes might be influenced by unobserved differences across communities.

To examine the effects of PAs on household welfare, I use Nepal's household survey data for years 1995/1996 and 2003/2004. In the last two decades, the Nepalese government introduced several kinds of PAs. I collect detailed information on geographical location of these PAs and surveyed villages. Then, I compare the household welfare in areas in the proximity of PAs to areas farther away from PAs. Continuous forest degradation, well-enforced PA management, and corresponding state-community conflict and the long tradition of successful community forest makes Nepal particularly interesting to understand any PA impact (Poudel, 2011).

Political economy of the forest management in Nepal suggests that state-level decisions are exogenous to individual-level choice behavior. Thus, this paper's identification strategy relies on the fact that the exposure to PA varies with time and region. I use a difference-in-difference estimator that controls for systematic variation of ban on resource access both over time and across regions. The main concern is that unobserved community characteristics (e.g., forest dependency or site selection) are source of bias in OLS estimates. The main contribution of this paper is to solve these problems and provide causal identification of the PA impact.

Forest livelihood is a relatively static social concept due to time-invariant physical attributes. A control group of forest communities not living near any newly established PAs forms a natural basis for comparison. To complement the argument based on systematic variation in "forest dependency" and "ecotourism possibility" between near-PA and not near-PA forest livelihood, I take another control group who are around previously established PA.

Following this strategy, I find evidence of a significant reduction in the amount of firewood collection around PAs. My estimates suggest that in between 1996-2003, household's firewood consumption decreases by almost 3 to 7 kilograms per day in areas closer to PAs. However, this decrease in collection of forest-good has not been translated to a larger market participation. The results also suggest that households do not spend more time in forest-good collection after the PA establishment. This may suggest that their commitment towards other activities do not allow them to reallocate time due to the establishment of PAs. My second set of results move beyond the forest-good collection and focus on standard of living. This is a natural extension of the previous literature which assumes that PA generates positive impacts on income by accelerating tourism industry. I find evidence to suggest that ecotourism industry is not significantly changing welfare outcomes in the study period. These results highlight the importance of considering potential non-spillover of tourism income in cases with an inflexible rural labor market and centralized tourism industry. An extensive literature on the rural labor market in developing countries demonstrates that labor supply does not respond easily to market openness, because of the close links to inherited land and occupation (Bardhan, 1983). I find a similar pattern in Nepal. A complete understanding of the impacts of the PAs also requires the analysis of the market and non-market channels (e.g., migration or remittance income, alternative fuels, and stove choice) through which households may react to the PA. I find that while the establishment of PAs appears to have had substantial effects on forest-good collection behavior, it mostly does not have any impact on any of these other channels.

This paper contributes to the economic literature studying the effect of PAs on forest conservation. A large body of literature exists on the spatial analysis of forest cover to understand impacts of PAs. Estimated impacts, in general, show that PA helps to protect biodiversity (Andam et al., 2008; Ferraro and Hanauer, 2011; Sims, 2010; Nelson & Chomitz, 2011; Shah & Baylis, 2015). Using landscape- level pixel data, these papers examine the effects of PAs on deforestation and find different magnitude of impacts in different contexts. This success in biodiversity conservation through PAs also intuitively implies a welfare reallocation among surrounding communities. However, aside from the evaluation of change in forest cover, there are only a handful of papers on the other side of this question- what is the socioeconomic impacts of PAs on local communities?

This paper is related to the growing literature documenting the impact of protected areas on human livelihood. The first papers discussing the impacts of PAs on human welfare are qualitative analyses based on cross-sectional case-specific data (Pattanayak et al., 2003; Cernea & Schmidt-Soltau, 2006). These studies show diverse impacts of PAs depending on the household characteristics. The first study that uses careful identification strategy to get the economic impact of protected areas on neighboring communities is Andam et al. (2010, PNAS). For Costa Rica, they use census tract poverty index data of 1973 and 2000. For Thailand, they use poverty headcount ratio at sub-district level (share of the population with monthly household consumption below the poverty line) from 2000 census. This poverty data has been shown to be non-negatively correlated with established protected areas. However, that paper uses a measurement of poverty that is an average score over several decades that is only a relative ranking of the areas. Several other papers have also found that PAs cause mixed impacts on regional level poverty index for different countries (Miranda et al., 2014; Bacarreza et al., 2013; Sims, 2010).

In addition to the aforementioned environmental economics literature studying the impacts of protected areas, this paper also contributes to a growing literature studying the labor market impacts from environmental regulation (Walker, 2011; Berman and Bui, 2001; Hanna and Oliva, 2015).

The remainder of the paper is organized as follows: In section 2 I present a simple model of forest-good users, and discuss the possible impacts of PAs. Section 3 describes data sources and section 4 presents the identification strategy. Section 5 presents the results. By examining different alternative explanations I develop a sense of underlying mechanisms in section 6, and section 7 concludes.

2 Theory

This section models a forest resource-user household's utility framework analogous to those in the development microeconomics (Bardhan & Udry, 1999) literature. Households choose their amounts of forest-good collection and consumption. Households also allocate their time endowment between forest-good collection and other wage-earning work. The purpose of the model is to understand the channels through which protected areas can change a household's consumption and labor supply decisions. The model starts with a general unrestricted forest resource; demand for forest products are derived from that framework. Then the model is extended to include the impacts of protected areas.

2.1 Modelling behavior of open access forest resource-users

The forest community has a number n of households who make decisions during a single time period. A community is defined as the smallest administrative zone and roughly corresponds to a village in the dataset. Each household i is endowed with time T; which they allocate among forest-good collection, t_f, wage earning, t_w, and leisure, l. However, the households can instead choose to buy any amount of the forest good from the market. The forest has total land, F, and all households have equal access to the forest. For tractability, I assume the labor market is perfect and all households sell their labor at the same wage rate in the labor market. The model follows a unitary decision-making framework. Based on stylized facts in Nepal, this model does not characterize market participation as a choice variable. The quantities of forest good exchanged in the market are negligible in rural Nepal, so spatial sorting of the households into buyer and seller groups is unnecessary (Baland et al., 2010; Key et al., 2000).

The household has a utility function over the forest product (x_f), non-forest product (x_a) and leisure (l). x_a can be thought of as a composite good which is available only at the market; households do not produce it. Households collect a quantity of forest good, Q_f by using time, t_f in forest-good collection and they can work for wage using labor time, t_w. Household i gains utility according to the following function,

$$u\left(x_a, x_f, l\right) = (x_f - A)^{\alpha}\,(x_a)^{\gamma}\,l^{\beta} \tag{1}$$

Equation 1 states that the household preference structure follows a Stone-Geary utility function over x_f, x_a and l. Note that setting A=0 gives Cobb-Douglas preferences. The model does not assume any restriction on parameters α, β and γ.

The time constraint of the household is,

$$t_f + t_w + l = T \tag{2}$$

The household cannot allocate more time to forest work (t_f) , non-forest wage work (t_w), and leisure (l) than the time endowment, T.

The forest-good collection function is specified in a format so that we can see the households' search effort to collect that forest good. That will help us later to understand the impacts of PAs. For any household i,

$$\therefore \quad Q_f = \begin{cases} 0, & \text{if} \quad t_f < \bar{t} \\ \mu\,(t_f{}^{\frac{1}{\delta}}) & \text{, if} \quad t_f \geq \bar{t}\,; \end{cases} \tag{3}$$

where $\bar{t}$ is the setup cost for searching, and $\delta > 1$.

The amount of forest-good collection is a function of only time. The technology function has a kink at $\bar{t}$. The distance a person needs to cover to collect the material from the forest, is denoted by this set-up cost, $\bar{t}$ (i.e., commuting cost). After $\bar{t}$, Q_f follows a regular convex curve $(\delta > 1)$. The assumption of decreasing returns to scale comes from the physical capacity constraint of the households. The parameter μ is the household-specific skill adjustment factor, which shows a household's comparative strength over forestry and non-forestry work.

For any household i, total income must be greater than or equal to total expenditure. If P_l is the market wage or opportunity cost of time, P_f is the market price of the forest goods and P_a is the market price of the non-forest goods, then the cash income constraint is

$$P_f Q_f + P_l t_w \geq P_f x_f + P_a x_a \tag{4}$$

Substituting equation (2) and (3) into equation (4),

$$P_f Q_f + P_l T - P_l t_f - P_l l \geq P_f x_f + P_a x_a \tag{5}$$

Equation 5 is the full-income budget constraint. Following the simple rational behavior of any agent, I assume here that if the household decides to collect any resource from the forest, the collection function will be at its convex fragment where $t_f \geq \bar{t}$. If collection effort is greater than zero, then collection amount will always be strictly positive. Gathering all of the equations together gives the following household optimization problem:

$$\underset{x_a, x_f, l}{\textbf{Max}} \quad u\left(x_a, x_f, l\right) = (x_f - A)^{\alpha} (x_a)^{\gamma} l^{\beta} \quad \text{subject to,}$$

$$(P_f Q_f - P_l t_f) + P_l T \geq P_f x_f + P_a x_a + P_l l \tag{6}$$

A detailed mathematical derivation of the solution for this problem is available in the appendix. A requirement for the solution to be valid is that the subsistence level of consumption needs to be reached for every household; that means in a closed market: $\sum_{i=1}^{n} Q_{f(i)}{}^{*} \geq nA$.

Figure 1 illustrates the intuition of the optimization problem. To capture the intuition of the model in a 2-dimensional graph, we focus on the forest-good consumption and corresponding effort level (measured in time). The Y-axis on the right side presents the forest-good collection of a household, and the Y-axis on the left side presents consumption of the same good. The X-axis presents time spent in forest. I_1 presents the indifference curve associated with equation (1) and Q_1 presents the collection function as in equation (3). *A* denotes the subsistence level.

$(P_f Q_f \;-\; P_l t_f\;)$ is the monetary surplus from the collection. The highest surplus from this collection function is presented by the slope at the maximum, E_1. This slope is the ratio of the two prices, $\frac{P_l}{P_f}$. So this slope also represents the budget line for the household. The optimal collection amount is denoted by Q_f^* and the optimal consumption is denoted by X_f^*. Household spends time, t_f^* to collect Q_f^*. We can explore the gap between demanded and collected quantity, Z= $({Q_f}^* - {x_f}^*)$. NLSS has information only on households' forest-good collection, and these households are not purchasing/selling forest good in the market. Using this stylized fact we can assume, ${Q_f}^* = \; {x_f}^*$. This is reasonable from the rationality point. Households collect resource according to their demand and so wastage of any resources (both forest resource and time endowment) is irrational.

2.2 Regulation on Resource Extraction

Using the intuition from the previous section**,** PAs affect the collection function by changing the slope and intercept. The distance to the nearest accessible forest is the intercept of the function,$\bar{t}$. The slope, δ can be thought of as a proxy for the intensity of protection. Households' reaction to a PA would depend mainly on the policy variables denoted by $\frac{P_l}{P_f}$, δ and $\bar{t}$. Higher protection (i.e. $\uparrow \delta$ and $\uparrow \bar{t}$) will move the entire collection function to the left. If selling labor at market is profitable than spending same time in forest, people would switch fuel from firewood to other alternatives (Bode et al., 2014). However, the forest-good market is not perfect in rural Nepal. Also, female economic participation is limited, so the opportunity cost of time is very low for them. These two factors influence traditional collection behavior; less than 2% of households use anything other than firewood in the dataset. Given insufficient cheaper alternatives and strong habit persistence, compositional change in search effort and collection amount is more likely.

The presence of the subsistence parameter, A, means that households may not have zero consumption. However, if ${x_f}^* - A$>>0, households can try to reduce the gap in reaction to creation of a PA. Welfare will not be reduced substantially if ${x_f}^*$ is unnecessarily higher than *A*. The equilibrium consequences of PAs will depend on whether preferences are towards 'over-exploitation' (that is, *C* in Fig-1) or 'necessity level' (that is, *A* in Fig-1) before the establishment. PAs could generate ecotourism revenue. Theoretically, this may introduce additional income to the cash income in equation (4) depending on both macro (e.g., infrastructure) and micro (e.g., local labor market) features of the country.

The model indicates that PA might have an impact on forest-good consumption, might have an impact on collection effort or the impact will be a mixture of these two to balance the consumption with the subsistence level, *A*. The impact of PAs on income and consumption depends on the adjustment power of the local economy and cannot be predicted from this model. This theoretical ambiguity means empirical analysis is needed to understand the effect of protected areas on households. The main target of the empirical section is to estimate treatment impacts of PA, where changes in forest good collection and welfare outcomes will be estimated for the communities living around newly established PAs.

3 Background and Data

My choice of case study is driven by the need to find a place with both available newly established PAs and multiple years of household-level detailed economic information. Traditional forest dependency, the establishment of new protected areas in recent years, and the availability of Nepal Living Standard Survey with detailed household-specific forestry information, makes Nepal a good choice. According to Census data (2011), 78% of Nepal's people depend on forest resources directly. Nearly two-thirds of the Nepalese people still use firewood as a primary source of fuel for cooking. The establishment of protected areas might alter this forest dependency by reducing the size of the forest available for extraction.

3.1 History of Land Conservation in Nepal

Prior to 1950, forests were under local communities' control. In 1957, the government nationalized forest land. Nationalization created open access resources and exacerbated degradation because of ineffective and corrupt governance. In 1967, Nepal introduced a special forest protection act to enable forest conservation.

Now Nepal has a complex structure of different levels of protection, though the forest cover loss is still very high in some areas. Nepalese forest cover declined at an annual rate of 2.7% between 1947 and 1990 and then at an annual rate of 1.23% between 1990 and 2010. Since 1973, Nepal has established twenty protected areas, consisting of ten national parks, three wildlife reserves, six conservation areas and one hunting reserve, altogether covering 18% of the total area. Nepalese government started to engage the army in management of national parks in 1975. Thus, enforcement of conservation is meaningful.

However, continuous degradation around PAs forced the Nepalese government to arrange a new system in 1996: the Buffer Zone Forest Management system (BZ). With this law, they started to increase the area of previously established national parks. To reimburse communities, the government promised to arrange different safety nets (e.g., vocation training). Thus, households around BZ have less power to extract resource but may have more access to a better lifestyle. In the meantime, importantly, starting in the late 1980's, the government has gradually been handing over national forest to local communities based on a forest management plan between the District Forest Office and local people. Any forestry community can apply to have a parcel of forest-land on the promise to reinvest 30-40% of the revenue in the land every year.

IUCN protected area management categories divide protected areas into six divisions with respect to their management objectives.[3] In the period 1996-2003, Nepal has three new PAs under IUCN category 1-4 (National Park and Conservation Area) and six new PAs under IUCN-6 (Buffer Zone). Aside from these PAs, forest land is under the National Forest System. Community and leasehold forestry areas are also included in the National Forest System. Table 1 describes the current structure of PAs in Nepal. Nepal's PAs are attractive tourist spots, but similarly to other agrarian rural economies, the ecotourism industry in Nepal has little interaction with local economies: parks hire few local workers, tourists buy few local goods, and tourism revenue is not distributed among local residents (Bookbinder et al., 1998).

3.2 Nepal Living Standard Survey

To analyze the impacts of these PAs on welfare and resource allocation, I use the Nepal Living Standard Survey (NLSS) collected by the Nepalese government with the assistance of the World Bank. By construction, this dataset is similar to the well-known 'Living Standard and Measurement Survey' collected by the World Bank. The dataset is nationally representative and

[3] Category I includes Strict Nature Reserve & Wilderness Area, Category-2 includes National Park, Category-3 includes Natural Monument & Natural Landmark, Category-4 includes Wildlife Reserve & Wildlife Sanctuary, and Category-5 includes Protected Landscapes/Seascape. Category-6 includes Managed Resource Protected Area.

has detailed information on collection of goods from forest, including the time spent to collect, amount of collection, and type of forest. NLSS has a community survey also.

Basic data is collected on each individual in the household. In this study, I focus on only rural Nepal as the forest-good demand structure is different in urban areas (Baland et al., 2010). I use the first two waves of NLSS collected in 1995/1996 and 2003/2004. NLSS-1 sample frame was taken from 1991 census, and NLSS-2 sample frame was taken from 2001 census. NLSS 1 ;and 2 follow the same survey stratification, they divide Nepal into ecological zones for mountain, hill, and low land. Probability sampling units (village wards) were selected from those ecological zones. I use NLSS-provided sampling weights wherever necessary in the analysis. In total, NLSS-1 interviewed 3388 households and NLSS-2 interviewed 3912 households. NLSS has both repeated cross section and panel data. As the panel part is small (but nationally representative), I utilize that as a robustness check for the repeated cross sectional analysis.

3.3 Geographic and Administration Data

Since a long lasted civil conflict between Maoists and Nepalese government took place during the study period, I use district level casualties information collected by Informal Sector Service Centre (Do and Iyer, 2009). There is no way to match households with this conflict data, and NLSS has no visible sign to predict household-level impacts from conflict casualties. However, the conflict was nationwide, and so it will not bias the results as the research design takes care of any macro impact by which treatment and control groups are affected similarly. Information on PA establishment and number of species is collected from World Database on Protected Areas and Nepal Biodiversity Strategy (2002). Tourism statistics is taken from Nepal Tourism Statistics (Ministry of Culture, Tourism & Civil Aviation, 2013).

4 Estimation and Identification Strategy

Previous estimates of PAs are conditional on, and highly sensitive to, controversial assumptions about what impacts would have been in the absence of PAs. In this study, I use a difference-in-difference approach exploiting two sources of variations in order to construct better estimates of the counterfactual outcomes: distance from households to the nearest PA and changes in outcome variables over time. There are two key parameters of interest. First, what is the effect of a PA on forestry-good consumption and collection time? Second, what is the effect of a PA on per capita income/consumption expenditure? This section explains my strategy for generating plausible estimates of these causal effects.

4.1 Empirical framework

The unit of observation is a household. My main outcome variable of interest is amount of collected firewood, time to collect firewood and a reduced form welfare variable in the form of per-capita consumption expenditure. Firewood is the most commonly used forest good in rural Nepal. I have chosen consumption expenditure over per capita income, as for developing countries per capita consumption is a better predictor of well-being (Deaton & Zaidi, 1999). However, this welfare variable is derived in a way that does not include personal collection and so this variable is not carrying the impact of forest-good collection.

The main independent variable is a policy indicator, which is 1 if the household is around any newly established protected area. I define "around" primarily as within "20 kilometers",[4] based on the information in Figure 3. Figure 3 shows a sharp jump of firewood collection in the range of 0 km to 20 km around PAs. NLSS data is not geocoded, so I use the name of the villages to map with PAs and I take the distance from the villages to the border of the nearest

[4] A caveat with using this is that it may also capture the other market/non-market spillovers associated with PA (e.g. switch to alternative fuel, migration etc.). In later section I examine these points in more detail.

protected area. However, in later robustness checks I also change the definition of proximity to PAs to see how that affects the results. The treatment group consists of 372 households in 1995/1996 and 540 households in 2003/2004.

Based on the potential outcome framework, the empirical strategy is to compare changes in outcomes in regions with protected area to areas where similar types of forest livelihood exists. The basic regression framework I use is the standard form of difference-in-difference regression following Imbens and Wooldridge (2009):

$$Y_{ist} = \alpha + \beta D_s + \delta Post_t + \rho (D_s * Post_t) + \gamma X_{ist} + \varepsilon_{ist} \quad \textbf{(7)}$$

i indexes individual, *s* indexes group and *t* indexes post-treatment dummy. D_s is the treatment dummy, which is equal to one if household is in treatment group. $Post_t$ equals one if an observation is in the after-treatment period and zero otherwise. $(D_s * Post_t)$ is the policy dummy which is an interaction of the treatment dummy and post-period dummy, and it is equal to 1 if the household is in treatment group after the establishment of a new PA. The impact coefficient is ρ which will capture the impact of protected areas. X_{ist} is the vector of covariates. In my preferred specification, this will include education level and age of the household head, household size, asset value, number of households in the village, and number of casualties in the district. I also control geographic belt (hill, mountain and low land) if that is correlated with the unobservable. For some specifications (e.g., household head labor supply), I control for the occupation category also.

The main empirical challenge is to find a suitable counterfactual, i.e., a measure of what would have happened to the households if they had not been subjected to PA. To identify the counterfactual we need a community around a forest which is comparable to the treatment group in the covariates. Matching on observed covariates cannot solve the problem, as "forest dependency” and “PA site/location choice criteria” are not observed in the dataset. In order to reduce the bias potentially introduced by these unobservable differences of forest-livelihood across treated and untreated, I construct a control group of households who live around a forest, but not around any kind of protected areas. To figure out distance from the forest, I use community survey question for “distance to forest” where distance is measured in the unit of time (hour). I define the control group to live at most 6 hours (one-way) away from a forest. Six hours have been chosen by analyzing the covariate distribution of ‘distance to forest’ for treatment group and control group. I excluded from the control group all households who live around any PA established before August, 2015 (control households are at least 40 km away from all PAs). The control group consists of 276 households in 1996 and 660 households in 2003. However, this distance is self-reported by the village head and so, might have measurement error

Another concern is location choice to establish PA (Allcott, 2015). Site selection may depend on the biodiversity richness and its potential to attract tourists. This unobserved pre-treatment difference may underestimate the impacts by using the control group who are not around any PAs. Conventional adjustment on covariates also need not eliminate that bias (Rosenbaum, 1987), because there is no observable way to understand location choice. Using supplementary information on PA establishment, I take another control group who are 20-km around any protected area established before 1996. Some of these PAs also have been extended to create BZ in 2006/2007, after my study period. This second control group addresses specific limitation of the first control regarding location bias. These previously established PAs may have the same kind of site selection criteria like new ones, and these control households may have same kind of adjustment process in reaction to PAs.

Recall that Nepal has protected areas of different categories which I divide into two parts- one group for conservation area (CA) and national park (NP) and another group for buffer zone (BZ). CA and NP follow the same management structure, so I merge them together. To understand the difference in the impacts of these types of PAs, I will use the multiple-group DID regression framework which is a slight modification of (1).

$$Y_{ist} = \alpha + \delta\, Post_t + \beta_1\, BZ_s + \beta_2\, NP_s + \rho_1\, (BZ_s * Post_t) + \rho_2\, (NP_s * Post_t) + \gamma X_{ist} + \varepsilon_{ist} \qquad \textbf{(8)}$$

BZ is equal to one if the households are around a buffer zone and NP is equal to one if the households are around a national park or conservation area.

4.2 Identifying Assumptions

Timing and placement of PAs are exogenous to a local household's behavior. This assumption is valid for a few reasons. First, state-level decisions are unlikely to depend on household-level consumption or labor supply decisions. Second, even if there is some discussion with community leaders, individual households should not have enough power to influence the state policy. Third, unlike some African countries, Nepalese protected areas are not established based on local demand.

DID assumes that any unobserved time invariants that are correlated with both treatment status and outcome variable will not bias the treatment effect. The DID result can be interpreted as the causal effect of PAs, under the assumption that in the absence of PA the increase in outcomes would not be systematically different in these two groups. In other words, there needs to be parallel trends in outcome variables. Unfortunately, Nepal did not collect any national household level data before 1996. Demography and Health Survey 1987 is the only pre-1996 household survey Nepal has, but this is only a focus group study. In the absence of any pre-baseline data, it is impossible for me to check the parallel trend assumption by gathering a longer period of data. To develop some intuitive evidence regarding parallel trend, I employ the lifestyle data from the community questionnaire. NLSS asks the community head whether the village is on an upward welfare trend over the last five years. 86% of the control group and 88% of the treatment group confirmed that the village was in upward trend in 1996. In 2003, this went down to 68% and 71% respectively for both control and treatment group because of the nationwide economic crises. This welfare-trend is definitely a self-reported qualitative measurement, but the similarity between treatment and control groups by time shows a similar movement of welfare.

Given the constant treatment effect assumption, unconfoundedness or conditional independence assumption is equivalent to independence of treatment assignment and error conditional on covariates. Violation of this assumption is empirically not testable. I employ two indirect strategies. First, I estimate the causal effect on a treatment group that is known not to have any effect by new PAs in the study period. I use the households around the four PAs which are established in the period of 2009-2010, long after my study period. This “false” or experimental treatment group should not have any impact in the study period (1996-2003). Second, I check the causal effect on variables known to be unaffected by PA. At first, I use agricultural income derived from crop sale revenue and input expenditure. However, agricultural income might also be affected by treatment through productivity shock. For that, I employ another outcome variable that is an imputed (self-reported) rental value of the dwelling. These households mostly have inherited dwellings and so establishment of PA should not have any impact on this rental value.

The next requirement for valid DID is that the support of the distribution of the conditioning covariates in the treatment group should overlap with the support of the distribution of these covariates in the comparison group. Table-2 presents the covariate balance. Economic theory helps us in classifying which variables need to be balanced on the basis of their role in the theoretical model of household behavior. The model says that the household's treatment status and corresponding reaction depends on distance to forest, household size, and household-specific demographic and asset level. PA site selection may depend on revenue-generating possibility, we can proxy for it by variables such as distance to market, slope and population size. Nepal is geographically much dispersed, which makes the district level maximum elevation factor imbalanced in Table 2. However, as a robustness check I will run an analysis in which mean elevation is balanced.

5 Results

In this section, I present my average treatment effect estimates and conduct a series of robustness and placebo tests following regression models 7 and 8. Treatment households have been compared to the households around those forests which are not designated as PA (control-1). Treatment households are also compared to the households around PAs established before the study period (control-2).

I start by estimating a specification equivalent to regression model 7 for the actual and pseudo experiment by using repeated cross-section data. Table 3 presents the results. Recall that the coefficients for the policy variable (post*treatment) are the impacts of PA on the surrounding households. Column 1 shows that PA causes average firewood consumption to decrease by .096 bhari per day. Column 2 and 3 show that there is no significant average treatment effect on firewood collection time and per capita consumption expenditure (a bhari is a basket that people can carry on their backs supported by a brace). I have a natural "pseudo" experimental group from PAs established in 2009 and 2010; as expected, this pseudo treatment has no significant impact on firewood collection as shown in Table 4.

Now as described above, this control group may bias the result as these households do not live around any PA. To check that, I compare this result with another control group who live around previously established PAs. This treatment impact show similar signs and somewhat bigger magnitude of the effect. For this alternative control group, per day firewood consumption goes down by .138 bhari per day from R1.

I can now estimate a reduced form relationship from different protection intensity by estimating 8. The result relies on the assumption that there are no omitted time-varying and group-specific effects correlated with the program. The identification assumption might, therefore, be satisfied only after controlling for those factors and so, I present different specifications that control for the demographic and community level covariates which might be changing over time (e.g., population size). Table 5 presents the results using the control households that are not around any PAs. For the strict protected area group (NP/CA), the estimates of the effects of PAs on households vary in the range of 0.15 bhari to 0.18 bhari per day. For Buffer Zone areas, the estimated impact on firewood collection is not statistically significant. Again, the estimates show no treatment impact on per capita expenditure and firewood collection time.

Using the other control group, who live around previously established PAs, I get slightly different magnitude but similar signs. For strict PAs, again the estimates range from 0.19-0.22 bhari reduction per day. Interestingly, using this second control group, I get average treatment effect on firewood consumption around BZ is lower than NP in magnitude and the reduction in consumption ranges from .11 to .14 bhari per day by different specifications. Again, other outcome variables show no significant average treatment effect from PA establishment for this control group also. BZ was selected as a protected site from before and in this study period it has been just extended to a greater zone. Strict PAs, on the other hand, just have been proposed to be protected. However, BZ also have significant impact if I change the proximity to PA (as in Table 5, panel C). All the estimates from alternative control group is similar to Table 5(B).

I also investigate the robustness of the preceding results to a number of alternative specifications. Table 6(A) presents the result of changing the definition of treatment to proximity to PA of 10 kilometers. For strict PAs, this does not show any significant changes in the results. However, contrary to previous results, now BZ also has a significant negative impact on average firewood consumption. This shows that in a closer circle, establishment of BZ also has negative impacts like strict PA. Table 6 (B) presents the robustness across geographic variation. At first, on the premise that lowland may have different firewood demand than hill/mountain (Baland et al., 2010), I estimate regression model 8 after dropping lowland areas in Panel A of Table 6(B). In Panel B of Table 6(B), I estimate the results after balancing the mean elevation of the treatment and control group. Overall the results are quite robust. Panel C shows the results after transferring the outcome variable to the standard deviation from the mean consumption level of the villages and this shows that the households are merging to a common level of consumption after the establishment of PA.

To complement this analysis of repeated cross-section data, Table 8 presents the estimates using regressiom model 7 on NLSS panel data where observation number for the treatment group is 84 and observation number for the control group is 84. The results show a similar pattern to the repeated cross section results. However, only 30 households live around strict PAs in this panel, which prevents me from estimating model 8.

I conduct additional robustness checks also that are not reported here.[5] The results are stable when I remove the national park established in 2002. The results are also stable when I

[5] All the removed results are available from author.

take the “park specific tourism revenue of 2004” and “number of foreigners visited to parks in 2011” as proxies for expected revenue of the parks and use that as a continuous treatment variable to understand impacts of PAs on per capita consumption expenditure.

It is important to evaluate the magnitude of the consequences of the PAs’ effects. The unit of measurement for firewood collection is bhari, which is a Nepalese local measurement unit. I convert bhari to kilogram using NLSS information. On average one bhari equals 33.28 kilograms. From different specifications, a naïve calculation predicts 3 kg to 7 kg less firewood consumption per day by an average household around PA. It shows almost 30% to 70% decline from the pre-treatment firewood consumption. On average these villages have around 150 households, so a village consumes at least 450 kg less firewood every day because of the PA.

More insight into why and how PA affects the households is obtained in the next section by examining different other intermediate or alternative mechanisms.

6 Mechanisms

In theory, several other mechanisms could drive the statistical relationship between the outcome variables and the establishment of PAs: 1) migration and remittance income may mitigate the PA impacts on welfare outcomes, 2) formation of community forest may also mitigate PA impacts, 3) decreased firewood consumption can be a response to conservation campaigns around PAs, 4) local labor and commodity market may also affect the causal relationship between PAs and welfare outcomes. In this section, I test these mechanisms to assess the validity of the core results. Table 9 presents tests of these mechanisms.

First, the establishment of PAs could cause increased migration around PAs. Movement of some individuals might not have any substantial impact on household’s firewood collection as per capita firewood consumption is almost negligible in any household. However, migration might be an important pathway for improving welfare outcomes. To check that, I employ two strategies. First, I use incoming remittance as another outcome variable. Table 9 shows that PAs do not have any effect on remittance. Second, I explicitly test for migration by using the number of migrated people from any household. If migration drives the core result, we would expect more people to migrate from the treatment region, but results show no significant impact.

Second, the impacts of PAs on forest-good consumption might also be influenced by the access to community forest. Nepalese government gives the right to form community forest to any group of people living around forest if they apply to the district-level administration. If there is spatial correlation between formation of forest-user group and establishment of protected area in a systematic manner, and people around new PAs are more inclined to form CF, then the access to CF likely to make people better off and reduce the negative impacts of PAs.

NLSS only asks the village head if the village has any community forest. This information is not useful as it may happen that the village has more than one CF, and the household still does not have membership in any of them. So I indirectly test this by using the location for firewood collection, which is a close proxy of “membership in CF”. NLSS divides this forest-land to collect firewood into government forest and community forest. If the household is collecting resource from community forest then it is definitely a member of a CF; otherwise it would not have the access to CF. I make a binary dummy for whether the household uses community forest. Column 4 of Table 9 shows that there is a significant positive probability around BZ to change the place of collection from the government forest to the community forest. Interestingly, people around strict PAs do not have any significant inclination to use CF. This may happen for two reasons: 1) people around newly established strict PAs may take more time to form a CF and that may affect the bureaucratic process of forming a CF, 2) the compensation mechanism around BZ may include CF clause. However, NLSS does not have detailed information to check these hypotheses.

Third, one may argue that the declining amount of forest-good consumption is an impact of awareness campaigns around PAs about ecological conservation. I try to explore this in two indirect ways. First, the dataset has information about the details of crop diversification which is an indicator of soil conservation. I extract a variable “crop rotation” from agricultural portion of the household dataset, which is an average number of crops on any plot owned by the households. On average these households cultivate 2 to 4 crops in any plot during a year. Table 9 shows that there is no significant treatment effect of PAs on crop rotation.

Economic intuition on private good versus common-pool resource suggests that households’ decisions regarding soil conservation can be very different than decisions about forest conservation. As an alternative strategy, I use the household’s choice of stove to explore the conservation idea. More than 95% of Nepal’s rural people use either mud-stove or open fireplace. Though both of these stoves use firewood to produce energy, mud stove is environmentally more efficient. I use a binary variable regarding stove choice of the households. PA establishment has no causal effect on stove choice, suggesting that the effect of PAs on wood-collection is not due to the changing attitude toward ecological conservation.

Fourth, one other argument could be that the people around PAs will switch to market alternatives for fuel as a reaction to PA. However, combining both treatment and control group, my whole dataset has only seventy-eight people using anything other than firewood. It can either be a result of very high fixed cost of shifting toward market fuels or strong habit persistence toward using traditional fuel. I argue that while there is a clear evidence that households do not shift toward market, there are not enough data to help us distinguish between these two reasons.

Marketing strategy?

Fifth, it may happen that households, being helped by spillovers from the PAs, have reduced labor supply but continued to have same consumption expenditure. This substitution of labor supply would also create greater welfare (more leisure in Equation 1) but we will not be able to see that from the analysis on per capita consumption expenditure. Column 3 of Table 9 shows that there is no visible sign of changing labor supply around strict protected areas. PAs have a negative significant impact on households around buffer zone, though at a very low significance level. The compensation mechanism around BZ may influence this, but we cannot infer anything from this very low level of significance.

Moreover, it may also happen that establishment of PA increases unemployment by moving people from forest-good collection. At the same time PA does not create jobs for those people, as employment at tourist spot is under the central government and also, tourism industry demands more skilled people. I extract a variable "number of unemployed" by households indicating the number of individuals in a household who are actively looking for job. Column 7 does not show any significant average treatment impact on unemployment.

For the alternative control group, the probability of changing to a CF around BZ does not have any treatment effect. One possible explanation could be that every PA community has same inclination to form CF and so, even if we see difference in changing to community forest when we are having control-1, we do not see that difference from control-2. All the other estimates are similar.

7 Conclusions

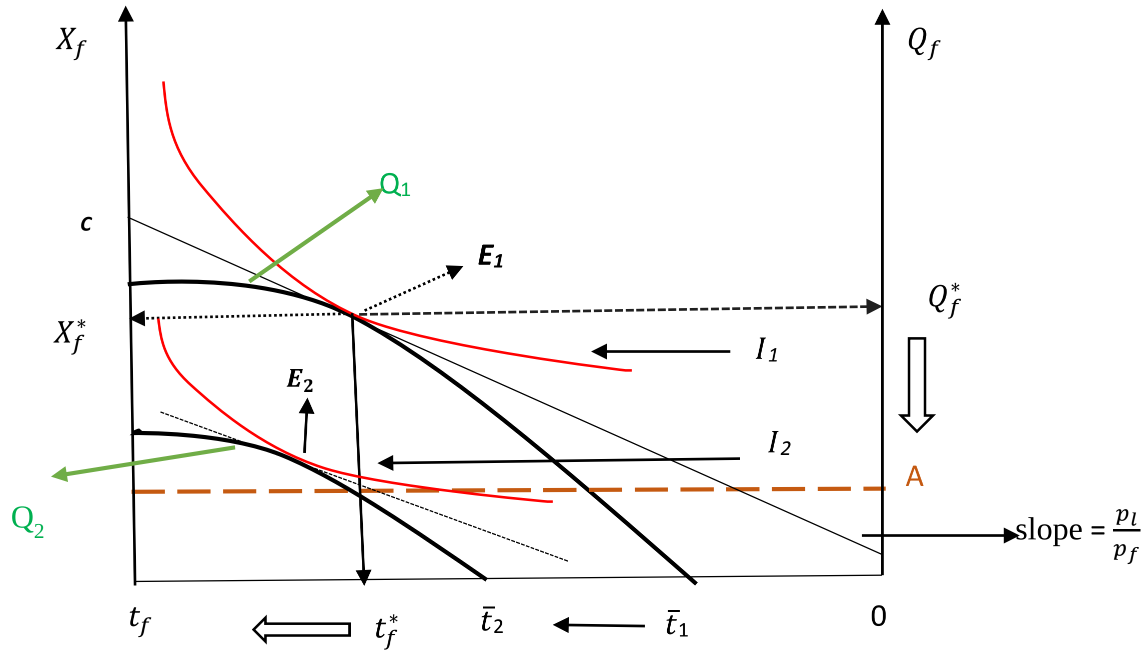
Establishment of PAs Nepal led to a decrease of firewood collection and consumption around PAs. The estimates of the effect of PAs on households vary in the range of 30% to 70%

compared to the pre-PA period. However, this decrease has not translated into a larger market participation for alternative fuel choices. Also, the establishment of PAs is not associated with significant changes in the standard of living of people who live near them; PAs have not inflicted great harm, not has establishment of an ecotourism industry led to great gains for local people in the study period. These results are robust to different alternative specifications and survive tests of internal validity, falsification tests, and inclusion of a wide range of control variables.

This study has policy implications for the design of conservation instruments. First, the results show that PAs can result in reduced forest-good collection without necessarily having a significant harmful effect on total household consumption. Policy makers should not always assume that PAs will hurt local people. Second, more stringent conservation measure can indeed have more beneficial effects in forest protection. Third, planners should not assume that PAs will attract ecotourism that will actually make local people better all; there is certainly no evidence of that in Nepal. A detailed understanding of local labor and commodity market is required before making any causal connection between the establishment of PAs and human welfare. However, disentangling direct impacts and market consequences of PAs is particularly important in light of IUCN's recent advocacy of the Payment for Ecosystem Services in Nepal (Paudel et al., 2015). It remains possible that these results are Nepal specific, and cannot be generalized to other situations with different political economy of forest management.

One limitation of my study is that it does not include indirect (displacement) impact of tourism on the labor market outcomes. The employees in the tourism sector may consist of temporary migrants and omitting this spillover may underestimate the overall welfare impacts. However, my dataset does not allow me to check for this possibility. Also, PA-based infrastructure development may take a longer period to influence the local market than my study duration. Tracking these PA communities for a longer period of time will help us to distinguish steady-state equilibrium from transitional impacts. Furthermore, this paper handles only average treatment effects and does not deal with any distributional burden of PAs. The poorest cohort may bear the largest adverse impact from PAs if they depend on the forest for basic survival. Answering these questions is beyond the scope of this paper, but future research could use the establishment of PAs to understand these incentives and welfare effects

Figure 1: Household's consumption and collection behavior



NOTES:

1) The *Y* axis on the right side is the forest good collection of a household.

2) The *Y*-axis on the left side presents consumption of the same good.

3) The *X*-axis is time spent in forest.

4) I_1 is the indifference curve associated with Equation (1).

5) Q_1 is the initial collection function as in Equation (3).

6) *A* denotes the subsistence level of the forest good.

7) $\bar{t}_1$ denotes the commuting cost to reach the nearest forest to collect the resource.

8) The model assumes the household does not collect more or less than it consumes.

9) The optimal amount of forest good to collect is Q_f^* and the optimal consumption is X_f^*.

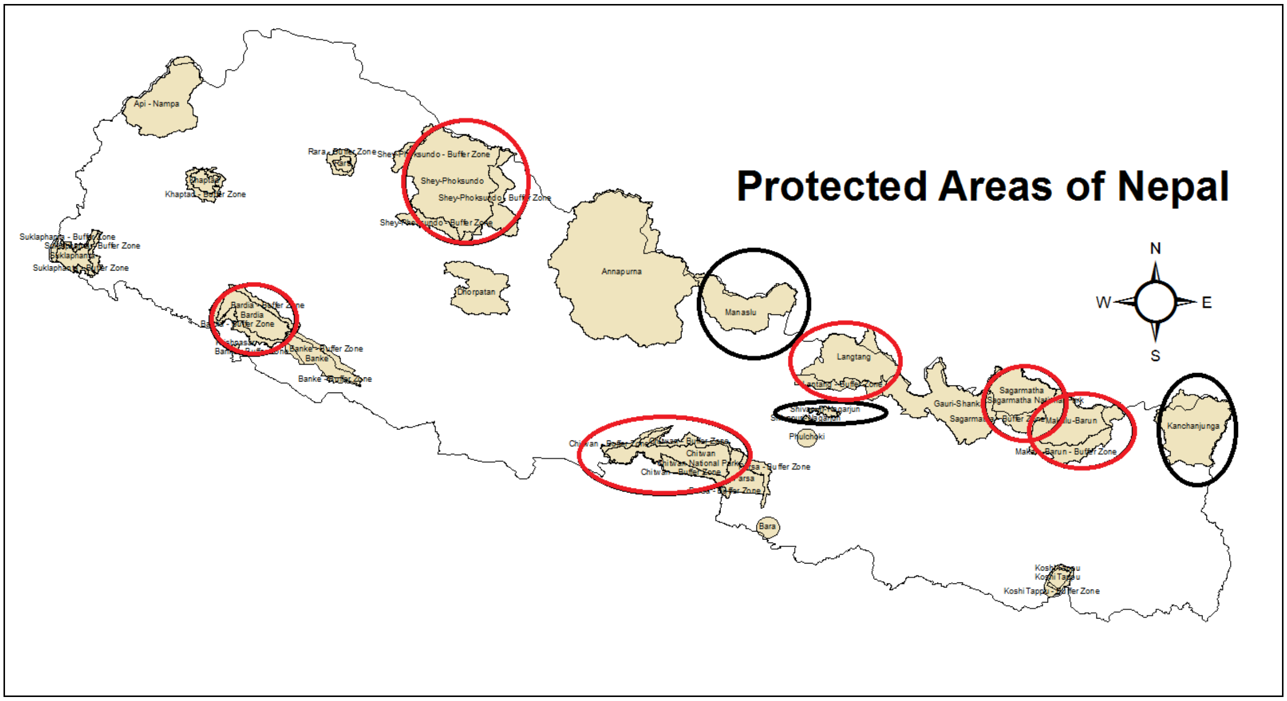
10) The household spends time, t_f^* to collect Q_f^*.

11) A protected area (PA) moves the collection function to Q_2. The PA may increase the commuting cost to $\bar{t}_2$[6] and PA households will be able to collect less forest good by using the same time, as the size of the unrestricted forest is smaller than before. Thus, Q^2 is flatter than Q^1.

12) I_2 is the highest indifference curve that can be achieved with the PA.

[6] Another case may arise if the park has been placed in the inner circle of the forest. Households may not need to spend more time in forest, $\bar{t}_2 \leq \bar{t}_1$. As the area of the unrestricted forest will go down, the slope of the collection function will be similar as Q_2. So time to collect forest resource would depend on the location of park. Amount of collection is always expected to decrease.

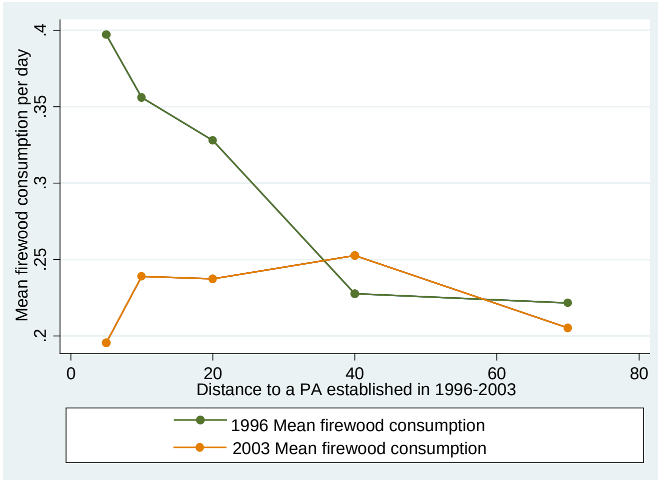
Figure 2: Protected Areas of Nepal



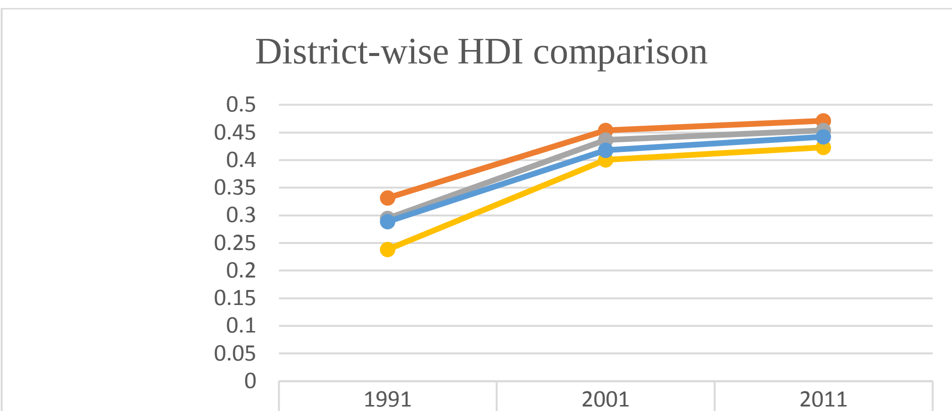
Note: Treatment areas are circled (PAs established in 1996-2003), BZ in red circle and NP/CA in black circle.

Source of shape file: World Database of Protected Area, Available at: www.protectedplanet.net

Figure 3: The correlation between distance to PA and forest good collection



Note: Intuitively, this shows the reason to use “20 km” as the treatment distance. After 20 km, the before-after contrast is negligible if we compare mean collection in 1996 with mean collection in 2003.



	1991	2001	2011
Treatment	0.3316923	0.454	0.4711923
distance Control	0.2943158	0.4362895	0.4536053
old pa control	0.23845	0.4006	0.42327
new pa control	0.28866	0.4177	0.44233

Source: UNDP Human Development Index Report

Table 1 Timeline: Establishment of Protected Areas in Nepal (1996-2003)

	Name of the Protected Area	Category	Year of Establishment	Area (square km)	Area before establishing BZ (sq. km)	Number of Species	Revenue (2004 Dollar)
a)	Kanchanjenga CA	1	1998	2035		293	2849
b)	Manaslu CA	1	1998	1663		214	
c)	Bardia NP	2	1996	328	968	632	49468
d)	Chitwan NP	2	1996	750	932	777	534143
e)	Langtang NP	2	1998	420	1710	396	48312
f)	MakaluBarun NP	2	1999	830	1500	529	1580
g)	Shivpuri-Nagarjun NP	1	2002	159		333	31611
h)	Sagarmantha NP	2	2002	275	1148	247	193446
i)	Sheyphoksundo NP	2	1998	1349	3555	246	1776

Source: Nepal Biodiversity Strategy (2002) and WDPA.

Category 1: Conservation Area and National Park, and Category 2: Buffer Zone; * (a) – (i) show the treatment group, where a,b and g are strict PAs

Table 2 (A): Mean Difference between Treatment and Control Community

	Control 1996 Mean	SD	Treatment 1996 Mean	SD	Mean Difference 1996	(t-statistics)	Control 2003 Mean	SD	Treatment 2003 Mean	SD	Mean Difference 2003	(t-statistics)
Distance to PA (km)	63.990	18.522	10.173	5.347	53.82	22.19	66.0707	20.175	7.604	6.084	58.47	18.94
Distance to any forest (hour)	2.368	1.5360	2.2827	2.228	0.086	0.22	1.8045	1.573	1.297	1.119	0.507	1.89
Number of HHs	161.681	176.039	158.619	167.822	3.063	0.09	214.814	176.021	200.711	208.502	14.10	0.40
Population of ward	917.477	908.234	1083.968	1220.986	-166.5	-0.77	1233.037	987.652	1141.614	1044.862	91.42	0.48
Distance to market (hour)	9.630	25.696	14.507	40.117	-4.877	-0.73	2.802	5.3348	5.7111	13.710	-2.909	-1.70
Maximum elevation ('000meters, district level)	2.602	.0998	4.657	.1501	-2.0548	-10.57	2.302	.0687	4.341	.1153	-2.0389	-15.793

Table 2 (B): Mean Difference between Treatment and Control Households

Variables	(1) Control 1996 mean	SD	(3) Treatment 1996 mean	SD	(5) 1996 Difference	t-stat	(2) Control 2003 mean	SD	(4) Treatment 2003 mean	SD	(6) 2003 Difference	t-stat
Household size (# people)	5.7161	.155	5.978	.151	-0.2625	1.2	5.402	.1004	5.394	.127	0.0075	0.11
Head age (years)	45.236	.924	44.487	.751	0.749	0.632	45.352	.5514	45.136	.6172	0.2153	0.264
Literacy head (year of education)	1.271	.027	1.244	.0241	.0266	0.734	1.353	.0188	1.440	.0224	-0.087	2.98
Dwelling value (Nepalese Rupee)	49186.8	6434.45	37812.92	2879.08	11373.88	1.615	128643.6	9292.08	145557.8	11645.41	-16914	1.135
Time to collect FW (hour)	4.456	.175	5.025	.1718	-0.5692	2.33	3.607	.0893	3.907	.299	-0.256	-2.291
Annual Per capita consumption (Nepalese Rupee)	7497.24	334.99	6851.983	224.57	645.257	1.590	12562.03	567.362	15619.53	574.504	-3057.5	-3.78
Wood consumption per day (in bhari)	.2462	.0122	.3291	.0104	-0.082	-5.005	.2115	.0055	.2222	.0072	-0.0133	-1.178
Observations	276		372				660		540			

[1]To utilize the survey nature of NLSS, the covariate means are estimated using sampling weights.

Table 3: Impact of Protected Area on surrounding households (Estimating R1)

	Panel A	Control -1		Panel B	Control-2	
VARIABLES	(1) Quantity of Firewood Collection	(2) Per Capita Expenditure	(3) Firewood Collection Time	(4) Quantity of Firewood Collection	(5) Per Capita Expenditure	(6) Firewood Collection Time
Post*Treatment Dummy	-0.0957**	1,385	0.0583	-0.138***	-541.8	-0.0321
	(0.0421)	(1,286)	(0.916)	(0.0315)	(1,297)	(0.726)
Treatment Dummy	0.103***	-1,252	0.385	0.150***	896.3	0.108
	(0.0364)	(844.3)	(0.752)	(0.0248)	(662.4)	(0.632)
Post	-0.0131	3,365***	-1.070	0.00341	5,896***	-1.257**
	(0.0330)	(965.5)	(0.719)	(0.0180)	(1,062)	(0.554)
Constant	0.161***	12,003***	4.125***	0.156***	9,485***	4.209***
	(0.0404)	(1,675)	(0.774)	(0.0262)	(1,504)	(0.545)
Observations	1,396	1,468	1,320	1,262	1,425	1,249
R-squared	0.169	0.257	0.083	0.208	0.291	0.116
HH Controls	YES	YES	YES	YES	YES	YES
Village Controls	YES	YES	YES	YES	YES	YES
Geographic Controls	YES	YES	YES	YES	YES	YES

[1]Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.
[2] Column 1, 2 and 3 show DID estimates compared with Control-1 and Column 4, 5 and 6 shows DID estimates compared with Control-2. Control-1 is defined as households living around forests but not close to any PA. Control-2 is defined as households living around pre-1996 PAs. Column 1 and 4 shows impact on per day firewood collection amount. Column 2 and 5 shows impact on per capita expenditure. Column 3 and 6 shows impact on firewood collection time.
[3]Controls include demographic features- household size, age and literacy of the household head, asset value; village controls- number of households in the village, geographic belt, and conflict casualties.
[4]Firewood collection quantity has been measured in bhari/per day (1 bhari = 33.28 kg). Per capita consumption has been measured in Nepalese Rupee. Time has been measured in hour to collect one bhari.
[5]As the sampling procedure is exogenous, regression estimates are not weighted using sampling weight (Solon et al., 2013)

Table 4: Control (Pseudo) Experiment

VARIABLES	Panel – A: Control-1 Quantity of Firewood Collected	Panel-B: Control-2 Quantity of Firewood Collected
Post*Pseudo Treatment Dummy	0.0124	-.00919
	(0.0338)	(.01911)
Pseudo Treatment Dummy	-0.00562	.02102
	(0.0271)	(.01443)
Post	-0.0214	-.00037
	(0.0209)	(.00965)
Constant	0.181***	.15798
	(0.0191)	(.01137)
Observations	1,625	1017
R-squared	0.052	0.0673
HH Controls	YES	YES
Village Controls	YES	YES
Geographic Controls	YES	YES

[1]Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.
[2]Pseudo Treatment group is defined as households near the PAs established in 2009-2010, far later than my study period.
[3] Control-1 is defined as households living around forests but not close to any PA. Control-2 is defined as households living around pre-1996 PAs.

Table 5 (A): Estimating R2- Impact of Protected Areas on Surrounding Households (by protection intensity) Using Control-1

VARIABLES	(1) Quantity of Firewood Collected	(2) Quantity of Firewood Collected	(3) Quantity of Firewood Collected	(4) Quantity of Firewood Collected	(5) Firewood Collection Time	(6) Firewood Collection Time	(7) Firewood Collection Time	(8) Firewood Collection Time	(9) Annual Per Capita Expenditure	(10) Annual Per Capita Expenditure	(11) Annual Per Capita Expenditure	(12) Annual Per Capita Expenditure	(13) Agricultural Income	(14) Rent of the Dwelling
Post*NP/CA	-0.177***	-0.148***	-0.149***	-0.162***	-0.683	-0.643	-0.643	-0.458	3,165	246.9	504.5	500.6	1,090	132.2
	(0.0607)	(0.0552)	(0.0544)	(0.0526)	(0.938)	(0.988)	(0.976)	(1.064)	(2,420)	(1,531)	(1,515)	(1,496)	(1,857)	(116.6)
Post*BZ	-0.0411	-0.0407	-0.0361	-0.0515	0.388	0.353	0.216	0.466	2,745	1,852	1,666	1,887	970.7	34.00
	(0.0448)	(0.0451)	(0.0456)	(0.0464)	(0.710)	(0.745)	(0.744)	(1.025)	(1,677)	(1,492)	(1,489)	(1,610)	(1,713)	(143.9)
NP/CA	0.202***	0.186***	0.190***	0.172***	0.573	0.665	0.765	0.823	1,199	483.4	198.5	-79.01	608.1	-62.29
	(0.0492)	(0.0444)	(0.0456)	(0.0444)	(0.895)	(0.947)	(0.936)	(0.978)	(1,092)	(991.7)	(1,034)	(1,070)	(1,229)	(47.02)
BZ	0.0463	0.0385	0.0473	0.0635	0.115	0.283	0.319	0.0918	-1,133	-1,065	-1,852*	-1,889**	815.5	-39.21
	(0.0414)	(0.0405)	(0.0419)	(0.0385)	(0.623)	(0.652)	(0.647)	(0.799)	(784.5)	(823.2)	(955.5)	(931.2)	(1,168)	(65.56)
Post	-0.0335	-0.0341	-0.0290	-0.0218	-1.044**	-0.965*	-0.984*	-1.159	4,923***	4,082***	3,497***	3,275***	-1,823	90.35
	(0.0340)	(0.0334)	(0.0338)	(0.0335)	(0.499)	(0.516)	(0.501)	(0.720)	(1,032)	(938.0)	(890.6)	(993.7)	(1,182)	(67.46)
Constant	0.246***	0.165***	0.160***	0.169***	4.661***	4.470***	4.141***	4.231***	7,495***	11,710***	11,551***	12,002***	-2,867	226.5
	(0.0320)	(0.0352)	(0.0395)	(0.0416)	(0.468)	(0.578)	(0.582)	(0.769)	(661.0)	(1,463)	(1,563)	(1,642)	(2,149)	(155.7)
Observations	1,747	1,408	1,396	1,396	1,620	1,330	1,320	1,320	1,848	1,480	1,468	1,468	1,439	1,233
R-squared	0.107	0.141	0.152	0.184	0.054	0.064	0.077	0.087	0.086	0.244	0.257	0.258	0.101	0.292
HH Controls	NO	YES	YES	YES	NO	YES	YES	YES	NO	YES	YES	YES	YES	YES
Village Controls	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES	YES	YES
Geographic Controls	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO	YES	YES	YES

[1]Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.
[2]Columns show DID estimates. Control is defined as households living around forests but not close to any PA. Column 1 to 4 shows impact on per day firewood collection amount (bhari/day). Column 5 to 8 shows impact on collection time (hour). Column 9 to 12 show impact on per capita consumption expenditure (in Nepalese Rupee). Column 13 and 14 shows the impacts on placebo outcomes, agricultural income and rent of the dwelling.
[3]Controls include demographic features- household size, age and literacy of the household head, asset value; village controls- number of households in the village, geographic belt, and conflict casualties.

Table 5(B): Estimating R2- Impact of Protected Area on Surrounding Households (by protection intensity) Using Control-2

VARIABLES	(1) Quantity of Firewood Collected	(2) Quantity of Firewood Collected	(3) Quantity of Firewood Collected	(4) Quantity of Firewood Collected	(5) Per Capita Expenditure	(6) Per Capita Expenditure	(7) Per Capita Expenditure	(8) Per Capita Expenditure	(9) Firewood Collection Time	(10) Firewood Collection Time	(11) Firewood Collection Time	(12) Firewood Collection Time	(13) Agricultural Income	(14) Rent of House
Post*NP/CA	-0.227***	-0.196***	-0.207***	-0.204***	1,347	-1,326	-1,985	-2,137	-0.714	-0.624	-0.188	-0.0980	1,368	222.8
	(0.0547)	(0.0515)	(0.0517)	(0.0519)	(2,483)	(1,624)	(1,647)	(1,632)	(0.901)	(0.898)	(0.946)	(0.950)	(2,063)	(135.2)
Post*BZ	-0.118***	-0.131***	-0.140***	-0.119***	818.5	865.4	-56.06	529.6	0.175	0.0724	0.289	0.0188	893.7	60.63
	(0.0389)	(0.0376)	(0.0402)	(0.0385)	(1,778)	(1,538)	(1,526)	(1,499)	(0.706)	(0.717)	(0.795)	(0.817)	(1,487)	(121.7)
NP/CA	0.255***	0.242***	0.263***	0.231***	1,753*	1,528	2,102**	1,926*	0.400	0.300	0.194	0.131	286.6	-1.897
	(0.0411)	(0.0385)	(0.0397)	(0.0379)	(1,029)	(931.1)	(952.6)	(1,017)	(0.828)	(0.818)	(0.873)	(0.892)	(1,103)	(46.70)
BZ	0.124***	0.122***	0.138***	0.134***	-470.5	-293.6	379.1	265.4	0.124	0.168	0.0257	0.0906	-1,347	21.69
	(0.0337)	(0.0315)	(0.0342)	(0.0315)	(724.7)	(633.8)	(667.7)	(635.9)	(0.578)	(0.578)	(0.689)	(0.675)	(994.4)	(71.67)
Time	0.00945	0.0118	0.0262	0.0150	6,741***	5,600***	6,135***	5,844***	-1.013**	-0.964**	-1.400**	-1.261**	-1,539	57.03
	(0.0215)	(0.0208)	(0.0238)	(0.0199)	(1,170)	(979.6)	(1,056)	(1,063)	(0.425)	(0.432)	(0.552)	(0.554)	(967.7)	(64.64)
Constant	0.184***	0.127***	0.0886***	0.125***	6,941***	9,078***	8,798***	9,735***	4.834***	5.048***	4.638***	4.226***	-2,019	81.74
	(0.0170)	(0.0198)	(0.0268)	(0.0275)	(550.8)	(1,113)	(1,518)	(1,433)	(0.321)	(0.374)	(0.519)	(0.554)	(2,040)	(114.8)
Observations	1,764	1,565	1,425	1,425	1,764	1,565	1,425	1,425	1,501	1,380	1,249	1,249	1,389	1,205
R-squared	0.143	0.189	0.214	0.249	0.136	0.289	0.290	0.293	0.054	0.057	0.101	0.116	0.105	0.218
HH Controls	NO	YES	YES	YES	NO	YES	YES	YES	NO	YES	YES	YES	YES	YES
Village Controls	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES	YES	YES
Geographic Controls	NO	NO	NO	YES	NO	NO	NO	Yes	NO	NO	NO	YES	YES	YES

**Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1. Columns show DID estimates compared with Control-2. Control-2 is defined as households living around PAs established before 1996. Column 1 to 4 shows impact on per day firewood collection amount. Column 5 to 8 shows impact on collection time. Column 9 to 12 show impact on per capita consumption expenditure (in Nepalese Rupee). Column 13 and 14 shows the impact on placebo outcomes.

Table 6(A): Robustness Checks - Impact of Protected Area on Treatment (where Treatment is Distance to PA <=10 KM)

VARIABLES	(1) Quantity of Firewood Collected	(2) Quantity of Firewood Collected	(3) Quantity of Firewood Collected	(4) Quantity of Firewood Collected	(5) Firewood Collection Time	(6) Firewood Collection Time	(7) Firewood Collection Time	(8) Firewood Collection Time	(9) Per Capita Expenditure	(10) Per Capita Expenditure	(11) Per Capita Expenditure	(12) Per Capita Expenditure
Post*NP/CA	-0.162**	-0.126**	-0.127**	-0.135**	-0.237	-0.199	-0.107	0.201	4,101	557.0	932.9	992.0
	(0.0697)	(0.0622)	(0.0612)	(0.0576)	(0.727)	(0.778)	(0.770)	(0.928)	(2,956)	(1,843)	(1,832)	(1,767)
Post*BZ	-0.101**	-0.103**	-0.0995**	-0.0924*	0.932	0.998	0.748	1.063	2,912	1,355	830.9	1,100
	(0.0463)	(0.0465)	(0.0487)	(0.0551)	(0.821)	(0.861)	(0.832)	(1.101)	(2,119)	(1,830)	(1,922)	(2,088)
NP/CA	0.171***	0.157***	0.161***	0.137***	0.215	0.363	0.414	0.418	636.6	-191.8	-572.1	-849.8
	(0.0570)	(0.0499)	(0.0507)	(0.0492)	(0.656)	(0.704)	(0.702)	(0.791)	(1,222)	(1,297)	(1,299)	(1,345)
BZ	0.0968**	0.0947**	0.101**	0.0985**	-0.0718	0.0689	0.120	-0.0908	-1,009	-795.4	-1,219	-1,343
	(0.0424)	(0.0419)	(0.0452)	(0.0474)	(0.704)	(0.742)	(0.705)	(0.824)	(956.4)	(1,026)	(1,238)	(1,219)
Time	-0.0335	-0.0329	-0.0296	-0.0274	-1.044**	-0.956*	-1.003**	-1.327*	4,923***	4,061***	3,502***	3,349***
	(0.0340)	(0.0334)	(0.0339)	(0.0344)	(0.500)	(0.517)	(0.501)	(0.746)	(1,033)	(933.0)	(886.0)	(1,052)
Constant	0.246***	0.164***	0.155***	0.167***	4.661***	4.758***	4.369***	4.626***	7,495***	12,235***	12,250***	12,560***
	(0.0321)	(0.0360)	(0.0401)	(0.0451)	(0.469)	(0.578)	(0.585)	(0.778)	(661.7)	(1,741)	(1,814)	(1,885)
Observations	1,415	1,144	1,132	1,132	1,311	1,079	1,069	1,069	1,500	1,202	1,190	1,190
R-squared	0.096	0.128	0.135	0.176	0.046	0.062	0.086	0.104	0.071	0.233	0.244	0.244
HH Controls	NO	YES	YES	YES	NO	YES	YES	YES	NO	YES	YES	YES
Village Controls	NO	NO	Yes	Yes	NO	NO	Yes	Yes	NO	NO	Yes	Yes
Geographic Controls	NO	NO	NO	Yes	NO	NO	NO	Yes	NO	NO	NO	Yes

[1]Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.

[2]Columns show DID estimates compared with Control-l. Control-1 is defined as households living around forests but not close to any PA. Column 1 to 4 shows impact on per day firewood collection amount (bhari/day). Column 5 to 8 shows impact on collection time (hour). Column 9 to 12 show impact on per capita consumption expenditure (in Nepalese Rupee).

Table 6 (B): Robustness Checks: Impact of Protected Area on Treatment (Excluding lowland, balancing elevation, changing outcome variable)

	Panel-A Excluding Lowland			Panel-B Balanced Mean Elevation			Panel C Standard Deviation from Village Mean
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Quantity Firewood Collected	Firewood Collection Time	Annual PerCapita Expenditure	Quantity Firewood Collected	Firewood Collection Time	Annual PerCapita Expenditure	Standard Deviation Firewood Collection
Post*NP/CA	-0.127**	-0.616	1,343	-0.267***	0.580	1,587	-0.0328***
	(0.0542)	(1.087)	(1,765)	(0.0992)	(0.703)	(2,188)	(0.0124)
Post*BZ	-0.0771	-0.353	2,047	-0.0109	1.332	2,041	-0.00356
	(0.0519)	(1.245)	(1,669)	(0.0488)	(1.193)	(1,802)	(0.0106)
NP/CA	0.146***	1.155	-631.4	0.206**	-1.199*	842.9	0.0310***
	(0.0469)	(0.967)	(1,141)	(0.0873)	(0.658)	(1,409)	(0.0104)
BZ	0.0509	0.863	-1,937	0.0538	-0.826	-2,038**	0.00108
	(0.0467)	(0.870)	(1,217)	(0.0425)	(1.110)	(954.1)	(0.00838)
Post	-0.0451	-0.838	2,225*	-0.0276	-2.113**	4,365***	-0.00356
	(0.0404)	(0.792)	(1,247)	(0.0340)	(1.036)	(897.9)	(0.0106)
Constant	0.159***	3.527***	14,332***	0.182***	5.439***	9,974***	0.0254**
	(0.0484)	(0.876)	(1,946)	(0.0434)	(1.077)	(1,973)	(0.0109)
Observations	963	942	987	1,059	984	1,123	1,172
R-squared	0.212	0.121	0.253	0.156	0.123	0.270	0.052
HH Controls	YES	YES	YES	YES	YES	YES	YES
Village Controls	YES	YES	YES	YES	YES	YES	YES
Geographic Controls	YES	YES	YES	YES	YES	YES	YES

[1]Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.
[2]Columns show DID estimates. Control is defined as households living around forests but not close to any PA. Column 1 to 4 shows impact on per day firewood collection amount (bhari/day). Column 5 to 8 shows impact on collection time (hour). Column 9 to 12 show impact on per capita consumption expenditure (in Nepalese Rupee). Column 13 and 14 shows the impact on placebo outcomes.
[3]Controls include demographic features- household size, age and literacy of the household head, asset value; village controls- number of households in the village, geographic belt, and conflict casualties.
[4]For Panel-B, mean(maximum elevation for control group) = 2.30, and mean(maximum elevation for treatment group)= 2.18
[5]Panel D presents the rate at which households are moving toward the village mean of quantity of firewood collection.
[6]To conserve space, this table reports only final specifications.

Table 7: Panel group characteristics at baseline

	(Control)		(Treatment)		(Mean Difference)	
	Mean	SD	Mean	SD		SD
Household size	5.958333	2.714684	5.922619	2.266647	0.0357	0.13
Per-capita consumption	6943.966	5205.649	7101.549	4201.677	-157.6	-0.22
Firewood consumption	.2700224	.204959	.3331325	.2026258	-0.0631**	-2.74
Distance to nearest PA	62.93024	19.18381	9.916786	6.308276	53.01***	34.03
Value of the land	143977	122827.4	172094.6	383740	-28117.6	-0.61
Distance to forest (hour)	2.011905	1.225908	2.625	1.668437	-.6130952**	.226578
Distance to market (min)	147.2727	39.01049	176.7949	81.92975	-29.52214	25.61845
Observations	168		168		336	

Table 8: Impact of Protected Area on Firewood Collection

VARIABLES	(1) Firewood Collection (Difference in Difference)	(2) Time to Collect (Difference in Difference)
Post*Treatment	-0.204***	1.046
	(0.0586)	(1.205)
Post	0.0524	-2.330*
	(0.0534)	(1.115)
Treatment (Group)	0.149*	-0.0176
	(0.0736)	(1.208)
Constant	0.0842	5.234***
	(0.0720)	(1.010)
Observations	349	309
R-squared	0.289	.107
HH Controls	YES	YES
Village Controls	YES	YES

[1]Standard errors are in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.
[2] Columns show DID estimates compared with Control. Control is defined as households living around forests but not close to any PA.
[3]Only 30 households live around strict PAs in this panel dataset, which restricts me to estimate regression model 8.

Table 9(A): Mechanisms using Control-1

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	**Number of Migrants**	**Total Remittance**	**Household Head Per Day Labor Supply**	**Community Forest**	**Crop Rotation**	**Stove Choice**	**Unemployed**
Post*NP/CA	0.0953	7,130	0.443	-0.0880	-0.0274	0.116	-0.0366
	(0.0697)	(19,498)	(0.661)	(0.0855)	(0.303)	(0.144)	(0.115)
Post*BZ	0.0347	-2,359	-1.006*	0.310***	0.292	-0.0260	0.0404
	(0.0747)	(24,594)	(0.550)	(0.104)	(0.278)	(0.121)	(0.132)
NP/CA	-0.138**	-25,269	0.271	-0.0314	0.272	0.0321	0.0391
	(0.0553)	(19,685)	(0.595)	(0.0584)	(0.230)	(0.117)	(0.112)
BZ	0.0146	-3,065	0.830*	-0.0120	-0.0370	0.0640	-0.0200
	(0.0644)	(21,978)	(0.452)	(0.0517)	(0.154)	(0.0753)	(0.112)
Post	-0.139**	1,386	1.389***	0.0965*	3.304***	-0.0331	-0.138
	(0.0564)	(16,775)	(0.354)	(0.0581)	(0.178)	(0.0800)	(0.0965)
Constant	0.249***	-15,016	3.230***	0.202***	0.403**	0.413***	0.461***
	(0.0850)	(17,367)	(0.747)	(0.0738)	(0.171)	(0.101)	(0.154)
Observations	1,468	360	1,618	1,468	1,624	1,373	1,468
R-squared	0.051	0.086	0.182	0.150	0.505	0.261	0.009
HH Controls	YES	YES	YES	YES	YES	YES	YES
Village Controls	YES	YES	YES	YES	YES	YES	YES
Geographic Controls	YES	YES	YES	YES	YES	YES	YES

[1]Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.
[2]Columns shows DID estimates. Control is defined as households living around forests but not close to any PA. Column 1 shows impact on number of migrated people, column 2 shows impact on total remittance, column 3 shows impact on labor supply, column 4 shows impact on the probability of collecting firewood from community forest, column 5 shows impacts on crop rotation, column 6 shows impact on energy efficient stove choice, column 7 shows impact on number of unemployed. Controls include demographic features- household size, age and literacy of the household head, asset value; village controls- number of households in the village, geographic belt, and conflict casualties.
[3]For the binary outcomes, I use linear probability model.

Table 9(B): Mechanisms using Control-2

	(1) **Migrant**	(2) **Total Remittance**	(3) **Household Head Per Day Labor Supply**	(4) **Community Forest**	(5) **Crop Rotation**	(6) **Stove Choice**	(7) **Unemployed**
Post*NP/CA	0.514	-2,804	0.0304	-0.197	-0.0370	0.162	-0.0490
	(0.368)	(7,204)	(0.512)	(0.196)	(0.334)	(0.138)	(0.126)
Post*BZ	0.0406	672.0	-0.863	0.162	0.320	0.0672	0.0318
	(0.174)	(12,316)	(0.545)	(0.138)	(0.315)	(0.106)	(0.100)
NP/CA	-0.160	-626.5	0.317	0.00722	0.533**	-0.0779	0.0403
	(0.162)	(4,801)	(0.411)	(0.135)	(0.240)	(0.113)	(0.111)
BZ	0.0342	9,800	0.389	0.0643	0.208	-0.00622	-0.0131
	(0.0945)	(9,905)	(0.455)	(0.0794)	(0.164)	(0.0722)	(0.0851)
Time Dummy	0.0403	14,705***	1.108***	0.325***	3.276***	-0.0972	-0.111
	(0.0898)	(5,089)	(0.370)	(0.0888)	(0.226)	(0.0670)	(0.0743)
Constant	1.285	-2487.704	4.311***	.339	.508	.5413	0.558**
	(.203)	(11023.6)	(0.645)	(.009)	(.234)	(.0854)	(0.229)
Observations	178	370	1,787	899	1,425	1,362	1,480
R-squared	0.065	0.059	0.130	0.231	0.517	0.234	0.008
HH Controls	YES	YES	YES	YES	YES	YES	YES
Village Controls	YES	YES	YES	YES	YES	YES	YES
Geographic Controls	YES	YES	YES	YES	YES	YES	YES

[1]Standard errors clustered at village level in parentheses. Statistical significance is denoted as *** p<0.01, ** p<0.05, * p<0.1.
[2]Columns shows DID estimates. Control is defined as households living around PAs established before the study period. Column 1 shows impact on number of migrated people, column 2 shows impact on total remittance, column 3 shows impact on labor supply, column 4 shows impact on the probability of collecting firewood from community forest, column 5 shows impacts on crop rotation, column 6 shows impact on energy efficient stove choice, column 7 shows impact on number of unemployed. Controls include demographic features- household size, age and literacy of the household head, asset value; village controls- number of households in the village, geographic belt, and conflict casualties.
[3]For the binary outcomes, I use linear probability model.

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Appendix

The optimization problem from Equation (6) in section 2:

$$\max_{x_a, x_f, l} \quad u\left(x_a, x_f, l\right) = (x_f - A)^{\alpha}\,(x_a)^{\gamma}\, l^{\beta} \quad \text{subject to,}$$

$$(P_f Q_f \,-\, P_l t_f\,) + P_l T \;\geq\; P_f x_f +\, P_a x_a +\, P_l l$$

We can assume that every household takes decision regarding labor supply to collect forest-good (t_f) independently from the other consumption choices. However, the model can be generalized to other cases also. Based on the separability assumption, we can start to solve the model (6) by maximizing the monetary surplus function of the forest good collection,$(P_f Q_f \,-\, P_l t_f\,)$, which is equivalent to general profit function. From this, first order condition with respect to labor supply in forest, t_f : $(P_f \mu \frac{1}{\delta}\, t_f^{\frac{1-\delta}{\delta}} -\, P_l) = 0$. The interior solution gives the following optimal search effort expression: $t_f^{\,*} = \left\{\frac{P_l}{P_f}\;\frac{\delta}{\mu}\right\}^{\frac{\delta}{1-\delta}}$. Substituting $t_f^{\,*}$ back to the collection function (3) gives optimal collection amount, $Q_f^{\,*} = \mu \left\{\frac{P_l}{P_f}\;\frac{\delta}{\mu}\right\}^{\frac{1}{1-\delta}}$

Now substituting $Q_f^{\,*}$ and $t_f^{\,*}$ in the budget constraint of (6) gives, $Y^* = (P_f Q_f^{\,*} -\, P_l t_f^{\,*}\,) + P_l T$. This is the optimal income after allocating time in forest, and we can substitute it back in (6) to set the Lagrangian of the model:

$$U\left(x_a, x_f, l\right) = \;(x_f - A)^{\alpha}\,(x_a)^{\gamma}\, l^{\beta} +\, \lambda\,[\,Y^* \text{-}\; P_f x_f -\, P_a x_a \;\text{-}\, P_l l\,] \qquad , \tag{9}$$

which gives the following first order conditions:

(i) $\frac{dU}{dx_f} = \alpha(x_f - A)^{\alpha-1}\,(x_a)^{\gamma}\, l^{\beta}$ - $\lambda\, P_f = 0$; (iii) $\frac{dU}{dx_a} = \gamma(x_f - A)^{\alpha}\,(x_a)^{\gamma-1}\,(l)^{\beta}$ - $\lambda\, P_a = 0$;

(ii) $\frac{dU}{dl} = \beta(x_f - A)^{\alpha}\,(x_a)^{\gamma}\, l^{\beta-1} - \lambda\, P_l = 0$; (iv) $\frac{dU}{d\lambda} = Y^*$ - $P_f x_f -\, P_a x_a$ - $P_l l \;= 0$

We get following interior solution:

(iii) $\frac{x_a}{(x_f - A)} = \frac{P_f}{P_a}\,\frac{\gamma}{\alpha}$ => $x_a = \frac{P_f}{P_a}\,\frac{\gamma}{\alpha}\;(x_f - A)$

(iv) $\frac{l}{(x_f - A)} = \frac{P_f}{P_l}\,\frac{\beta}{\alpha}$ => $l = \frac{P_f}{P_a}\,\frac{\beta}{\alpha}\;(x_f - A)$

Substituting in (iv): Y^* - $P_f x_f -\, P_a \frac{P_f}{P_a}\,\frac{\gamma}{\alpha}\;(x_f - A)$ - $P_l \frac{P_f}{P_l}\,\frac{\beta}{\alpha}\;(x_f - A) \quad = 0$ (10)

We get optimal forest-good consumption by solving (10), $x_f^{\,*} = \frac{Y^*}{P_f\,(1+\frac{\gamma}{\alpha}+\frac{\beta}{\alpha})} - \frac{A\,(\gamma+\beta)}{(\alpha+\gamma+\beta)}$