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ASSESSING THE IMPACTS OF CHANGING CLIMATE ON FOREST ECOSYSTEM SERVICES AND LIVELIHOOD OF BALAKOT MOUNTAINOUS COMMUNITIES

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Abstract

Mountainous communities are facing some profound climatic changes and environmental degradation due to their higher dependence on natural resources. The current study has estimated vulnerability of mountain forests and the provision of forest services to Balakot local community in context of climate change. The study had mapped three integral ecosystem services as provisionary (fuel wood, timber, fresh water), regulatory (protection from natural hazards) and cultural (recreation) through the local community's perception. Carbon stock assessment as a regulatory service of the forest was carried out in the standing trees and from the soil of five selected sites in Balakot. Results have shown that these forests provide myriad of services to their surrounding communities in the form of timber, firewood, climate regulation and recreation etc. In terms of change in delivery of ecosystem services, 66% respondents informed that fuel wood has declined, 82% were of the view that forest cover has been reduced and 83% were agreed that their local forest is important for peace and harmony. The total carbon stock assessment was found to be 243.79 t/ha with an average tree biomass of 207.41 t/ha and the soil carbon of 36.38 t/ha. The study concluded that these forests are playing a vital role for the livelihood of the surrounding community as well as contributing in the climate change impacts mitigation. Therefore, these forest needs to be managed sustainably for the continuity of numerous services to mankind.

Key words: Ecosystem services, Carbon stock assessment, Climate change, Vulenrability, Balakot.

Introduction

Ecosystems are distinct boundaries where biotic and abiotic components live together and interact. These boundaries are of climatic parameter which indicates a certain type of life within. Mountain Ecosystems are defined by their elevation above sea level between 300-1000m and are most fragile ecosystems occupying one fifth of the terrestrial biome in the world (Briner *et al.*, 2012). Twenty percent of the world's population lives on the mountains or their edges while nearly 40% of mankind depends on mountains and associated resources for their livelihood (Schild, 2016). These are the world's water towers on which people are relying for their domestic use, industry, irrigation and pivots for global biodiversity. Mountains are known to be hotspots of climate change. Ecosystems and the services they provide are intrinsically dependent upon climate (Keenan, 2015). According to Millennium Ecosystem Assessment (MEA), "ecosystem services" are the benefits people obtain from an ecosystem and these benefits are basic livelihood activities in certain communities (Anon., 2005). There exists a very strong relationship between human beings and the nature through these tangible and intangible services (Aryal *et al.,* 2018). MEA broadly categorize these benefits as provisionary, regulatory, cultural and supporting services. Mountain Forests as most beneficial ecosystems provide many services to their surrounding community in terms of water purification and regulation (Ponette-Gonzales *et al.*, 2010), air quality regulation (Hein *et al.*, 2006), climate regulation (Shaheen *et al.*, 2016), erosion prevention (Klein *et al.*, 2007), soil fertility maintenance (Gallai *et al.*, 2009) and few intangible benefits including cultural diversity, nature based recreation, spiritual and educational values (Raymond *et al.*, 2009). These forests act as the major sink of carbon dioxide as half the dry weight of these trees is carbon (Padilla *et al.*, 2010). Sequestering atmospheric carbon into trees and soils is considered as one of the most acknowledged service of the forest ecosystem (Anon., 2016).

Asia occupies 14% of the World's forests with 432 million ha of natural forests and 116 million hectare of planted forests (MacDicken *et al.*, 2015). Pakistan is having only 3.1% of total forest land with a fast decline being reported in the overall forest land of Pakistan from 3.3% in 1990 to 1.9% in 2015 (Anon., 2016). The second highest source of GHGs emission globally is because of deforestation which releases almost 2 gigatons of carbon yearly (Quere *et al.*, 2015). Mountain forests like other biomes play a vital role in absorbing atmospheric carbon dioxide into trees and soils (Anon., 2013). Therefore this is by far the most accepted, cost effective and long term course of reducing global warming and climatic changes (Ciurean *et al.*, 2013). The world's forest occupy almost 3869 million hectare of land which have almost 421 x 10^6 tonnes of total aboveground biomass (Bain *et al.*, 2015). This indicates that the pool of carbon tends to accumulate till the equilibrium state of forest growth. In converse, deforestation will result in losing carbon sinks. It is said that in 21st century, climate driven change will be dominant in terrestrial ecosystems affecting specially forest biodiversity, and altering species structure and function (Thorne *et al.*, 2017). Himalayan forests are facing rapid degradation due to economic development as well as higher population pressure (Lindner *et al.*, 2014). These local forests are contributing in global climate change mitigation and if the pace of degradation and deforestation is continued, this will be a greater loss for local communities as well as national calamity. These provides livelihood to local people with no other life opportunity (Shedayi *et al.*, 2016). It is reported that sub-tropical Himalayas of Kashmir accounts for 186.24 t/ha of total carbon (Shaheen *et al.*, 2016); similarly in a local study of District Neelum AJK-Pak, it is reported that 57% of the local community was using herbal medicines for their ailments (Shaheen *et al.*, 2017). This shows higher dependence of local people on natural resources of their areas, which makes them more vulnerable to the changing climatic conditions.

Mountainous environments are at high-risk of landslides, earthquakes, volcanic eruptions, avalanches and glacial lake outburst floods (GLOFs) which threaten life in mountain regions and surrounding areas. Such threats can wipe out major livelihood resources such as fertile land, standing crops, stored food and seeds (Veith & Shaw, 2011). Due to fragile soils and the vegetation cover, these areas have become vulnerable to environmental degradation (Peterson & Halofsky, 2017). It is evident that the socioeconomics of mountain people will be affected and altered by the biophysical instability of its ecosystems (Kok *et al.*, 2016). These amplify natural disasters and disturb people's lives in mountainous regions worldwide. These people retain traditional ecological knowledge on how to manage the land in a challenging mountain environment (Rahut & Ali, 2017). The mountain forests and their associated communities are more vulnerable to climatic changes as having higher exposure and sensitivity to the perturbations and stressors (Gobiet *et al.*, 2014). The social elements coupled with ecosystem functions need to maintain or adapt to change for subsistence livelihood (Anon., 2014).

The conceptual note underpins that the study is very interdisciplinary dealing with people, their livelihood, ecosystems and climate change. The foundation of current study is that the ecosystem services provide basics for people's livelihood and if there is some change in an ecosystem, this will positively or negatively affect the local community and their wellbeing. To judge this postulate, current study has investigated various ecosystem services provided by Balakot mountainous forest to the local community and the vulnerability provoked by changing climate in provision of these services.

Materials and Methods

Study Area: The study area is Balakot (34.54°N; 73.35°E), one of biggest tehsil of District Mansehra which lies in the lower Himalayan with an altitude of 900-5000m (Qasim *et al.,* 2010). The Pakistan's part of Himalayan is experiencing an increase in summer and winter's temperature which has affected the water volumes as well as crop production at local level (Anon., 2007). The change in the rate of precipitation has severely affected the livelihood of locals who depend mostly on natural resources of the region. Climate change has emerged as a challenge and threat to carry on traditional practices of daily life. Himalayan livelihood is marginalized and vulnerable to the changing climatic conditions (Aryal *et al.*, 2014).

The area is surrounded by Balakot sub-forest division which is connected to the Main Kaghan Forest Division, KPK Pakistan and has an estimated area of 20,879 acres (8.449.1 hectares). The main land use types identified are the forested area, cultivated land, settlements and a part is the barren land (Anon., 2007). The average precipitation of Balakot is recorded 1471 mm which is very high as compared to rest of the country. The maximum temperature is 43.5ºC with a minimum temperature of -3ºC (Anon., 2016). The favorable climatic conditions have made it a popular tourist station. The vegetation of the dry sub-tropical Himalayan forest is dominated by *Pinus roxburgii* sarg. Commonly called chir pine. The tree is popular among the local community for its fuelwood value, medicinal as well timber value. Along with dominated forest of *Pinus roxburgii*, there are few patches of *Quercus leucotricophora* and *Cedrus deodara* at the foothills. The area under study was hard hit by the earthquake of 2005 and most of the community people lost their valuable assets (Soomro *et al.,* 2012). After the major calamity, the livelihood opportunities for the local people are in the form of the surrounded forest. The mountain forest is therefore providing many valuable services to the local community in the form of water, fuel wood, timber, and medicinal plants (Soomro *et al.,* 2010). In addition, these forests are indirectly acting as barriers to natural hazards, controlling soil erosion, helping in carbon storing and soil nutrient formation. Many of the locals are involved in nature based tourism which is also an important service provided by the mountainous forest (Basharat *et al.,* 2016). A list of forest services to Balakot Community is prepared which was highlighted by the locals during the field visits and focus group discussions (Table 1). In the view of climate change, these ecosystem services are exposed and expected to diminish. As a result, local people are highly vulnerable due to their marginalized and natural resource-dependent livelihood. Map of the study area is shown in Fig. 1.

Forest services assessment method: To achieve the objectives of current study, field surveys were done in five selected sites in tehsil Balakot using multi methods as described in Table 2. The tehsil has almost 22894 persons distributed in four main villages in almost 2857 households (Shahzad *et al.*, 2018). Out of these, 200 households were visited from March 2017 to November 2017 to gather data from the head of each household. Few key informants were also interviewed, these people were stakeholders and chosen from union councils, forestry department, and community representatives.

The ecosystem services mapped in the study area were categorized according to the Millennium Ecosystem Services (Anon., 2005). To gather data on provisionary, regulatory and cultural services of forest to local community, a questionnaire was used in face to face interview as well as focus group discussions were conducted. Field surveys were carried out into the forested area to estimate carbon stock of the forest.

Table 1. List of goods and services identified by Balakot community from the surrounding forest.

Types of ecosystem services as identified by MEA 2005	Goods and services mapped by the locals in the study area	Components of Human well-being and livelihood
Provisionary goods	Fresh water Fuel-wood Fodder to animals Medicinal value (barks; leaves; stems; seeds; roots) Food value (honey, fruits and vegetables, fish, nuts, mushrooms) Timber production NTFPs (Resins etc)	Basic life necessity Shelter Food Adequate livelihood Health of individuals Access to clean air water and food Feeling well about own place Longevity due to peaceful living Access to goods Life security Social interaction and cohesion Livelihood provision
Regulatory services	Local climate regulation (carbon sequestration) Flora and fauna diversity Air quality regulation Water purification Pest control Natural hazard protection	
Cultural attachments	Recreation and tourism Spiritual values Sense of place Aesthetic value	

Table 2. Ecosystem services measured in the study area and the method of assessment.

Ecosystem services mapped	Data input method	Change in provision of services	Climate based vulnerability assessment
Provisionary Fuel wood Fiber/food Fodder to livestock Fresh water	Focus group discussion\ Questionnaire	Interviews with Key informants Focus group discussion Household survey	Focus group discussion and people's perception based on comparative regional studies
Regulatory Climate regulation (Carbon sequestration) Water Purification Protection from natural hazards	Aboveground/Belowground biomass Questionnaire		
Cultural Educational value Sense of peace Recreational/ ecotourism Spiritual and religious value	Focus group discussion\ Questionnaire		

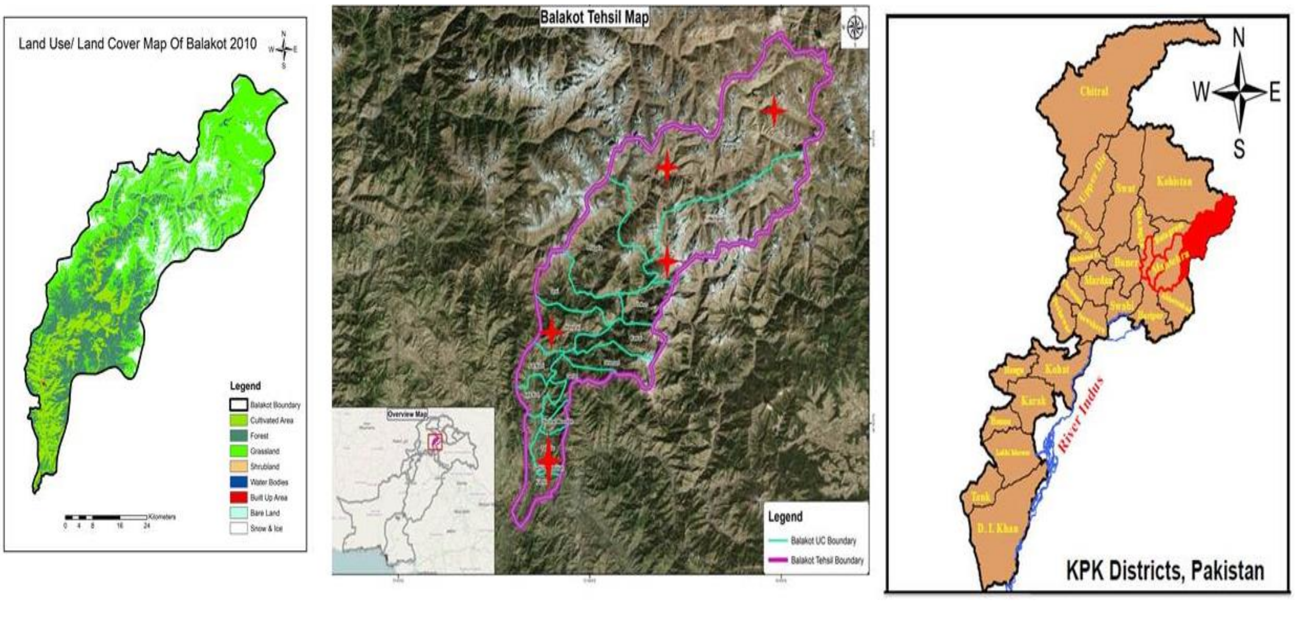

Fig. 1. Map of the Balakot study area with locations of sites (center) and overall land cover (left side).

Provisionary services: Using focus group discussion and interviews through the questionnaire, local people were asked to value their forest services as high, medium and low. They were further inquired about of fuel wood consumption, and collection pattern, fiber/food, fodder to livestock and fresh water availability. They were asked about their family size and size of their grazing herds (Acharya *et al.*, 2011). Respondents were asked about the change in services of their neighborhood forest from the last thirty years. Their response in change was measured as increase, decrease or no change in a service.

Regulatory services: Local people were inquired about the roles of forest for protecting the community and their assets from natural hazards, and in purifying water for their use. They were also asked about the role of trees in cooling their surroundings (Butt, 2006).

Cultural services: Although, cultural benefits are mostly intangible which make them difficult to valuate, yet the role of local forest in providing peace, harmony, and education was asked from people. It was also inquired to assess the value of tourism associated with nature.

Climate regulation by carbon sequestration: To estimate the carbon stock, a non-destructive method was used in which height and diameter at the breast height of an individual tree was measured in field. The selection of five forest sites was made on the basis of community utilization and access of local people to the mountain forest. From each site, 10 quadrats of 25x25m were taken, making a total area of 625 m^2. The quadrats were selected randomly throughout the study area to have representative forest and species mass. Similarly, from each site soil samples were taken from two depths i,e., surface soil at 0 cm and sub-surface soil about 20cm deep. It was done as most of sites were of rocky conditions below 20 cm. The height and diameter at breast height (DBH, 1.37 m from ground) of all the trees were measured in sampling quadrats following standard techniques (Ahmed & Shaukat, 2012). For each site; latitude, longitude and altitude were noted using GPS (Garmin, Rino-130). Anthropogenic burden on forest was observed through grazing, deforestation and distance from their settlements.

To estimate aboveground biomass (AGB) of an individual tree, following allometric equation was used:

AGB (kg) = tree volume (m3) x wood density (kg/m3)

whereas Tree volume was calculated as follows:-

V= π r2H; π = 3.14; radius was taken from diameter of tree; and wood density of species was taken from the world agroforestry database (Cheng, 1992).

For *Pinus* species (Shaheen *et al.*, 2016), aboveground total biomass was calculated as:-

$$AGTB = 0.0509 \times \rho D^2 H$$

where, AGTB is in kg; wood specific gravity (ρ) in g cm^3; tree diameter at breast height (D) in cm; and tree height (H) in m.

For estimation of below ground biomass (BGB), aboveground biomass was multiplied by factor of 0.26 as the root to shoot ratio:-

BGB (kg/tree) = AGB (kg/tree or ton/tree) x 0.26

Total Tree biomass was calculated using following relation:-

TB = Aboveground tree biomass + Belowground tree biomass

whereas, it is provided that total carbon is half of the total biomass in a tree (Anon., 2007), therefore *carbon stock calculated from Biomass = Total Biomass/2 or Total Biomass*0.5*

Soil carbon: Samples were tested for their carbon content by Walkley Black wet oxidation Method (Nizami *et al.*, 2009). Soil organic matter was calculated by using soil bulk density, organic carbon and depth of collected soil. Soil bulk density was measured by oven dried weight of soil divided by the volume of cylinder. The measured amount of carbon was transformed into soil organic carbon by using following relation:-

SOC (t/ha) = OC (Mg/Kg) x Bulk Density (g/cm3) x soil depth (cm)

Vulnerability assessment of forest to the climate change: Vulnerability assessment of the forest was carried out on the basis of people's perception of exposure and sensitivity to climate and other socio-economic changes (Bhatta *et al.*, 2015). Local forest of Tehsil Balakot was exposed to climatic changes and as a result, the delivery of forest goods and services to local people was changed in comparison of last 20 years. Keeping this view-point, people's perception was inquired for the change in delivery of any forest service which would be susceptible for future provision of services. A theoretical framework of study was developed to indicate vulnerability of local forest due to climate change by posing potential change in the livelihood and well-being of the community (Fig. 6).

Results and Discussion

Community's perception on Balakot forest services: These forests were valued by the local people for their subsistence livelihood due to provision of goods and services. Mostly, people were rural and influenced by climate based vulnerability. Water was identified as an important service of ecosystem which was essential for agriculture, forestry and livestock rearing. According to survey response (Fig. 2), 67% households gave high value to forest fuel wood, 46% identified higher forest role in providing fresh water, 60% gave higher weightage to fodder to livestock and 44% gave high value to NTFPS. In terms of regulatory services, 73% of households agreed that trees have a higher role in regulation of climate, with

62% identified the role of forest in purifying their water (Fig. 3). Balakot is highly vulnerable to natural disasters, 64% of respondents' recognized the greater role of forest in protecting from natural hazards. Cultural services provided by the local forests were mostly ignored which indicate their intangible nature; local people were agreed that their surrounding forest is important for their livelihood and peace; 81% gave it higher value, 58% considered it important for recreation and tourism, 53% gave it low value in terms of spiritual and religious attachment (Fig. 4). Locally valued services were mostly those which sustain human wellbeing (Burkhard *et al.*, 2012). Studies on mapping ecosystem services have reported similar findings where local people's perception develop a sense for the decision making and to sustainably manage the local resources (Oort *et al.*, 2015).

Change in delivery of forest services to local community: In the absence of any alternative source of energy, local people were cutting more trees for fuel wood which increased in the winter season due to very low temperature. In addition to this, many families have their livestock grazing in the forest which is an additional benefit to them. In the survey, considering this on-going process of forest degradation, locals were asked about change in delivery of forest goods and services from last 10-20 years. It was made sure that respondents for this part of study must be living in the area from last 20 years (Shedayi *et al.*, 2016). The change in delivery was measured as "positive" which indicates the goods and services have increased, "negative" means decreased and "none" refers to no effect in the stated period of time. In terms of provisionary services, 66% of respondents said that fuel wood has reduced, 49% reflected that there is no effect in water quality and quantity. This perception of local people was because of greater availability of spring water in the region. The respondents (56%) shared that the availability of fodder to the livestock has decreased due to change in forest structure and composition whereas 39% said that there is no effect noted on availability of non-timber forest products (NTFPs) (Fig. 5). For the regulatory services of the forest, 82% of respondents said that the forest cover had declined. The reduced forest cover has increased the community's vulnerability to climate change and natural disasters. In terms of cultural services, 83% responded said that the role of forest in creating a sense of peace has decreased which was due to increased tourism in the area. The recreational value associated with the local forest has increased which was shown by 54% positive responses (Fig. 5).

Role of forest in carbon sequestration: Carbon stock assessment was done to assess the important regulatory service of forest in combating climate change. Out of five selected sites for carbon stock assessment, two sites (Site 1 and 4) were pure stands of *Pinus roxburgii*, which were moderately degraded as observed from stumps present. Site 2 and 3 showed the higher number of *Pinus roxburhii* as compared to *Cedrus deodara* and *Quercus leucotricophora* both sides showed higher degradation which was due to the reason as human settlements was greater and closer to the forested sites. Site 5 had Pine stands and *Quercus* in good health, the site was far from the human tenancy (Table 3). This pattern has indicated that the forest degradation was greater where people had better access considering their vicinity and slope of the mountain (Jina *et al.*, 2009). Near the mountain tops, better forest growth was observed with less floor grazing (Joshi *et al.*, 2013).

The study revealed that the average carbon stock value at Tehsil Balakot was 243. 79 t/ha (Table 4) which was also comparable to the value of carbon stock reported by Houghton & Hackler, 1999 as 250 t/ha in Southeast Asian Forests. Few similar studies reported more carbon stock as the Central Himalayan with the value of 262.6 t/ha (Jina *et al.*, 2009); Garhwal Himalayan with the maximum of 490.33 t/ha (Joshi *et al.*, 2013) but our results showed a higher value of carbon stock than a related study conducted in Muzaffarabad Region, AJK Pakistan showing an average value of 186.29 t/ha (Shaheen *et al.*, 2016). The fluctuation in carbon stock values may be attributed to the type of vegetation and method of allometric measurement used (Zhang *et al.*, 2012). The current study has reported an average biomass calculated from the aboveground and the belowground biomass as 414.82 t/ha; carbon biomass of 207.41 t/ha with soil carbon matter as 36.38 t/ha. This value is much lower for the Himalayan region as a study reported 1157-827 t/ha (Sharma *et al.*, 2014). It is said that the forest biomass is mostly affected by the type of anthropogenic activity involved on land, therefore higher grazing and the human habitation pressure leads to lower forest productivity (Rosenfield & Souza, 2013).

The results of species-wise carbon stock assessment has indicated that *Pinus roxburgii* was more significant species having the highest biomass value of average 194.66 t/ha whereas *Cedrus deodara* had 1.7 t/ha and *Quercus leucotricophora* had 47.5 t/ha (Table 5). The average DBH value recorded for *Cedrus sp.* was 122 cm which was highest at site-2 with a minimum value of 25 cm for *Quercus*. The tree features like the height and DBH affects the ability of tree in biomass production. Our study has reported lower values in terms of tree height as compared to other studies in Himalayan (Shrestha *et al.,* 2013; Nautiyal & Singh, 2013). The average tree DBH in the current study was also lower than the studies in the Nepal forest and the sub-tropical Indian forest (Mishra *et al.,* 2009). Average tree height for the forest stand was 14.2 m with a maximum value for *Pinus roxburgii.* The carbon stock assessment was highest for *Pinus roxburghii* showing 97.33 t/ha and least for *Cedrus deodara* as 0.85 t/ha which indicated that *Pinus roxburgii* has the highest contribution in carbon stock of Tehsil Balakot.

There is considerable research in the world on goods and services of different ecosystems to human beings and their accountability. The degradation in quantity and quality of the environment will reduce or decline the services of these natural ecosystems (Shaheen *et al.*, 2011). It was observed that the site-2 and site-3 were having a higher rate of forest degradation which was apparent from the lower value of soil organic carbon (Wani *et al.*, 2010). As the both sites had greater grazing pressure, fuel-wood collection and close to human settlement; earlier studies have shown similar results where degraded pine forest had low productivity and poor soil condition (Rawat & Singh, 1998; Soto-pinto *et al.*, 2010).

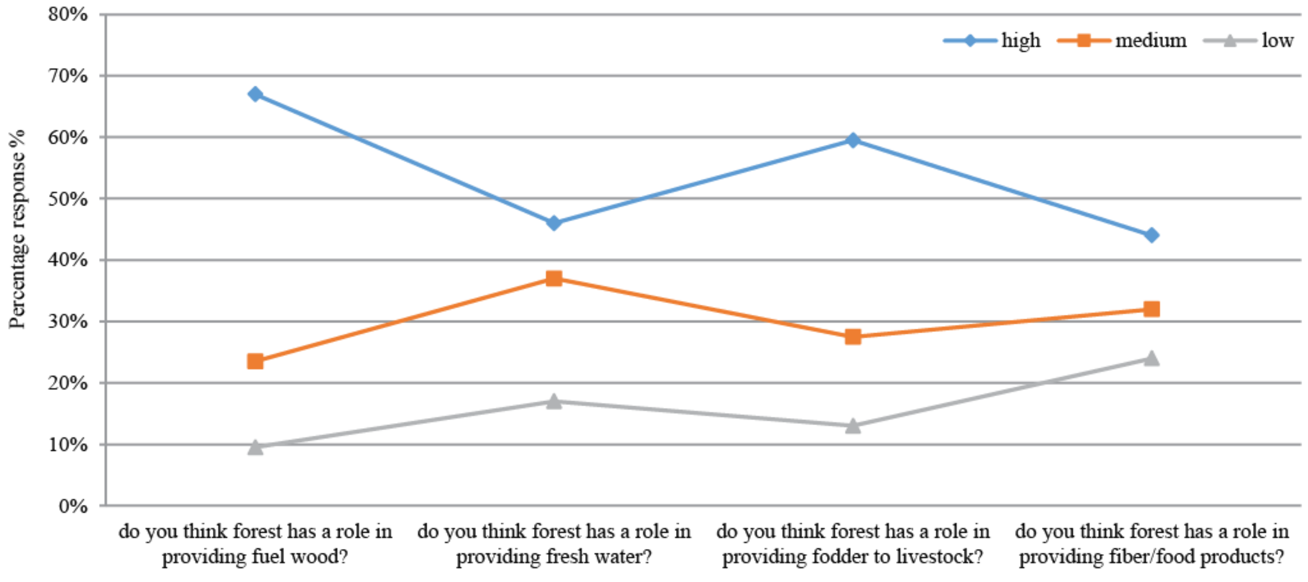

Fig. 2. Provisionary forest services to Balakot community.

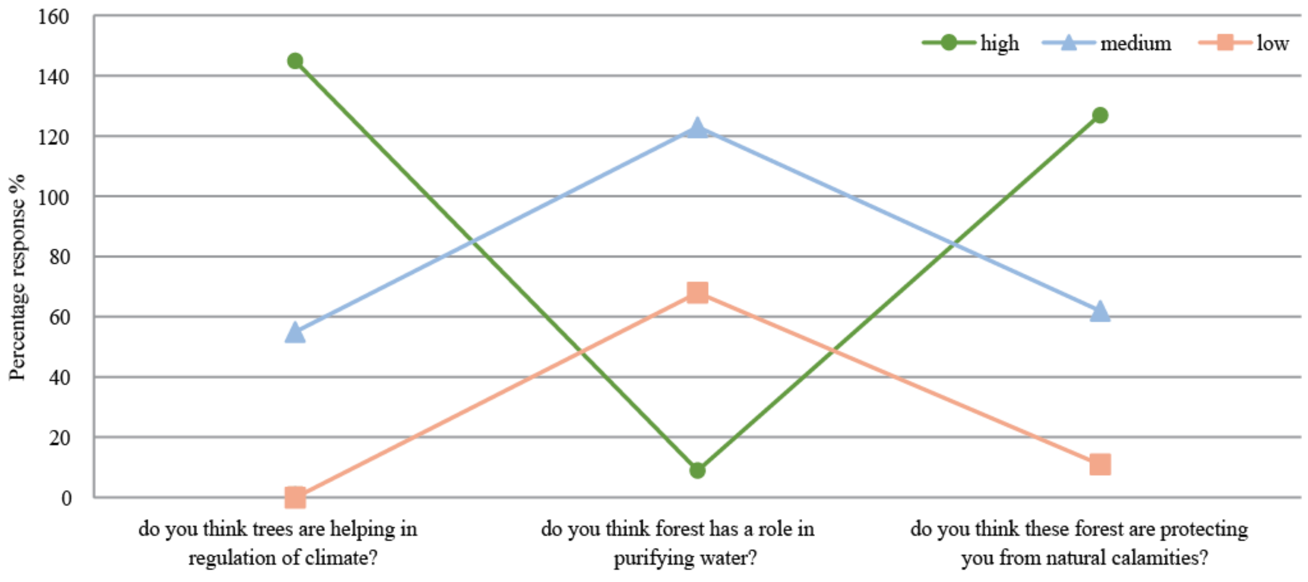

Fig. 3. Regulatory forest services to mountainous community.

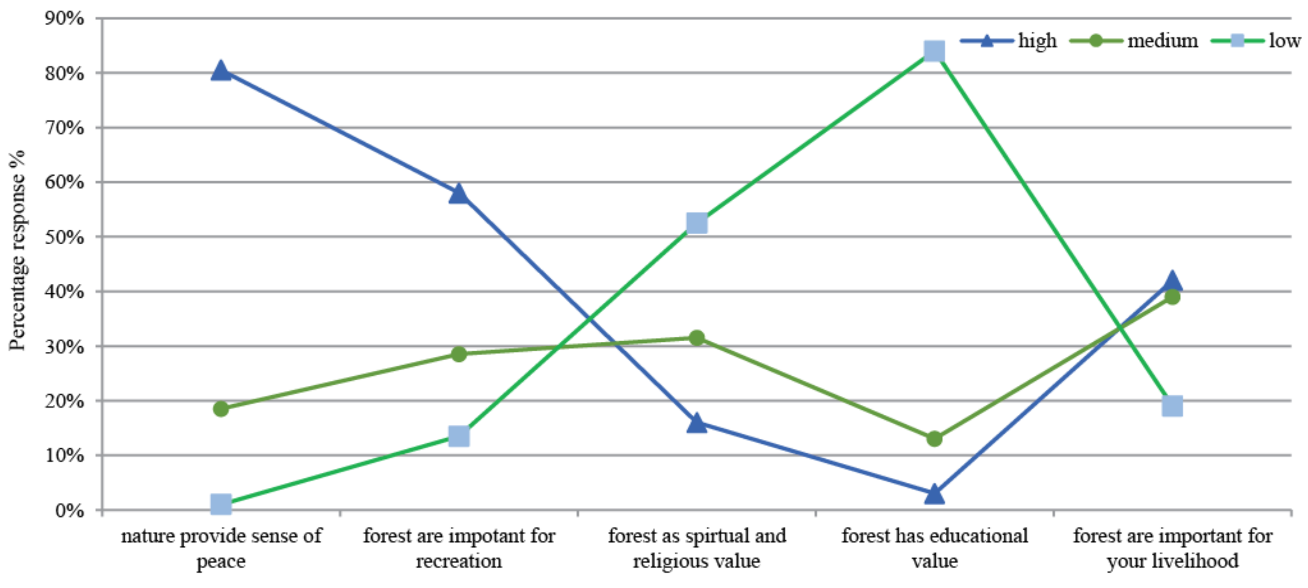

Fig. 4. Identified Cultural forest services to local people.

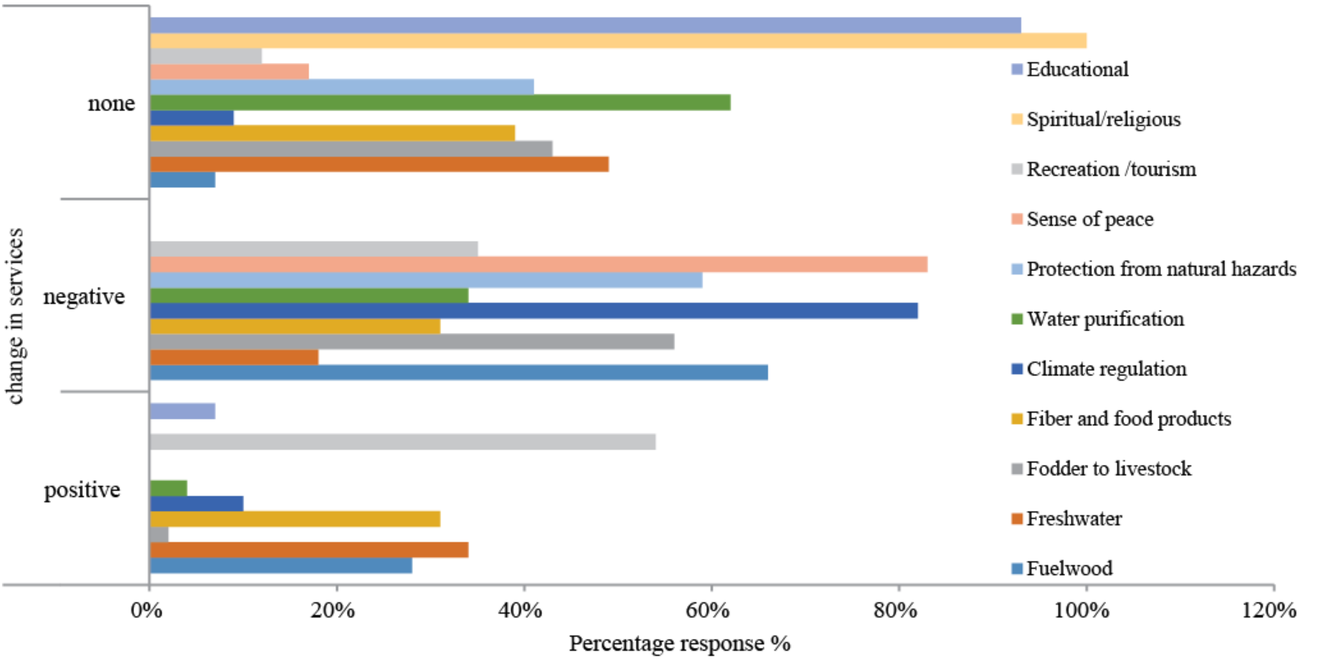

Fig. 5. People's perception of change in forest services.

Table 3. Tree density and status of degradation at five different sites in Tehsil Balakot.

Tree species	Common name	Site-1	Site-2	Site-3	Site-4	Site-5
Pinus roxburgii	Chir Pine	95	57	77	116	95
Cedrus deodara	Deodar	-	10	4	-	-
Quercus leucotricophora	Banj Oak	-	13	12	-	30
Aggregate		95	80	93	116	125
Status of degradation		Moderately degraded	Highly degraded	Highly degraded	Moderately degraded	Non degraded
Fuel wood consumption kg/day/capita		2.40	3.84	4.62	1.38	1.01
Herd size (average in household)		4.41	2.23	6.13	2.45	3.24

Table 4. Average biomass and Soil Carbon at five different sites.

Site No.	Tree density/ha	Total biomass (t/ha)	Biomass carbon (t/ha)	Soil organic Carbon (t/ha)	Total carbon (t/ha)
1	95	316.43	158.22	31.25	189.47
2	80	280.18	140.09	27.92	168.01
3	93	298.01	149.01	38.55	187.56
4	116	516.01	258.01	43.41	301.42
5	125	663.5	331.75	40.77	372.52
Average	101	414.82	207.41	36.38	243.79

Table 5. Species-wise carbon stock assessment (t/ha) in Balakot tehsil.

No.	Species	Site-1	Site-2	Site -3	Site-4	Site-5	Biomass t/ha	Carbon stock t/ha	% Age contribution in total carbon stock
1.	*Pinus roxburgii*	210.5	95.2	121.5	255.5	290.6	194.66	97.33	79.8
2.	*Cedrus deodara*	-	6.3	2.2	-	-	1.7	0.85	0.69
3.	*Quercus leucotricophora*	-	64.2	66.8	-	106.5	47.5	23.75	19.47

Vulnerability to climate change of forest dependent community: The Balakot mountainous forest (Moist and dry temperate of Himalayan) were more vulnerable to the adversative effects of changing climate not only due to climatic factors but also other socio-economic stressors (Chaturvedi *et al.*, 2011). It was projected by Anon., (2014) that climate change will be more visible at higher elevations and in marginalized communities. Such impacts are well documented in Himalayan region, especially in Nepal and India. In the Upper Koshi region of Nepal Himalayan, the reduced rainfall has effected winter crop production and paddy cultivation. Reduced forest covers and decreased in fuel wood availability and other forest goods were also reported (Bhatta *et al.*, 2015). In other studies, water scarcity, drought, soil erosion, and floods have affected the livelihood of rural communities by impacting on agriculture, pasture land, and forestry (Cannon & Muuller-Mahn 2010; Gentle & Maraseni 2012). In the Western Himalayan region of India, decrease in water quantity and forest cover due to erratic rainfall was reported which had affected the dependent communities (Joshi & Negi, 2011).

In case of Tehsil Balakot of KPK, Pakistan, it is the first study to report climate based vulnerability of forest dependent communities by gathering their perception of change in delivery of ecosystem goods and services. The local communities have identified change in forest cover and decline in provision of certain ecosystem goods and services. They have viewed the change in their precipitation pattern as well as in agricultural productivity. *Pinus roxburghii* has become dominant in absence of *Quercus leucotricophora* as it was popular for fuelwood in past and over cutting has resulted in the decline of species. Similar findings were reported by Somroo *et al.*, 2012 in same region. The study has attempted to develop the nexus between human wellbeing, due to livelihood opportunities from the forest ecosystem in the face of climate based vulnerability. The framework has shown the Balakot community will be vulnerable if locals have low adaptations to change however, a resilient community will show better adaptations for their survival (Fig. 6).

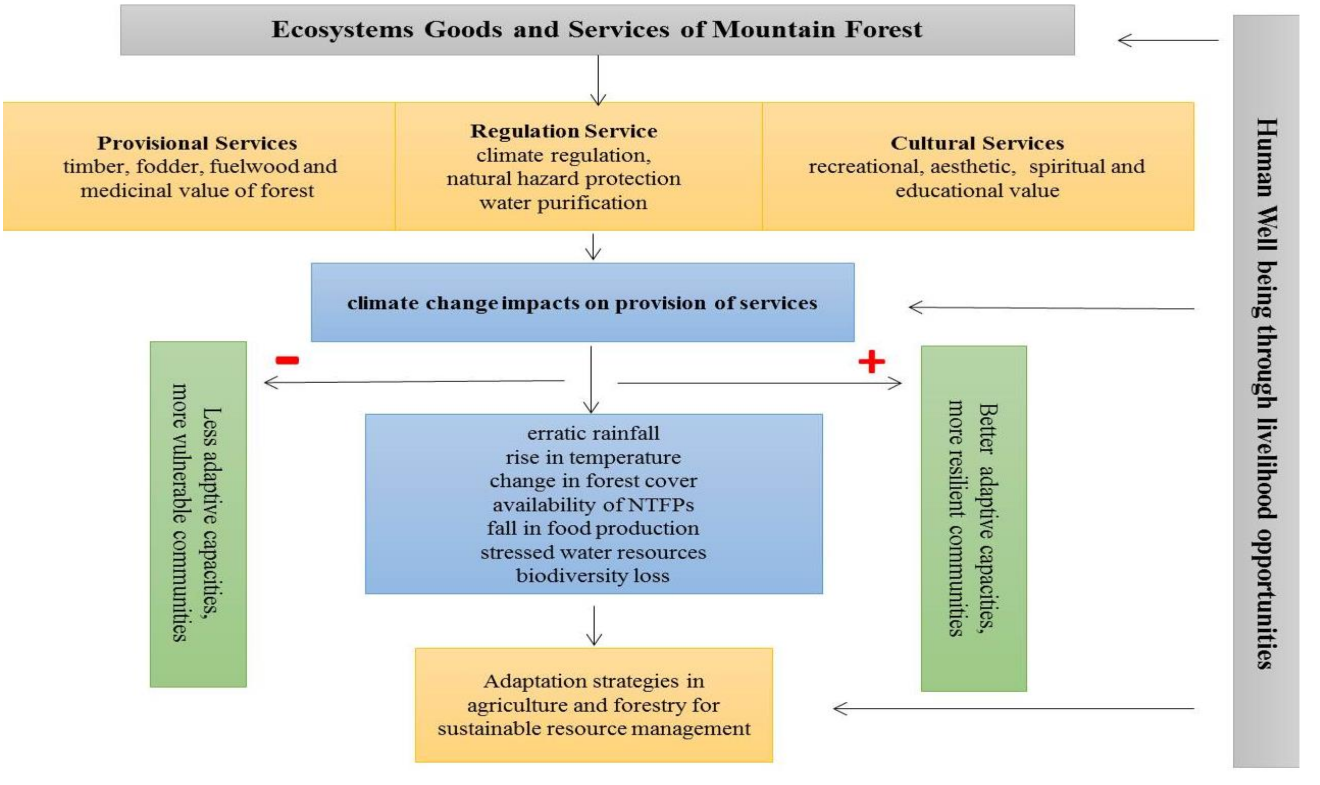

Fig. 6. Theoretical Framework of study indicating link between ecosystem services, climate change impacts and community livelihood.

Conclusion

Himalayan forests are facing degradation due to prevailing poverty and higher natural resource dependence. This region has become more vulnerable in changing climate and environmental gradients. The mountain forests are combating the global warming by storing excess carbon-diooxide and reduced forest cover will enhance community vulnerability. Overall local community identifies the role of local forest in providing beneficial services to sustain their life and to provide livelihood. Such studies are important for policy makers to conserve the resources which are under higher anthropogenic pressure. Sustainable forest management is needed in highly vulnerable and marginalized regions to support communities and natural resources at same time.

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