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Community Based Forest Management for Climate Change Adaptation and Mitigation Under Terai Arc Landscape Program in Nepal

KEYWORDS: Landscape approach, community forestry, climate change, adaptation, mitigation

Ram Prasad Lamsal — Kathmandu University, Nepal

Dr. Sanjay Nath Khanal — Kathmandu University, Nepal

ABSTRACT *Landscape approach in conservation has gained prominence to reconcile conservation and development tradeoffs and tends to generate impacts not only on conservation of biodiversity and ecosystem services, improvement of livelihoods but also on climate change. Using community forests of Terai Arc Landscape (TAL) area of Nepal, this study (a) reviews an observed and perceived climate change impacts and (b) offers some community-based mitigation and adaptation techniques for curbing challenges with the issues on identification and assessment of impacts*

The study is based on literature reviews, field visits, case studies, participatory action research and forest inventory. This study illustrates the practice and outcomes landscape level conservation in Nepal as an approach to improve biodiversity conservation and natural resources management to minimize the negative impacts and reveals potentiality of adaptation and mitigation through biodiversity conservation and sustainable forest management.

Introduction

Landscape approach has been gained importance in response to increasing societal concerns on conservation and development tradeoffs (Sayer, 2000) Now, the approach has been central to some major national and international conservation initiatives (Sayer. et al, 2013). Globally and also in Nepal, initiated through the principle of island biogeography and meta-population theory for maintaining viable population focused to strengthen protected area system (Kingsland, 2002; Shimberloff& Abele, 1982;), the concept has now widen to embarrass the people-centered and multifunctional landscape, beyond protected areas and wildlife (Bennett, 1998, 2003). In recent years in Nepal, the landscape-based conservation approach and community based management has been adopted as an opportunity to scale up conservation initiatives (WWF, 2004), the Terai Arc Landscape (TAL) programme as an example. Effective landscape approach can lead to higher level of biodiversity conservation and management, improved livelihood of local communities, sustainable forest management with increased carbon sequestration and hence change mitigation and adaptation. (UNEP, 2009; FAO, 2010; Parrotta, et al., 2012). By strengthening protected areas and community forests (CFs), TAL supports an effective framework for forest based climate change mitigation and adaptation.

Objectives

Using CFs of TAL area of Nepal, this study (a) reviews an observed and perceived climate change impacts; and (b) offers some community-based mitigation and adaptation techniques for curbing challenges and (c) discusses issues on identification and assessment of impacts.

Methods

The study is based on primary data and literature reviews. Three active and heterogeneous Community Forest User Groups (CFUGs) of TAL area were selected as the study sites namely Basanta CFUG, Kailali district, Khata CUFG, Bardia district and Pragatishil CFUG, Dang district (Table 1). Different participatory tools such as focus group discussion (FGD), discussion with committee members, key informants' survey and semi-structured questionnaire survey were used to generate the primary data. The sample size (n=71) was determined based Cochran's formula for categorical data collection using sampling error of 10 percent. In addition, CF inventory data were analyzed and compared to the nearby government managed forests (GMF) to estimate biodiversity indices and growing stock.

Table 1: Sample CFUGs selected for the study

District	FUG name	handover year	Area ha	HHs
Kailali	Basanta	2010	48.46	52
Bardiya	Khata corridor	2009	21.00	134
Dang	Pragatishil Women	1998	9.93	49
Total			79.39	235

(Source: Field Survey, 2011)

Result and discussion

Observed and perceived impacts

Reviewing literature shows that there is no increases in annual temperature over Nepal based on data from 1960-2003 (McSweeney, et al. 2008). However, there are citations on increase in temperature in recent years at higher altitudes by Agrawala, et al. 2003; Bhutiyani, et al. 2010. Hot nights have increased by 2.5% (McSweeney, et al. 2008). Average temperature is predicted to rise significantly by 0.5 to 2.0 °C by 2030 (NCVST, 2009). Since the mid-1970s average air temperature in Nepal has risen by 1° Celsius (Shrestha, et al., 1999). Projected mean annual precipitation for Nepal does not show a clear trend with reference to both increases and decreases (NCVST, 2009). At community level, both observed data and local perception reveals that climate change is no longer a future reality.

Perceptions

Table 3 shows the total number and proportion of respondents responding Yes or No or Do Not Know to each perception statement. Higher proportion of respondents said that they do not have the idea of climate change with statistically significant on Chi-square test (n=38, 67.61%,

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X^2_2=37.55; P=0.000). Only 35.21 percent respondents said that they have experienced a significant increase in temperature in recent years, which was not statistically significant at 5%(X^2_2 =1.229; P=0.541).

The statistically significant perceptions at 5% were as: feeling more heat in summer and cold in winter (n=35, 49.3%, X^2_2=8.901; P=0.012); increase in rainfall than before (n=44, 61.97%, X^2_2=26.394;P=0.000); delayed in rainfall (n= 34, 47.89%, X^2_2= 8.901; P=0.014); increase in period of drought (n= 51, 71.83%, X^2 = 49.465; P=0.000); increase in floods (n=45, 63.38%, X^2_2 = 31.887; P=0.000); and decrease in water availability (n=51, 71.83%, X^2_2= 71.83; P=0.000).

Table 2: Perception of local people on climate change

Impact statement	Y	N	DK	X^2	p
Overall awareness on climate change	11(15.49)	12 (16.90)	48(67.61)	37.55	0.000
Increased seasonal temperature	25 (35.21)	19 (26.76)	27 (38.01)	1.229	0.541
Hot winter and cold summer	35 (49.3)	15 (21.13)	21 (29.58)	8.901	0.012
Increased rainfall	44 (61.97)	12(16.90)	15 (21.13)	26.394	0.000
Delay in rainfall	34 (47.89)	14 (19.72)	23 (32.39)	8.479	0.014
Increased drought	51 (71.83)	5 (7.04)	15 (21.13)	49.465	0.000
Increased floods	45 (63.38)	7 (9.85)	19 (26.76)	31.887	0.000
Decreased water availability	51(71.83)	4 (5.84)	16 (22.54)	50.394	0.000

(Responses: Y= Yes; N= No and DK= Do Not Know; X^2 test with df=2. The figures in parentheses are percent)

Impacts of climate change

Proportion of responses showing statistically significant at p<0.005 were: changes in the flowering and fruiting time of the forest and agricultural species (n=50, 70.42%, X^2_2 = 44.141; P=0.000); disappearance of some local non timber forest products ($NTFP_S$) in CF (n=37, 52.11%, X^2_2= 38.18; P=.001) and deceased production of agriculture crop (n=41, 57.75%, X^2_2= 38.18; P=0.000).

The proportions of respondents who said "do not know" were significantly higher than those who thought yes or no were on extinction of plant species (n=45, 63.38%, X^2_2 = 32.986; P=0.000); increase in forest fire (n=35, 49.30%, X^2_2 = 8.901; P=0.012) and increase in invasive species (n=36, 57.75%, X^2_2 = 50.70; P<0.008);

Chi-square tests do not show the difference to be statistically significant at 5% were on: decreased availability of forest products (n=29, 40.85%; X^2_2 = 2.1.41; P=0.343); decrease in soil moisture (n=28, 39.44%; X^2_2 = 1.718; P=0.424) and change in wind pattern (n=29, 40.85%; X^2_2 = 2.141; P=0.343) (Table 3).

Table 3: Impacts of climate change

Impact statement	Y	N	DK	X^2	p
Changes in flowering and fruiting time	50 (70.42)	9 (12.68)	12 (16.90)	44.141	0.000
Decreased availability of forest products	29 (40.85)	23 (32.39)	19 (26.76)	2.141	0.343
Decreased availability of NTFPs in forest	37 (52.11)	12 (16.90)	22 (30.99)	13.380	0.001
Decease production of agriculture crop	41 (57.75)	12 (16.90)	18 (25.35)	19.803	0.000
Extinction of plants species	20 (28.17)	6 (8.45)	45 (63.38)	32.986	0.000
Increase in forest fire	21 (29.58)	15 (21.13)	35 (49.30)	8.901	0.012
Increased invasive species	17 (23.94)	18 (25.35)	36 (50.70)	9.662	0.008
Soil moisture depletion	28 (39.44)	24 (33.80)	19 (26.76)	1.718	0.424
Wind pattern changes	29 (40.85)	19 (26.76)	23 (32.39)	2.141	0.343

(Responses: Y= Yes; N= No and DK= Do Not Know; X^2 test with df=2. The figures in parentheses are percent)

Environmental benefits of CFs

CFs have been proliferated throughout the TAL and a large areas are now under the management of CFUGs. As shown in Table 4, statistically higher percent respondents agreed that CF has effect on providing cool air in summer and maintaining the atmospheric temperature (n=44, 61.97%, X^2_2=26.394;P=0.000). The higher percent of respondents said Do Not Know on role of CF on stabilizing soil and reducing the natural hazards (n=33, 46.48%, X^2_2 = 5.606; P=0.061). The respondents expressed that the CF preserves the water sources, provides grass and firewood were found statistically significant (n=55, 77.46%, X^2_2 = 37.742; P=0.000).

The proportions of respondents who said "do not know" were significantly higher than those who thought yes or no were on role of CF in sequestering carbon (n=40, 56.34%, X^2_2 = 17.099; P=0.000); Only 19.72 percent respondents perceived that CFs sequesters carbon. Higher proportion of percent respondents agreed for CF providing income and employment (n=51, 71.83%, X^2_2 = 48.704; P<0.05) which was significant.

Table 4: Perceived environmental impact of CF

Impact statements	Y	N	DK	X^2	p
Provides cool air and maintain temperature	44 (61.97)	12 (16.90)	15 (21.13)	26.394	0.000
Stabilizes soil and control natural hazards	20 (28.17)	18 (25.35)	33 (46.48)	5.606	0.061

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Provides forest products and water sources	55 (77.46)	7 (9.86)	9 (12.68)	37.742	0.000
Sequesters carbon	14 (19.72)	17 (23.94)	40 (56.34)	17.099	0.000
Provides income and employment	51 (71.83)	6 (8.45)	14 (19.72)	48.704	0.000

(Responses: Y= Yes; N= No and DK= Do Not Know; Test of proportions; S= significant; NS= Not significant; X^2 test with df=2. The figures in parentheses are percent)

Local Adaptation Practices

The adaptation practices are diverse, local knowledge based and integrally linked to CFs. The following adaptive practices were reported from respondents (Table 5): 39.44 percent on agroforestry for multiple land use objectives, 69.71 percent on alternate income generation including remittances, 29.58 percent on artificial irrigation, 16.90 percent on bioengineering;, 100 percent preferred biogas and improved stove, 19.72 percent deep tube well, 100 involved in group formation, 100 percent increased awareness, 46.48 percent on modification of cropping practices, 43.66 percent on modification of houses and changing on construction materials and design; 71.83 percent on stall feeding and 100 percent on tree plantation (Table 5)

Table 5: Adaptation measures undertaken by communities

Adaptation measures	Number of respondents	Percent
Agroforestry	28	39.44
Alternative income generation	48	67.61
Artificial irrigation	21	29.58
Bioengineering measures	12	16.90
Biogas and improved stove	71	100.00
Establishment of deep tube well	14	19.72
Formation of community groups	71	100.00
Awareness raising	71	100.00
Modification of cropping practices	33	46.48
Modification of houses	31	43.66
Stall feeding	51	71.83
Tree plantation	71	100.00

(Source: Field Survey, 2011)

Mitigation

Forest carbon stocks has been conserved through reduction of deforestation and forest degradation by sustainable management, fire control, silvicultural operations and management of forest biodiversity. The analysis and comparison of inventory data of CFs and nearby Government managed forests (GMFs) shows the following results:

Biodiversity

The comparative analysis of three CFUGs and nearby GMFs on α biodiversity indexes, it is possible to observe that CF environments are diverse (N=12322, S = 23; d= 440/ha; Dmg=2.6678; Dmn=0.433) compared to GMFs (N=1999; S = 7; d= 220/ha; Dmg= 0.944; Dmn=0. 289) (Table 6).

Table 6: Species number and Apha biodiversity estimator for CF and GMF

Variables	Annotation	Avg of CFs	Avg of GMFs
Average number of plants, abundance	N	12322	3999
Species richness, S	S	33	17
Average number per species, density	^0D	440	272
Simpson Index	λ	0.362	0.750
Dominance Index	D	0.629	0.249
Reciprocal Simpson Index	1/λ	3.443	1.642
Shannon Index	H'	3.152	1.874
Menhinick Index	DMn	0.433	0.289
Buzas and Gibson's Index	E	0.456	0.632
Pielou's	J'	0.708	0.846
Simpson Index Approximation	A λ	0.181	0.375
Dominance Index Approximation	AD	0.810	0.623
Alternate Reciprocal Simpson Index	N2	6.834	3.234
Berger-Parker Dominance Index	d	0.307	0.695
Inverted Berger-Parker Dominance Index	1/d	3.630	2.320
Margalef Richness Index	DMg	2.677	0.944
Gini Coefficient	G	5.727	2.092

(Source: Field Survey, 2009 and 2013)

All diversity indices, including Reciprocal Simpson Diversity Index (1/λ), Shannon Diversity Index (H'), Dominance Index (D) Inverted Berger-Parker Dominance Index (1/d) highlight that the CFs are diverse. The GMFs (1/t = 1.642; H' = 1.874; D=0.249; 1/d=2.320) show greater evenness degree (J=0.846 and E=0.632).

The CFs record a greater abundance as well as a higher variety of environments that are able to be develop by forests species than in GMFs. GMFs represent the most extreme type of environment, poor governance and higher threats acting as limiting factors in the diversity. Increased species diversity is linked to the local climate and inevitably to climate change as it is the foundation for the natural processes of climate regulation. Biodiversity and ecosystem services are the foundation of many successful adaptation strategies, especially for poor people. They can also deliver climate change mitigation benefits.

Growing stock

The state of forests in CFs has improved over the past 5 years (Table 7). The average basal area of CFs was 13.41 m^2/ha compared to GMF with 6.33 m2/ha. Mean species/ha was 33 in CFs compared to 17 species in GMF. The density/ha in CFs was 12117 plants compared to 2348 in GMFs. In CFs, the mean volume was 150 m^3/ ha and in GMF it was 89 m^3/ha. The increase in growing stock in CF compared with GMF shows the role of CF as leading to a steady increase of forest carbon stocks by reducing forest disturbance and supporting mitigation measures (FAO, 2010).

Table 7: The stand structure of CF and GMFs

Variables	Average of CFs	Average of GMF
Mean basal area (m2/ha)	13.41 (1.57)	6.33 (0.75)
Mean no. of species/ha	12117 (4188)	2348 (391)
Mean species (number/ha)	33 (2)	17 (1)
Mean volume (m3/ha)	150 (17)	89 (11)

The values in parentheses are ± S.E. (Source: Field Survey, 2009 and 2013)

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Issues on identification and assessment of impacts

To take account of all important impacts and interactions, including indirect and cumulative effects, in practice, it is often difficult to identify, prioritize, understand and use the full set of landscape level conservation outcomes on climate change science, data and information (Buck et al, 2006; Tillmann&Siemann, 2012). The required data is difficult to find, not available at an appropriate scale or time, or is not available in useful and accessible formats (Tillmann&Siemann, 2012). Despite significant interest in addressing landscape level conservation issues including climate change, lack of skills, resources and institutional capacity prevents planning, action or acquisition of services to adequately address the issues. Climate-related priorities compete with other development priorities and climate change has not been mainstreamed sufficiently into current policy priorities.

Conclusion

Climate change induced stresses have affected community welfare through complex causal pathways on livelihood option often combine with non-climate stressors. However, CFs under landscape level conservation play an important role in both adaptation and mitigation as they provide local ecosystem services in holding large stores of carbon and harbouring important biodiversity, and are critical for the livelihoods of communities. CFs actions have the most immediate and greatest benefits for both carbon and biodiversity. Until recently, adaptation and mitigation have often been considered separately in climate change science, policy and implementation, but they need to be integrated in CF under landscape level conservation.

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