Do Communities Respond to Economic Incentives for Protecting Environment? Findings from REDD+ Experiences in Nepal

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Abstract

Reducing Emissions from Deforestation and Degradation (REDD and REDD+, where plus refers to increased removal) is a market based incentive mechanism aimed at addressing the fundamental collective action problem of how to enhance carbon stored in forests for climate change mitigation. Several international REDD+ experiments are on-going that seek to ascertain how local communities can be engaged in the effort to sequester forest carbon while improving welfare and reducing poverty. This study analyzes the findings from one such experiment conducted in three ecological regions of Nepal, where incentives were piloted.

The study uses a standard difference-in-difference methodology, with baseline and end line data collected at a two years interval from treatment and control community forest user groups selected through propensity score matching method. The expected outcomes of interest were change in forest carbon stocks, primary forest extractions, switching to alternative fuels and household income from forest program activities.
The findings showed that there was statistically significant change in liter carbon though not in forest carbon stocks indicating prospects of forest carbon increment in a longer time period. There was no reduction in basic forest product extraction and consequently no relative welfare loss by forest dependent households due to REDD+. This is in contrast to what is generally feared about REDD+. The differences in the pace of switching from conventional to convenient and cleaner fuels in treatment versus control communities indicate that this can be a more effective channel for realizing REDD+ goals within a short period of time. The treatment group households also benefited relatively from forest program activities. Relative improvement in several ecological indicators signal improved forest management practices that can enhance forest carbon without reducing forest product extractions for community needs in the future.

1. Introduction

Climate change is an established fact and the scientific community is currently exploring effective measures to prevent and mitigate its impact. Consequently, there is growing interest and expectations related to a mechanism referred to as Reducing Emissions from Deforestation and Degradation (REDD and REDD+, with the plus sign for forest carbon enhancement through improved forest management), that seeks to engage rural communities in the effort to sequester carbon (Angelsen, 2008; Bosetti *et al.*, 2011; FAO, 2011). The answer to the question, "Do communities respond positively to economic incentives to reduce deforestation and deforestation through the REDD+ mechanism?", is of growing interest and a number of REDD+ projects are being implemented in different parts of the world (Angelsen *et al.*, 2012; Wertz-Kanounnikoff and Kongphan-apirak, 2009). Our findings from a piloting REDD+ project in Nepal show that communities do respond to economic incentives, indicating that REDD+ may be a viable mechanism to reduce deforestation and degradation.

In the context of unsatisfactory success of previous measures to reduce deforestation, REDD+ has become tremendously ambitious during its short history since its international recognition in 2009 (Pistorius *et al*., 2011). The major reason behind it is because it is considered significant, cheap and quick. REDD+ can be a significant carbon mitigation strategy because it has the potential to reduce around one fifth of global emissions. It can also be a relatively cheap mechanism because deforestation and degradation is only marginally profitable compared to other forest land uses. It is quick because it can come into effect through 'stroke of the pen' reforms and can be achieved without time taken for technological innovations (Angelsen, 2008). Besides, it is capable of producing co-benefits such as bio-diversity conservation, socio-economic welfare of forest dependent communities, improved forest governance and improved ecological benefits (Sunderlin *et.al*., 2010). These expectations have given urgency to the need to understand what works and what does not within a short time.

REDD+ seeks to solve a fundamental collective action problem by creating a market for an environmental good, carbon sequestered and stored in forests (Angelsen *et al.*, 2012). Once REDD+ markets are established, high carbon emitting developed countries are expected to make carbon payments to low emitting, forest abundant developing countries for reducing deforestation and forest degradation. The underlying ideas of REDD+ are simple but there are complex issues such as measurement, scale, funding, permanence, liability, leakages and reference levels etc. to be addressed (Angelsen, 2008; World Bank, 2010). In fact, the economic viability of implementing REDD+ at the national level depends on at least three important criteria- effectiveness, efficiency, equity, along with the production of co-benefits. Effectiveness would ensure that the net emission reductions from REDD+ implementation are positive and significant; efficiency requires that emission reduction is less costly relative to benefits and other emission reduction options; and REDD+ is likely to succeed only if the benefits are distributed equitably among various stakeholders. Thus, implementing REDD+ is a very challenging task requiring learning from diverse institutional, governance and biophysical settings.

This paper discusses experience from one REDD+ pilot experiment being conducted in rural Nepal. In this pilot, several organizations in Nepal and one international donor have come together to test the viability of REDD+ by providing monetary incentives to villages that manage community forests. Our paper follows this real-life experiment and uses a difference-in-difference approach, with statistically matched treatment and control groups, to analyze REDD+ impacts on carbon, ecological and socio-economic indicators.

2. Study Context

REDD+ was scheduled to be launched officially after 2012 upon the expiry of the first commitment period of the Kyoto Protocol (2008-12). As a preparation, more than 200 various REDD+ projects are being implemented or developed in 40 countries around the world to produce knowledge on various aspects for successful implementation of REDD+ (Lin *et al.*, 2012). These piloting research projects are at different phases known as generations. The first generation REDD+ research projects focused on 'designing REDD+ and learning from related experiences in the past' to produce knowledge base on "What REDD+ should look like? The second generation REDD+ research projects focused on the political economy and implementation of REDD+. The third generation REDD+ research focused on assessing the impact of REDD+ and seeks to answer to questions such as: Does REDD+ work? How can REDD+ work better? And; how could REDD+ outcomes be measured? Though some insights have been available from first and second generation REDD+ projects, insights from the third generation research are still premature.

Motivated by the promises of REDD+, Nepal became one of the first countries to receive financial support from REDD+ preparedness from the Forest Carbon Partnership Facility (FCPF) of the World Bank and is currently in a process of developing REDD+ strategy past 2012. In this context, the International Centre for Integrated Mountain Development (ICIMOD) partnered with the Federation of Community Forest User's of Nepal (FECOFUN) and Asia Network for Sustainable Agriculture and Bio-resources (ANSAB) to implement a REDD+ demonstration project entitled "Design and setting up of a governance and payment system for Nepal's Community Forest Management under Reducing Emissions from Deforestation and Forest Degradation (REDD+)", at a pilot scale. Nepal was chosen for this piloting as it is considered one of the countries having successfully implemented the model of community forest management (CFM) leading to significant forest regeneration over the last few decades (Bushley and Khatri, 2011). As a country rich in bio-diversity, geographical and cultural diversity, Nepal provides a high degree of replicability and applicability to act as a model where CFM is practiced. To ensure replicability, the piloting has been conducted at eco-system level in three different geographical regions representing the mountains (high altitude), hills (moderate altitude) and the plains (low altitude). This is also expected to enhance better understanding in terms of the impact of topographical factors on forest carbon stocks and the response of forest dependent population in such regions.

The immediate goal of the experiment was to pilot a REDD+ seed grant payment mechanism in community managed forests in three watersheds of Nepal. The long term goal of the project was to establish a national demonstration payment mechanism for carbon credits in Nepal for the community forestry sector. The project also aimed to strengthen the role of community forest user groups (CFUGs) as civil society organizations in REDD/REDD+ process and to enhance their capacity in understanding and institutionalizing this process such that the rights of the local communities, indigenous people and women that mainly depend on forest resources are protected while participating in REDD+ activities. It was Nepal's first carbon offset project under the REDD+ arrangement in the forestry sector.

After the project's onset in 2009, a project baseline on carbon was established in 2010 and training provided to community forest user groups to undertake carbon inventory.

The forest carbon stock data was collected annually for four years from 2010 to 2013. As a part of this project, a Forest Carbon Trust Fund (FCTF) was established in 2011 to institutionalize the REDD+ payment mechanism and carbon seed grant payments were disbursed annually.

The REDD+ carbon seed grant payment started to be distributed from the mid of 2011 to the CFUGs. Instead of the pure market kind of carbon trading based on carbon stock, the modalities developed in Nepal used a combination of carbon enhancement as well as socio-economic characteristics (safeguards) of the CFUGs as a criteria for carbon payment (CFRP/N, 2011). According to these criteria, REDD+ carbon payment is a function of four different components with various weights assigned to each of them. These components and the respective weightage were: (i) Change in forest carbon, 40 percent (ii) Ethnic diversity: indigenous and Dalit[1] population, 25 percent (iii) Sex ratio: number of women in CF, 15 percent and; (iv) Percentage of poor households in CFUG, 20 percent.

Weighted indices were constructed for the respective years for each of the CFUG in the REDD+ watershed based on these four variables. The total REDD+ seed grant of US$ 95000 was distributed each year for three consecutive years to the CFUGs on the basis of that index. Instead of making payment to the households, the carbon funds were provided to the management committees of the REDD+CFUGs. The committees in consultation with the community members developed modalities, prioritized for fund allocation and disbursed these funds. The Carbon Trust Fund constituted at the national level developed a guideline for allocation of such funds and the CFUGs had to strictly follow those guidelines and report to the FCTF in a given format every year for claiming REDD+ carbon seed grant payments (CFRP/N, 2011). The CFUGs, however, had discretion on the percentage of funds to be used along these activities. The guideline had directed allocations of the funds along activities that reduce deforestation and degradation, conserve and enhance forest carbon stocks and biodiversity, reduce poverty and improve livelihood, raise awareness on climate change and capacity building of communities, forest carbon monitoring, auditing and verification etc.

There are many similarities among REDD+ projects in different countries but some country specific differences exists. The findings from Nepal, a country small in

[1]Dalits are households of deprived groups considered untouchable traditionally.

geographical area, but with high bio-diversity, topography and socio-cultural diversity is important in enhancing the understanding of the prospects and problems of REDD+ for similar countries in the world.

Section 3 of this paper discusses the study methods with conceptual framework, sampling design and sources of data. Section 4 discusses the findings of the study while section 5 concludes with discussion and conclusion.

3. Study Methods

This paper aims to analyze whether communities respond to economic incentives by changing their behavior to reduce deforestation and degradation. Accordingly, this study uses a quasi experimental research design for the selection of comparable non-REDD+ forest communities in the study area. The following section discuses the conceptual framework of the study, the method of selection of project (treatment) and non-project (control) CFUGs, sampling design, sources of data and results from the balancing test of project and non-project CFUGs. We adopt the terminology: "treatment CFUG" or "REDD+ CFUG" for REDD+ Project CFUGs and "Control CFUG" or "non-REDD+ CFUG" for non-REDD+ project CFUGs

3. 1 Conceptual framework

The study is based on a comparative analysis of a REDD+ treatment CFUGs and control CFUGs using panel data for baseline (2011) and end-line (2013). The Difference in Difference between end-line versus baseline and treatment versus control provides a true measure of Impact (Khandkar *et al.*, 2010).

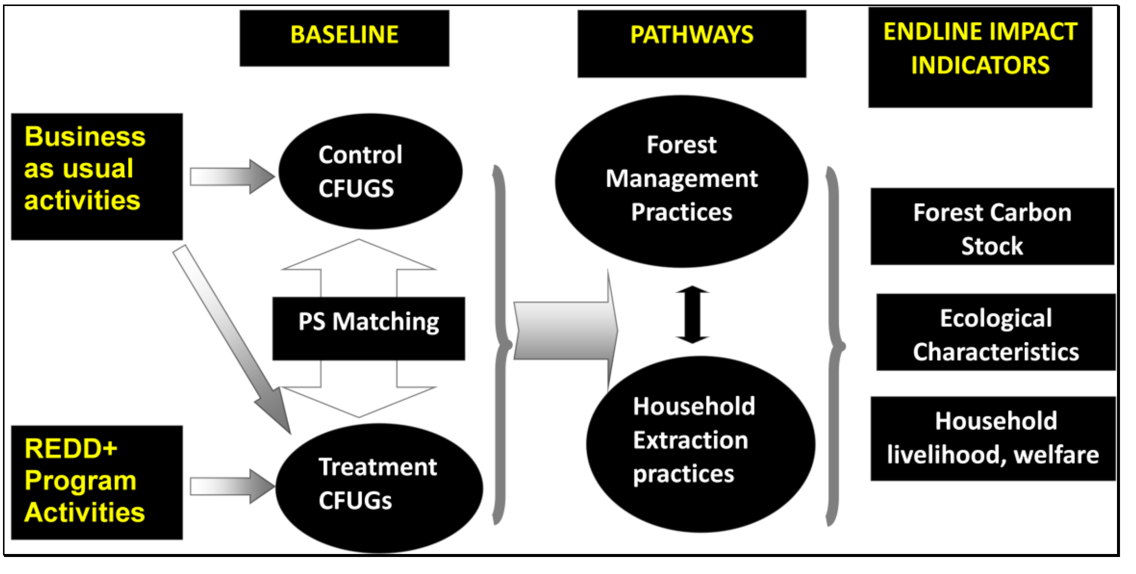
Table No. 1
The Difference in Difference Analytical Framework

CFUG category	**Target variable in**		
	Baseline	**End-line**	**Difference**
REDD (treatment)	T_0	T_1	Treatment
Non-REDD (control)	C_0	C_1	Control
Difference	$T_0 - C_0$	$T_1 - C_1$	$(T_1 - C_1) - (T_0 - C_0)$
DID components: carbon, ecological and socio-economic			

It was necessary to ensure both external and internal validity in the study. The study ensured external validity by ensuring that the selected REDD+ and non-REDD+ CFUGs are representatives of the general CFUG population. Similarly, the study aimed to ensure internal validity by ensuring that the control CFUGs were similar in all respects except for the REDD+ intervention so that the community and forest characteristics of the intervention CFUGs is the net of all other confounding factors. This was done by selecting randomly from among the pool of REDD+ and control CFUGs following a quasi experimental design through the propensity score (PS) matching.

Figure No. 1

Impact Analysis Framework



There was business as usual activities in all CFUGs, both treatment and control. But treatment CFUGs undertook REDD+ program activities in addition to business as usual activities. The REDD+ Project was expected to produce impacts on three aspects: forest carbon characteristics, ecological ad community socio-economic characteristics. This study thus aimed to identify these three kinds of characteristics of the REDD+ project CFUGs and whether these characteristics differed with the non-REDD+ CFUGs.

The carbon stocks in the two kinds of CFUGs were analyzed to see if the amounts of carbon stocks are specific to REDD+ CFUGs. the ecological characteristics examined changes in the ecology of the CFUGs due to change in human forest interface. Similarly, the socio-economic variables including household characteristics, forest extraction practices, and livelihood options were analyzed to examine how REDD+ CFUGs differ from non-REDD+ CFUGs.

3.2 Selection of control CFUGs: the propensity score matching

The selection of a set of statistically matching control CFUGs for each set of REDD+ pilot CFUG was challenging. The prior selection and intervention of the REDD+ program led to non-randomized designing of the study. The issue of spillover effects from nearby REDD+ changing forestry related behavior of the control CFUGs was also likely. The control CFUGs were identified on the basis of the following objective criteria: (i) They are nearby but not adjoining to the watershed community forests (to avoid the effect of carbon leakage) (ii) Have similar topographical and forest characteristics (iii) Socio-economic, forest use, infrastructure and market access characteristics among CFUG member households are similar to those of the REDD+ pilot CFUGs.

This study adopted the CIFOR technical guideline for selection of REDD+ treatment and control sites with some modifications (Sunderlin *et al*., 2010). The guideline suggested the use of 8 variables: deforestation pressure, NGO presence, strength of forest tenure, number of active community groups, population size, extent of forest cover around the village, forest dependence and the distance to the main road, further blown up into 22 sub-variables which were earlier used in Brazil, Cameroon, Indonesia, Tanzania and Vietnam for the selection of the matching villages for REDD+ experiment. The study adopted these variables with necessary adjustments to obtain quantitative indicators that match with the local Nepalese context. Based on this list of variables, the study identified 26 quantitatively measurable variables. The data for these 26 variables were collected from the Operational Plan (a document approved by the District Forest office during registration or renewal of the forest user group) and focus group discussion (FGD) with key informants such as the members of the executive committees of the CFUG, social workers, school teachers etc. These 26 variables were again later compacted and synthesized to 11 variables for the PS matching (see Table No. 3 for the variables). For instance, the area of the community forest and the number of CFUG households were compacted into number of households per hectare of CF.

The number of non-REDD+ CFs were in excess of the REDD+ piloting CFUGs. The study team conducted a workshop at each of the districts to reduce the number of the potential matching REDD+ and non-REDD+ CFs into a reasonable number. This was done through participation of the forestry officials and the executive committee members of the Federation of Community Forest Users of Nepal (FECOFUN) members in the District level as key informants knowledgeable of the characteristics of the REDD+ and non-REDD+ CFs in the district. The workshop listed the REDD+ CFs and the non-REDD+ CFs that were most comparable in terms of vegetation type, topography, ethnic composition, extraction practices, access to market etc. Two or more rounds of screenings were conducted to finally obtain 14 REDD+ CFs and then 14 non-REDD+ CFs for the collection of the matching data for PS matching. The data for the matching were collected from the operational plan and through the FGDs at each of the 14 REDD+ and 14 non-REDD+ CFUGs in the three districts respectively. Accordingly, the number was reduced to 42 REDD+ piloting and 42 non-REDD+ or control CFUGs for the matching. Data were collected for each of the 84 CFUGs for PS matching.

The PS matching based on these variables consisted of creating a weighted average, where weights are the inverse of the elements of the variance-covariance matrix of these 11 variables for each of the potential CFUGs. The noisiest variable received the lowest weight. The study identified a subset of 7 REDD+ and 7 non-REDD+ for which index values were close as measured by the mean value for each of the 11 variables. That is for the set of variables in the control CFUGs, the mean for each variable was statistically similar for the mean for the same variable in the REDD+ CFUGs. This index called the Mahalanobis Metric was estimated using the statistical software STATA. Instead of following one-to-one matching of REDD+ and non-REDD+ CFs, the study selected 7 matching REDD+ and 7 non-REDD+ CFs in each district.

3.3 Sampling methodology and data collection

The study area are the three watersheds covered by the project entitled "Design and setting up of a governance and payment system for Nepal's Community Forest Management under Reduced Emissions from Deforestation and Forest Degradation (REDD+)". These watershed areas are Charnawati in Dolkha district, Ludikhola watershed in Gorkha district and Kayarkhola watershed in Chitwan district covering a total area of over 10,000 ha of community managed forest involving more than 18,000 households. The REDD+ piloting was conducted in 58, 31, 16 CFUGs in Dolkha, Gorkha and Chitwan respectively. As mentioned earlier in the conceptual framework, three categories of data were collected for the study.

3.3.1 Carbon data

The survey design for the carbon data consisted of collecting carbon related data from the 7 REDD+ and 7 control CFUGs in each of the study districts identified by the PS matching. The Project had prepared GIS maps of the CFs and forest lands were categorized into dense and sparse in the study area. Permanent plots were set in the REDD+ CFs. The numbers of sampling plots were determined on the basis of the variation in the characteristics of the CFs.

Table No.2
Distribution of dense and sparse plots by type of Sampling Plots

CFUG Type	Dolkha		Gorkha		Chitwan		Sub-total		Total
	Dense	Sparse	Dense	Sparse	Dense	Sparse	Dense	Sparse	
Treatment	29	3	37	6	63	15	129	24	153
Control	29	10	28	7	34	16	91	33	124

Using similar methods, GIS information was collected in the control CFs for sample plot determination. Instead of permanent plots, unmarked GIS plots were set in the control CFs to avoid contamination due to behavioural change in the extraction patterns by the community so that the business as usual scenario is maintained in the control plots. Accordingly, 124 GIS plots were identified in the control CFUGs as a counter part of the 153 permanent plots in the treatment CFUGs.

The carbon stock in the each of the REDD+ CFUGs was obtained from carbon monitoring by the Project. Carbon monitoring was conducted based on a technical guideline following international standard (ANSAB/FECOFUN/ICIMOD, 2010). Besides carbon data, the Project also collected bio-physical and ecological data such as altitude, slope, aspect, soil type, soil depth, forest type, human intervention such as grazing, firewood collection, forest fire were collected along with the carbon stock data. Exactly similar carbon data collection from the control CFUGs were also assigned to ANSAB, the institution endowed to collect carbon data in the REDD+ sample plots, to ensure uniformity in methods and calibration of equipments. The baseline carbon data in the REDD+ CFUGs were collected in March-May, 2011 while the baseline carbon data in control CFUGs were collected in July-August, 2011. Carbon payment to the REDD+ CFUGs were allocated in July, 2011 but were disbursed at the community after November, 2011.

The end line carbon data from the treatment CFUGs were collected in March-May, 2013 while the end line carbon data from the control CFUGs were collected in July-August, 2013, exactly two years after the baseline data collection.

This data set consists of data on carbon stock in aboveground tree biomass, aboveground sampling biomass, herbs and grass, leaf litter, below ground biomass and soil organic carbon. These were aggregated to obtain the carbon stock in tones of carbon per hectare (tC ha^{-1}). The carbon stock in the CFs was estimated using the following relationship:

Forest carbon stock of a stratum:

$$\mathrm{C(LU)} = \mathrm{C(AGTB)} + \mathrm{C(AGSB)} + \mathrm{C(HG)} + \mathrm{C(BB)} + \mathrm{C(L)} + \mathrm{SOC}$$

Where,

C (LU)	= carbon stock for a land use category [tC ha-1];
C (AGTB)	= carbon stock in aboveground tree biomass [tC ha-1];
C (AGSB)	= carbon in aboveground sapling biomass [tC ha-1];
C (HG)	= carbon in herbs and grass [tC ha-1];
C (L)	= carbon in leaf litter [tC ha-1];
C (BB)	= carbon in belowground biomass [tC ha-1];
SOC	= soil organic carbon [tC ha-1];

The total forest carbon stock has been converted to tons of CO_2 equivalent by multiplying by 44/12, or 3.67 (Pearson et al, 2007; cited in ICIMOD/ ANSAB/ FECOFUN, 2010).

3.3.2 Socio-economic data

The population in both the kinds of CFUGs were first stratified into three groups – indigenous, Dalits and higher status households. The Dalits are households traditionally considered untouchables and lie in the lowest social strata. A total of 15 households were selected randomly in proportion to the population of the CFUG households from among the given three ethnicity stratum. This gave a total of 210 households (105 REDD+ households and 105 non-REDD+ households) in each watershed. A total of 315 REDD+ households and 315 non-REDD+ households from three districts were surveyed to make a total of 630 households for the survey.

The baseline socio-economic data was collected around August-November, 2011. The questionnaire for the household survey was developed through several rounds of field visits to ensure uniformity in methods of collecting data under different kinds of agricultural and forestry related practices in the three topographical regions. Accordingly, the survey questionnaire collected information under various sections. These sections were: general section (household rooster, education, occupation etc.); forestry section (forest product extraction by source, production and transaction cost, perceptions about community forestry activities and; their perceived benefits); household assets, consumption, major sources of family income and coping mechanism against risks; Community characteristics (presence of external agencies, participation in community activities and access to public facilities). The household survey data also contains a wide range of information such as occurrence of any crisis in the household and its coping mechanism, the presence of non-governmental organizations in the community, household involvement in social organizations, incidence of acute and chronic sickness and workdays lost, perception of household welfare status, access to public services such as banks, roads, police centres etc. The data on locally prevalent agricultural wage rate was collected for estimating the value of household time.

The questionnaire was pre-tested in the non-sampled REDD+ and non-REDD+ CFUGs in two of the three districts and accordingly revised to ensure coherence and flow and the ease for respondents to follow. Master level students from the faculty of Economics, Tribhuvan University were employed as research assistants to administer the questionnaire. These research assistants were trained in workshops as well as in the field setting. Mechanism was ensured to have the questionnaire filled by one enumerator checked by another enumerator and a final checking by team supervisors.

The end-line socio-economic data was collected in August-November, 2013, two years after the baseline data was collected. The same set of questionnaire with some additional questionnaire at the end to capture some additional forest related behavior and perception questions were used to collect the end line data.

The data so collected were entered in the data entry software CSPro and analyzed in STATA 11.

3.4 Results from the balancing test

As mentioned earlier, the matching of treatment and control CFUGs using the PS matching was performed on the basis of 11 variables from the data collected through operational plan and FGDs with the key informants. This led to the selection of 7 treatment and 7 control CFUGs in each of the three districts. A balancing test was conducted after household survey was completed to see whether the selected treatment and control CFUGs were balanced. Among the 11 variables used in the PS matching, data for 5 variables were collected at the household level too. The remaining variables were related to forest characteristics and household level data collection was not possible. A balancing test based on household data indicated that two of the five variables were statistically different for the treatment and control households while the other three were not statistically different. A Hotelling's t-square test statistics using the 5 variables was estimated to analyze overall equality between treatment and control CFUGs. The test score with a F-statistics (5, 624) was 8.780 and allowed for rejection of the null hypothesis of overall equality with 99 percent confidence level [p-value=0.000]. Thus, there was no overall equality between the treatment and control CFUGs in terms of these five variables. The difference in these characteristics between the treatment and the control CFUGs need to be taken account during the final impact analysis.

Table No.3
Result from the balancing Test

S. No.	Matching Variables	REDD+	Non-REDD+	Difference (Non REDD$^+$ - REDD$^+$)
Variables from Household Survey				
1.	Number of local organizations/NGOs	3.08 (0.09)	2.37 (0 .07)	**0.711***** (0.11)
2.	Percentage of households with LPG	0.25 (0.02)	0.18 (0.02)	**0.07**** (0.03)
3.	Percentage of HHs with biogas among large ruminant owners	0.10 (0.02)	0.08 (0.02)	0.03 (0.02)
4.	Firewood collection time from CF in minutes	229.06 (5.79)	218.23(5.30)	10.84 (7.85)
5.	Average time taken to reach public facilities	83.81 (3.14)	81.90 (2.42)	1.91 (3.97)
Variables from matching FGD				
6.	Years of CFUG handover	10.9 (1.35)	9.9 (1.15)	1.00 (1.17)
7.	Income per hectare from CFUG product	2683.00 (912.36)	3399.10 (1216.23)	-716.09 (1520.4)
8.	Growing stock per hectare in CFUG	4918.45 (1212.20)	3924.41 (627.32)	994.04 (1364.90)
9.	Household per hectare CFUG	2.59 (0.45)	2.42 (0.44)	0.16 (0.63)
10.	Indigenous and Dalit population in community	69.05 (5.90)	71.29 (6.46)	-2.24 (8.75)
11.	Quality forest cover	77.14 (2.25)	78.81 (1.79)	-1.67 (2.88)

Figures in parentheses are standard errors; * ,** and *** denotes t-statistics significant at 10, 5 and 1 percent level of significance respectively.

Source: Field survey, 2011

The six variables for which data was collected for the matching at the community level using operational plans and FGDs were statistically not different individually for treatment and control CFUGs. Hotellings's T-square test statistics for overall equality for the 6 variables estimated F (6, 35) of 0.2330 with a probability value of F (6, 35) of 0.9629 indicating that the null hypothesis of overall equality could not be rejected.

In summary, the results of the balancing test after household level data were available indicated that there were differences in characteristics between the treatment and the control CFUGs for all three districts taken at once.

3.5 Tools of analysis

This study has used the DID impact analysis tools using econometric models. One set of econometric models were used for carbon and ecological impact analysis. The other set of econometric model was used to analyze the impact of REDD+ on forest product extractions and household choices of alternative fuels.

3.5.1 Econometric model for Forest carbon and Ecological impact

Since the study covered a short duration of two years of intervention, we assume that changes in tree carbon and total forest carbon are less likely. So we assume that only litter biomass and herb biomass extraction can change in the short run. We use the ordinary least square (OLS) regression equations. We use an econometric model for analysis of impact with treatment, year and district. The regression equation can be written as:

$$Y_i = \beta_0 + \beta_1 REDD + \beta_2 ENDLINE + \beta_3 INTERACTION + \beta_4 DISTRICT + e_i$$

Where, Y_i is the target variable for impact analysis such as litter biomass, herb biomass, sapling biomass by the i^{th} household. REDD is the treatment dummy with REDD+ CFUG equals one, non-REDD+ CFUG equals zero; the ENDLINE is the year dummy with end-line year equals one and baseline year equals zero. The INTERACTION is an interaction variable, a product of REDD and ENDLINE. DISTRICT is the district dummy with Chitwan district as a base or reference district. The e_i is the stochastic error term. The coefficient of the interaction dummy (β_3) examined the sign of the impact o the dependent variable on the variable whose impact is being examined while the p-value gives the statistical significance of the impact[2].

[2] The STATA command for the regression was:

reg Y_i REDD ENDLINE INTERACTION DISTRICT

3.5.2 Econometric model for forest dependence and alternative fuel for cooking

Similar as in case of the carbon and ecological impact analysis, since this impact evaluation was undertaken within a very short time of two years, which might not be sufficient for communities to adjust their behavior and choices, we expect behavioural changes in a few variables only. These variables are mainly forest dependence such as consumption of firewood, fodder-grass and leaf-litter; adoption and dependence on alternative fuel and income to household from activities conducted by CFUG. It was expected that in addition to normal extraction activities from the CF, the CFUG initiated several activities in the REDD+ treatment group that Accordingly, we used different models for the impact analysis of REDD+. Model1 is a basic model controlling only for treatment and year and is almost similar to the carbon impact or ecological impact model for the dependent variables (regressors) except for the dependent variables. The other models were constructed by including additional variables. For instance, Model 2 controls for the unbalanced variables in the matching besides the variables in model 1. The unbalanced variables in the matching were the percentage of household with LPG and the number of local organizations in the community. Model 3, Model 4, and Model 5 controlled for household socio-economic characteristics based on relevant literature, in addition to the variables in Model 2. The last model controlled for the district fixed effects in addition to the random effect model run earlier. We run these several models to examine the stability and consistency of the impact of REDD+ on the assumed outcomes of interest. All regression estimates were clustered at community user group level for robustness.

4. Findings and Analysis

In the first sub-section we discuss the impact of REDD+ on the forest biomass, forest carbon and ecological variables. In the second sub-section we discuss impact of REDD+ on forest dependence (particularly firewood, fodder-grass and leaf-litter). We also discuss the adoption of bio-gas and improved cook stoves as an alternative to firewood and efficiency enhancing technology. We then examine the impact of REDD+ on the percentage share of firewood, bio-gas and liquefied petroleum gas in household cooking.

4.1 Carbon and ecological impacts of REDD+

4.1.1 Carbon impact of REDD

We discuss the carbon impact of REDD+ by analyzing the impacts on the components of the forest carbon such as litter biomass, herb biomass, sapling biomass, tree biomass and the forest carbon stock as an aggregate of all the components.

Table No. 4

Mean values of forest carbon components (ton per hectare)

Carbon components	**Baseline mean**		**End-line mean**	
	Treatment	Control	Treatment	Control
Herb biomass	0.37	0.49	0.77	1.08
Litter biomass	4.55	3.10	5.01	2.12
Sapling biomass	6.91	3.39	6.47	3.56
Tree biomass	242.91	232.23	250.26	237.28
Soil organic carbon	106.00	86.90	107.19	87.75
Total forest carbon	248.56	221.17	254.08	224.74

The mean values indicate that there is diverse pattern of growth of the forest carbon components. The baseline and end-line comparision of the total forest carbon indicate that there is a positive net increment in forest carbon for both the treatment and the control CFUGs. Whether there is a net impact due to REDD+ can be examined by analyzing the DID impact analysis from the OLS estimate. The findings indicate that there is statistically significant difference between treatment and control CFs only for litter biomass while the changes in the other components are not statistically significant (see Table No. 6). Tree biomass and soil organic carbon were the major components of the forest carbon stock while litter, herb and sapling biomass constituted very small shares. The impact on forest carbon stock and other components indicate that it takes time for growth in tree biomass and soil organic carbon that ultimately lead to increment in forest carbon stocks.

4.1.1 Ecological impact of REDD+

The ecological data were collected during the carbon inventory survey for the treatment and the control CFs during the baseline and end-line. The percentage of the plots with these ecological indicators is given in Table No 5. The difference in difference can be ascertained by examining the OLS estimates for these variables.

Table No. 5

Mean value of indicators at the plot level (Percentage of occurrence)

Carbon components	Baseline mean		End-line mean	
	Treatment	Control	Treatment	Control
Forest fire occurrence	28.76	12.90	4.58	21.95
Fodder collect signs	58.17	52.42	62.75	54.84
Grazing signs	30.72	50.00	36.60	50.81
FW collect signs	47.71	58.87	75.82	66.94
Timber extract	28.76	40.32	24.84	52.42
Encroachments	21.57	5.65	1.31	5.65
Soil erosions	10.46	24.19	4.58	26.61
Wildlife signs	47.71	80.65	81.05	90.32

An analysis of the data on ecological characteristics of REDD+ and control CFUGs for 2011 and 2013 indicated that there are important changes in ecological characteristics of the forests taking place with REDD+ intervention (see Table No. 7). For instance, forest fire and forest encroachments have declined while signs of wild animals and grass cover have increased in the REDD+ CFUGs compared to the control CFUGs. The results also indicated that there is increase in the signs of people collecting firewood. Since there is no decline in total forest carbon, we assume that people must have collected more firewood through improved forest management. These test results were statistically significant at one percent level. There is reduction in timber extraction in the treatment compared to the control CFUGs and the difference of the difference is statistically significant at 5 percent level.

These ecological indicators overall indicate that there are changes taking place in the direction of improved forest management, less harmful extraction methods and reduced human interference in the forests. Though these could not contribute to forest carbon stock enhancement within a short time period, they will have positive impact in the longer time span.

Table No 6

Impact of REDD+ on forest carbon components

VARIABLES	LITTER_BIOMASS	HERB_BIOMASS	SAPLING_BIOMASS	TREE_BIOMASS	TOTAL_FOREST_CARBON
END_YEAR	-0.99**	0.58***	0.16	5.04	3.57
	(0.49)	(0.12)	(1.04)	(22.74)	(13.76)
REDD+	1.41***	-0.10	3.90***	-4.61	20.90
	(0.47)	(0.11)	(0.99)	(21.73)	(13.15)
INTERACT	**1.45****	-0.18	-0.61	2.30	1.95
	(0.66)	(0.16)	(1.40)	(30.59)	(18.52)
DISTRICT_2	-0.31	0.27***	3.59***	-144.18***	-61.00***
	(0.41)	(0.10)	(0.86)	(18.89)	(11.44)
DISTRICT_3	0.53	-0.40***	1.35	-73.83***	-54.98***
	(0.39)	(0.09)	(0.83)	(18.21)	(11.02)
Constant	3.05***	0.52***	1.88**	298.42***	255.87***
	(0.40)	(0.10)	(0.85)	(18.52)	(11.21)
Observations	554	554	554	554	554
R-squared	0.09	0.14	0.07	0.10	0.08

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table No 7

Impact of REDD+ on forest ecological indicators

VARIABLES	FOREST FIRE	FODDER COLLECT	GRAZING	FWOOD COLLECT	TIMBER EXTRACT	ENCROACH-MENT	WILDLIFE SIGN
END_YEAR	0.09**	0.02	0.01	0.08	0.12**	-0.00	0.10**
	(0.04)	(0.05)	(0.06)	(0.05)	(0.06)	(0.03)	(0.05)
REDD+	0.15***	0.04	-0.21***	-0.10*	-0.10*	0.14***	-0.32***
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.03)	(0.04)
INTERACT	**-0.33*** **	0.02	0.05	**0.20*** **	**-0.16** **	**-0.20*** **	**0.24*** **
	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)	(0.04)	(0.06)
DISTRICT_1	-0.11***	-0.18***	-0.15***	0.13***	0.16***	-0.17***	0.10**
	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.03)	(0.04)
DISTRICT_2	-0.26***	-0.63***	-0.51***	-0.39***	-0.29***	-0.17***	-0.41***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)
Constant	0.24***	0.76***	0.69***	0.66***	0.44***	0.16***	0.89***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.03)	(0.04)
Observations	554	554	554	554	554	554	554
R-squared	0.15	0.29	0.22	0.23	0.17	0.17	0.35

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.2 Impact of REDD+ on forest dependence and shift to alternative fuels

This section examines the impact of REDD+ on household forest dependence and other related aspects. Since the forest dependence is less likely to change within a few years time due to structural factors related to household energy consumption for cooking and heating purpose, we explore into other several aspects that are likely to change within a short duration. The major change that was expected to take place within a short duration was the introduction of alternative fuel and decline in the share of the traditional sources of energy for household cooking. The other expected change was in the income directly from CFUG initiated activities. The discussion that follows examines into these issues.

4.2.1 Impact of REDD+ on forest dependence

A large percentage of households depend on CF for primary forest products such as firewood, fodder-grass and leaf-litter. Unsustainable and indiscriminate extraction is one of the reasons for forest degradation in Nepal. It is a major cause inhibiting carbon sequestration in the forests. REDD+ payment aims to enhance forest management and reduce forest product extraction for greater carbon sequestration. The mean extraction of these forest products for the treatment and the control CFUGs for the base year and end year indicate that there is no common pattern in the change in firewood, fodder-grass and leaf-litter extraction. Our interest is mainly on the difference in difference between the treatment and the control for the end-line relative to the baseline. We controlled for household characteristics such as household size, livestock units and per capita consumption. Larger sized household have higher energy demand as well as the required human resource to collect firewood from CFs.
Similarly, larger herd size requires that they need more firewood, fodder-grass and leaf litter to prepare animal feed and bedding matter. We also included the district dummy to control for the district fixed effects.

Table No. 8

Mean value of indicators at the plot level (percentage)

Forest product/district	**Baseline mean**		**End-line mean**	
	Treatment	Control	Treatment	Control
Firewood				
Dolkha	63.71	69.33	63.66	71.81
Gorkha	45.54	59.12	45.49	57.19
Chitwan	55.43	59.18	54.00	58.06

All districts	54.90	62.55	54.38	62.54
Fodder-grass				
Dolkha	499.31	486.06	436.99	466.77
Gorkha	406.97	507.31	398.50	473.58
Chitwan	451.20	500.57	473.48	452.44
All districts	452.50	497.98	436.56	464.31
Leaf-litter				
Dolkha	157.49	182.97	118.81	161.55
Gorkha	40.11	55.66	26.38	42.18
Chitwan	62.40	98.51	100.19	108.71
All districts	86.67	112.38	81.91	105.26

The mean extraction of these forest products for the treatment and the control CFUGs for the base year and end year indicate that the extractions are higher in Dolkha followed by Chitwan and Gorkha. Higher extraction of firewood in Dolkha is because of the climatic factor in high altitude requiring more energy for cooking and heating. Dolkha also had higher fodder-grass and leaf-litter consumption because of more dependence on agriculture and livestock. From a general observation, there is no common pattern in the change in total firewood, fodder-grass and leaf-litter extraction. Our interest is mainly on the difference between the treatment and the control for the end-line relative to the baseline. This is examined by estimating the DID estimator using OLS regression equation discussed in the methodology section.

The findings from the regression equation indicated that there was no statistically significant impact in the extraction of firewood, fodder-grass and leaf-litter due to REDD+ (see Table No. 10, 11 and 12). The interaction variable was significant for none of the models in these regression estimates.

4.2.2 Impact of REDD+ on shifting to alternative fuel and cleaner technology.

Improved cook stoves (ICS) provide technological improvement to reduce kitchen smoke and savings in firewood for cooking. With the monetization of the economy and improved road access, LPG cook stoves are also rapidly substituting for traditional technology such as firewood cook stoves. Bio-gas plants and bio-gas stoves provide a substitution to the non-renewable energy by utilizing cattle dung. There is also a growing practice of connecting latrines to bio-gas digesters for utilizing human waste to produce household cooking and lighting energy. With the following mean values of the variables related to alternative fuel usage (Table No. 9), we examine the impact of REDD+ payment on the choice and shifting to cleaner and convenient fuels such as ICS, LPG and biogas using OLS estimates. We validate our findings by the change in the share of traditional fuels by cleaner and convenient fuels.

Table No. 9

Mean value of ICS and household fuel for cooking (percentage)

Fuel for household cooking	**Baseline mean**		**End-line mean**	
	Treatment	Control	Treatment	Control
HHs with ICS	15.24	7.94	20.33	11.65
HHs with bio-gas	10.48	8.89	16.07	10.03
Share of Bio-gas (%)	6.65	5.83	10.20	6.17
Share of FW (%)	81.15	87.50	75.86	84.28

We used several control variables based on the findings of available literature on the factors determining the household choice for shifting to alternative fuel and the factors determining their magnitude. The choice for shifting to biogas is determined by household size, the number of cattle or livestock units, the economic capacity to afford for the installation cost, the awareness of the household about such technology etc (Rahman et al., 2014; Wang et al., 2012). We use the tropical livestock units as a proxy for the livestock units, the per-capita consumption of the household as a proxy for the economic capacity to afford for the installation cost and the literacy status of the household head as proxy for household awareness of the benefits of the technology. The other factors are the household size, the availability of permanent toilet to allow for greater gas generation to supplement for animal dung. Human waste has higher bio-gas production potential (K.C. *et al.*, 2014) and there is a policy of encouraging household to connect their toilets to the bio-gas plants in Nepal. We include the district dummy to control for the district fixed effects.

The findings of the DID indicated that there is no statistically significant change in the use of ICS (see Table No. 13) and LPG, but there is a statistically significant increase in the number of household with bio-gas plants as revealed by the interaction variable (see Table No. 14). The result is valid for a number of models and indicates that the result is consistent.

We tried to validate this result by the share of various fuels in household cooking. A single household may have more than one form of fuel use for household cooking. For instance, a household primarily using firewood does have LPG cook stove too.

Respondents informed that with children attending schools, it might be late for them to reach school in time while cooking only on firewood. In such cases, they use LPG cook stoves to supplement firewood. Similarly for household cooking primarily on bio-gas might have to resort to firewood during colder weather when decomposition and release of gas is slow due to low temperature.

The OLS results revealed that there is a general increase in the share of bio-gas in the REDD+ communities as shown by the interaction variable. We cross examined the validity of this result by looking at the change in the share of the traditional fuel firewood. This was confirmed by a decline in the share of firewood in household cooking in these communities (see Table No. 15 and 16).

4.2.3 Impact of REDD+ on income from CF initiated activities.

CFUGs undertake a wide range of activities as per the guideline provided them by the government of Nepal. Broadly, these are activities related to forest management such as income generation grants, employment in forest management activities, provision of improved cook-stoves and grants in the installation of bio-gas plants provided by REDD+ CFUGs among others. We control for whether the household is a member of the CFUG executive committee as they can influence decision in the distribution of the CF resources in their favour. We also control for ethnicity as CF are criticized for elite capture by higher status ethnic groups to the disadvantages of the indigenous and Dalit groups. We include the district dummy to control for the district fixed effects.

The findings indicated that there is positive increment in the income from CFUG initiated activities in the treatment compared to the control CFUGs. The result were not statistically significant for two models but were statistically significant for the other three models (see Table No. 17).

Table No 10
Determinants of total firewood consumption from all sources

	(1)	(2)	(3)	(5)	(6)
REDD	-7.65**	-5.24	-4.86	-5.14	-5.68**
	(3.69)	(3.11)	(3.16)	(3.14)	(2.77)
ENDLINE	-0.01	1.68	3.09	3.37*	3.09
	(1.84)	(1.88)	(1.86)	(1.88)	(1.89)
INTERACTION	-0.51	-1.86	-1.56	-1.35	-0.83
	(2.59)	(2.61)	(2.58)	(2.59)	(2.61)
HAVE_LPG		-16.63***	-15.83***	-13.51***	-9.79***
		(3.19)	(2.90)	(2.41)	(2.23)
LOCAL_ORG_COUNT		-1.69***	-2.28***	-2.11***	-1.73***
		(0.58)	(0.61)	(0.65)	(0.64)
HOUSEHOLD_SIZE			3.60***	2.88***	2.90***
			(0.52)	(0.50)	(0.52)
TROPIC_LIVEST_UNIT				1.85***	2.37***
				(0.61)	(0.62)
PER_CAPITA_CONSUMP				-0.00*	-0.00**
				(0.00)	(0.00)
_IDISTRICT_2					-10.66***
					(3.01)
_IDISTRICT_3					-12.74***
					(2.36)
Constant	62.55***	69.50***	52.02***	51.79***	57.12***
	(2.16)	(1.66)	(3.14)	(3.82)	(4.03)
Observations	1,244	1,244	1,244	1,244	1,244
R-squared	0.02	0.11	0.20	0.21	0.26

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table No 11
Determinants of total fodder-grass consumption from all sources

	(1)	(2)	(3)	(4)	(5)
REDD	-45.49	-30.61	-38.62*	-39.07*	-41.18**
	(32.87)	(26.90)	(20.50)	(20.50)	(19.09)
ENDLINE	-33.67**	-10.24	-4.38	-3.77	-4.42
	(13.61)	(12.87)	(13.29)	(13.34)	(13.20)
INTERACTION	17.74	13.07	24.13	24.01	25.88
	(21.15)	(20.30)	(19.35)	(19.33)	(19.43)
HAVE_LPG		-124.29***	-72.36***	-67.52***	-58.67***
		(30.71)	(18.63)	(16.80)	(16.41)
LOCAL_ORG_COUNT		-8.00	-6.89	-6.29	-4.10
		(6.38)	(4.71)	(4.76)	(4.76)
HOUSEHOLD_SIZE		34.97***	9.32***	8.63**	9.35***
		(3.97)	(3.16)	(3.34)	(3.27)
TROPIC_LIVEST_UNIT			87.10***	87.05***	88.56***
			(8.62)	(8.60)	(8.49)
PER_CAPITA_CONSUMP				-0.00	-0.00
				(0.00)	(0.00)
_IDISTRICT_2					-29.04*
					(16.36)
_IDISTRICT_3					-53.82***
					(18.49)
Constant	497.98***	356.95***	270.56***	276.99***	292.76***
	(22.36)	(29.29)	(22.91)	(24.89)	(24.59)
Observations	1,244	1,244	1,244	1,244	1,244
R-squared	0.01	0.14	0.43	0.43	0.43

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table No 12
Determinants of leaf-litter consumption from all sources

	(1)	(2)	(3)	(4)	(5)	(6)
REDD	-25.71	-23.61	-22.64	-22.92	-23.22	-26.68
	(23.16)	(21.01)	(21.22)	(21.34)	(21.32)	(16.49)
ENDLINE	-7.12	-3.71	-0.07	0.14	0.54	-2.59
	(11.83)	(11.77)	(11.54)	(11.46)	(11.49)	(11.50)
INTERACTION	2.37	-0.22	0.58	0.97	0.89	4.73
	(16.23)	(15.94)	(15.98)	(15.92)	(15.89)	(15.81)
HAVE_LPG		-71.15***	-69.09***	-67.24***	-64.07***	-24.03***
		(11.30)	(11.19)	(11.17)	(11.67)	(7.17)
LOCAL_ORG_COUNT		4.35	2.81	2.85	3.24	3.88
		(3.07)	(2.94)	(2.96)	(2.97)	(2.75)
HOUSEHOLD_SIZE			9.28***	8.37***	7.91***	6.31***
			(2.33)	(2.52)	(2.60)	(2.15)
TROPIC_LIVEST_UNIT				3.10	3.06	7.95***
				(2.52)	(2.52)	(2.26)
PER_CAPITA_CONSUMP					-0.00	-0.00**
					(0.00)	(0.00)
_IDISTRICT_2						-104.59***
						(15.03)
_IDISTRICT_3						-73.31***
						(18.84)
Constant	112.38***	114.72***	69.69***	66.62***	70.84***	119.81***
	(18.35)	(18.20)	(20.19)	(20.84)	(20.69)	(19.10)
Observations	1,244	1,244	1,244	1,244	1,244	1,244
R-squared	0.01	0.07	0.10	0.10	0.10	0.21

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table No 13
Household with improved cook stoves (ICS)

	(1)	(2)	(3)	(4)	(5)
REDD	0.07*	0.07	0.07	0.07	0.05
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
ENDLINE	0.04	0.04	0.04	0.04	0.02
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
INTERACTION	0.01	0.02	0.02	0.02	0.03
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
HAVE_LPG		-0.03	-0.03	-0.04	-0.02
		(0.03)	(0.03)	(0.04)	(0.03)
LOCAL_ORG_COUNT		0.01	0.01	0.01	0.01
		(0.01)	(0.01)	(0.01)	(0.01)
HOUSEHOLD_SIZE			-0.00	0.00	0.00
			(0.01)	(0.01)	(0.01)
LITERATE_HHHEAD				0.04	0.03
				(0.02)	(0.02)
PER_CAPITA_CONSUMP				0.00	0.00
				(0.00)	(0.00)
PERM_TOILET					0.08***
					(0.02)
2.DISTRICT					-0.12**
					(0.05)
3.DISTRICT					-0.16***
					(0.05)
Constant	0.08***	0.06*	0.06	0.03	0.05
	(0.02)	(0.03)	(0.04)	(0.04)	(0.03)
Observations	1,244	1,244	1,244	1,244	1,244
R-squared	0.02	0.02	0.02	0.02	0.07

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table No 14
Households with biogas

	(1)	(2)	(3)	(4)	(5)
REDD	0.02	-0.00	-0.00	-0.01	-0.00
	(0.03)	(0.04)	(0.04)	(0.03)	(0.03)
ENDLINE	0.01*	0.00	0.00	-0.00	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
INTERACTION	**0.04***	**0.05***	**0.05***	**0.06****	**0.05***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
HAVE_LPG		-0.05*	-0.05*	-0.08***	-0.14***
		(0.03)	(0.03)	(0.03)	(0.03)
LOCAL_ORG_COUNT		0.03***	0.03***	0.03***	0.02**
		(0.01)	(0.01)	(0.01)	(0.01)
HOUSEHOLD_SIZE			-0.00	-0.00	-0.00
			(0.01)	(0.00)	(0.00)
TROPIC_LIVEST_UNIT				0.03***	0.02**
				(0.01)	(0.01)
LITERATE_HHHEAD				0.06***	0.07***
				(0.02)	(0.02)
PER_CAPITA_CONSUMP				0.00**	0.00***
				(0.00)	(0.00)
PERM_TOILET				0.08***	0.08***
				(0.02)	(0.02)
2.DISTRICT					0.16***
					(0.03)
3.DISTRICT					0.18***
					(0.04)
Constant	0.09***	0.02	0.02	-0.12***	-0.20***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)
Observations	1,244	1,244	1,244	1,244	1,244
R-squared	0.01	0.03	0.03	0.08	0.14

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table No 15: Percentage share of Bio-gas

	(1)	(2)	(3)	(4)	(5)
REDD	0.83	-0.74	-0.76	-1.18	-0.70
	(2.45)	(2.42)	(2.43)	(2.35)	(2.04)
ENDLINE	0.34	-0.26	-0.31	-0.79	-0.58
	(0.41)	(0.53)	(0.56)	(0.64)	(0.67)
INTERACTION	**3.21***	**3.73****	**3.72****	**4.30****	**3.84****
	(1.70)	(1.65)	(1.66)	(1.73)	(1.74)
HAVE_LPG		-3.87**	-3.90**	-5.87***	-9.22***
		(1.73)	(1.72)	(1.86)	(1.95)
LOCAL_ORG_COUNT		2.60***	2.62***	2.12***	1.71**
		(0.78)	(0.78)	(0.74)	(0.67)
HOUSEHOLD_SIZE			-0.13	-0.39	-0.44
			(0.34)	(0.36)	(0.34)
TROPIC_LIVEST_UNIT				1.67***	1.20**
				(0.55)	(0.56)
LITERATE_HHHEAD				4.36***	4.43***
				(1.50)	(1.46)
PER_CAPITA_CONSUMP				0.00**	0.00***
				(0.00)	(0.00)
PERM_TOILET				4.70***	5.12***
				(1.39)	(1.45)
_IDISTRICT_2					9.58***
					(2.03)
_IDISTRICT_3					12.32***
					(2.82)
Constant	5.83***	0.34	0.96	-8.01***	-13.11***
	(1.78)	(2.09)	(3.03)	(2.87)	(3.33)
Observations	1,244	1,244	1,244	1,244	1,244
R-squared	0.01	0.03	0.03	0.08	0.13

Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table No 16
Percentage share of firewood

	(1)	(2)	(3)	(4)	(5)
REDD	-6.35	-1.72	-1.69	-2.06	-2.65
	(5.25)	(2.99)	(3.01)	(2.90)	(2.57)
ENDLINE	-3.22**	0.37	0.59	1.07	0.64
	(1.21)	(0.76)	(0.74)	(0.69)	(0.69)
INTERACTION	-2.07	**-5.04****	**-4.96****	**-5.03****	**-4.39****
	(1.93)	(1.97)	(1.98)	(1.91)	(1.85)
HAVE_LPG		-40.30***	-40.02***	-36.11***	-31.05***
		(3.74)	(3.58)	(3.28)	(2.28)
LOCAL_ORG_COUNT		-2.37***	-2.45***	-1.97**	-1.65**
		(0.78)	(0.79)	(0.79)	(0.70)
HOUSEHOLD_SIZE			0.43	-0.12	-0.19
			(0.41)	(0.42)	(0.43)
TROPIC_LIVEST_UNIT			0.28	0.23	0.90
			(0.69)	(0.66)	(0.67)
PER_CAPITA_CONSUMP				-0.00***	-0.00***
				(0.00)	(0.00)
_IDISTRICT_2					-13.89***
					(3.07)
_IDISTRICT_3					-13.68***
					(2.32)
Constant	87.50***	100.28***	97.51***	102.69***	109.41***
	(3.19)	(1.99)	(3.68)	(3.66)	(3.87)
Observations	1,241	1,241	1,241	1,241	1,241
R-squared	0.02	0.36	0.36	0.38	0.42

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table No 17
Household income from CFUG activities

	(1)	(2)	(3)	(4)	(5)
REDD	616.67*	470.44*	455.87	459.22	521.73**
	(330.04)	(277.66)	(282.63)	(273.62)	(248.16)
ENDLINE	-210.85	-263.12*	-264.20*	-223.37	-222.53
	(125.57)	(132.97)	(132.94)	(138.82)	(134.33)
INTERACTION	398.43	444.38	**460.74***	**483.78***	**450.10***
	(268.80)	(266.56)	(268.92)	(269.86)	(266.63)
HAVE_LPG		-460.84**	-480.20**	-404.11**	-207.33
		(197.51)	(193.02)	(178.30)	(163.70)
LOCAL_ORG_COUNT		252.96**	244.86**	240.16**	160.94**
		(98.09)	(100.67)	(98.63)	(72.45)
EXEC_MEMBER			428.01	396.07	391.17
			(285.05)	(284.68)	(245.27)
INDIGENOUS				356.16**	44.30
				(145.10)	(150.27)
DALIT				683.55*	759.06**
				(355.68)	(336.97)
HOUSEHOLD_SIZE				133.60***	82.76***
				(32.16)	(27.61)
_IDISTRICT_2					-165.29
					(166.27)
_IDISTRICT_3					1,237.22***
					(428.33)
Constant	579.62***	61.68	36.77	-932.60**	-705.90**
	(119.46)	(226.81)	(220.32)	(364.04)	(321.33)
Observations	1,244	1,244	1,244	1,244	1,244
R-squared	0.03	0.05	0.06	0.08	0.14

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.

5. Discussions and Conclusions

The main challenge of an impact evaluation of a programme is to determine the counterfactual. Successful impact evaluation thus hinges on avoiding the selection bias and finding perfectly matching comparision groups (Khandker et al., 2010). In the absence of randomized control trials, creating a comparision group through statistical design is the best alternative. For a scientific impact evaluation of a REDD+ program conducted in Nepal, this study aims to fill up the caveat of randomized control trial by combining the difference in difference (DID) method with the PS matching by creating statistically comparable groups. Collection of baseline data on a diverse range of variables would allow for examining and cross validating the impact of REDD+ across different dimensions of livelihood and community welfare. The design of this study also allows triangulating the findings from three interrelated evidences generated through technical data from carbon monitoring, ecological data and socio-economic data on household practices and behavior from household survey.

REDD and REDD+ is a recently proposed international mechanism for bringing the environmental services of the vast forestry sector into market for carbon. It is supposed to be significant, cheap and quick and REDD+ is based on the assumptions that economic incentives can be effective to prevent forest degradation and conserve forests for carbon to mitigate climate change impacts. But there is in-sufficient evidence on the effectiveness of such incentives in the case of public goods such as forests.

Our paper presents findings from a real life experiment on REDD+ in Nepal and produces strong evidence that such incentive mechanisms do work. The strength of our findings rests on the methodological approach used. The analysis of increment in the mean values of the treatment and control CFUGs indicate that there is net positive carbon increment in both the treatment and the control CFs implying that communities are conserving forest with and without REDD+. The DID impact evaluation indicated that except for litter biomass in the expected direction, there were no statistically significant impacts on the components and the total forest carbon. On the other hand, the ecological indicators have signaled improvement in forest management practices as there is statistically significant reduction in forest fire incidence, timber extraction, increased signs of wildlife in the treatment compared to the control groups. All these findings indicate that communities have started responding to the REDD+ incentives but it takes time for communities to bring change in the structure of the household energy use, livestock holding and other practices that lead to carbon stock enhancement. No statistically significant impact on extraction of main forest products such as firewood, fodder-grass and leaf-litter also validated this argument. Interestingly, a number of studies have warned that REDD+ might deprive communities from the extraction of forest products that are vital for rural livelihood (Lederer, 2012; Pistorius et al., 2011). Our finding has ruled out such fears. Our findings have indicated that communities respond positively to REDD+ by utilizing REDD+ incentives for adopting bio-gas to reduce dependence on firewood for household cooking. This is validated by the decline in the share of firewood in household cooking. Though it might seem contradictory that there is decline in the share of firewood in household cooking but no decline in the extraction of firewood, it seems logical. Nepal is a temperate and cold climate country and in addition to cooking, household need fuel to warm their houses. So, even rational household try to collect firewood in a sustainable way and without violating community norms from all available sources for household heating beyond their need for household cooking. The differences in the pace of switching from firewood to bio-gas indicate that switching from conventional to convenient and cleaner fuels can be a more effective channel for realizing REDD+ goals within a short period of time. The findings that treatment communities have benefitted more from CFUG initiated activities also indicate that communities have benefitted from REDD+ incentives. Overall, these findings indicate that communities do respond to economic incentives by bringing about behavioural changes that are possible in the short run while preparing for more effective responses for environmental protection in the long run.

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