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Community Forestry Management and its Role in Biodiversity Conservation in Nepal

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Abstract

Community forest management is one of the successful stories of green economy sectors in Nepal recognized by the United Nation Environment Programme. It was initiated in Nepal to mitigate increasing deforestation and forest degradation and address the negative impacts on rural livelihoods. Different studies are conducted by researchers to assess the role of community forest in biodiversity conservation in Nepal. Researchers focused on analysis of biomass, carbon stock analysis, calculation of biodiversity index, change in land use and land cover, spatial analysis of forest resources, camera trapping of wild fauna and socioeconomic analysis by using different primary and secondary data collection techniques. It can be concluded that community forestry management had a great role in biodiversity conservation in Nepal. Biomass, carbon stock, growing stock, soil organic carbon, forest cover, forest products and benefit from forest resource had increased due to community forestry management. Wild animals such as leopard, porcupine, monkey and other birds were increased in the forest. It is recommended to provide skill development trainings and financial support for the installation of renewable and alternative energy technologies to minimize the use of forest resources. More researches on assessing role of community forestry management in biodiversity conservation should be conducted.

Keywords: community forestry management, conservation of flora, conservation of fauna, Nepal

1. Introduction

Forestry means use of forests for achieving specific objective that introduces it into different types [1]. The aim of industrial forestry is to produce wood-based products for national and

international markets. But the objective of other approaches of forestry is to create and enhance wildlife habitat and water quality [2]. Managing forests with the express intent of benefiting neighbouring communities is community forestry (CF) [3]. Beneficial functions of the forest had attracted various actors and stakeholders, including the state, private enterprises and local forest users. Also, they have built up distinct interactions with the forest to satisfy their economic, political and social needs [4].

In community forestry, forest user group (FUG) controls and manages the local forests [1]. Harvesting and pricing of all forest products and forest management are governed by an executive committee elected in the FUG assembly [5–7]. Local people gain membership and receive cash subsidy as an incentive for forest management after registration of FUG in District Forest Office (DFO). Surplus income of community forestry forest user group (CFUG) has been used for the purpose of infrastructure development [1, 5]. Therefore, co-operation and collective actions will be obtained by transferring authority and responsibility for forest management to local users [5]. Incentives are made to control the forest through the practice of sustainable activities for income generation.



Figure 1. CFUG members carrying firewood from CF. (Source: Author).

Many rural communities that depend on nearby forests take community forestry (CF) as a tool for the globalization of the economy. It provides benefit from timber and non-timber forest resources, as shown in **Figure 1** and **Figure 2**, and also creates job opportunities. Community forestry provides benefits to local users from nearby forests. As neighbouring communities

suffer most from resource degradation, community forestry provides overall role to local people in forest decision making [2]. It provides great opportunity for resource managers to utilize the indigenous knowledge of local people for sustainable management. Rural development practitioners utilize potential of forestry for forest protection, community strengthening and economic development [2].



Figure 2. Local fruits extracted from CF of Syangja. (Source: Author).

In community forestry, forest can be sustainably managed to protect natural resource and forest ecosystem functions and also provide income opportunities to community residents from traditional and non-traditional products and services. The benefits and services of forest ecosystems include non-timber forest products, watershed protection, recreational use, tourism, carbon storage, spiritual and cultural significance, genetic resources, medicinal plants and wildlife habitat [2]. In spite of the market values from timber and wood products, non-market values include environmental stability, quality of life and the economic strength of a region. Community forestry is practiced on public forest lands with the partnerships and coordination between communities and forest landowners to foster forest stewardship and economic development. It should be under the management of the local community to emphasize collaborative and participatory management in local needs and local knowledge.

1.1. Community forestry in Nepal

Historical experience shows that unless people are given user rights and ownership to control and make decisions, people lose interest in active practices of forest management [5]. Community forestry management (CFM) originates in Nepal due to the progressive degradation of hill forests caused by institutional failure [3]. Before the 1950s, forests in the Middle hills of Nepal were managed by local landlords and there was free access to non-commercial forest products. During 1951–1961, forests were nationalized and controlled by the Department of Forest (DoF). But, they were unable to manage it which creates an open access situation and local users lacked incentives to regulate forest use. It leads to unregulated extraction by creating conflicts between villagers and DoF staff. After this, land registration processes started in Nepal, which lead to encroachment and forest degradation by threatening the sustainability of livelihoods in the Middle hills [8]. There was increasing loss of forest areas due to the increase in the values of timber and other natural resources [4]. Involving local people in forest management was necessary so community forestry management was introduced to establish community-based organizations for collective management of forest resources [8].

Forest policies have been changed as the state and local communities experience forest losses and degradation after the 1950s. The process of nationalization formulates a centrally designed and scientifically informed forest policy in the context of Nepal. The new policy could not work longer as it had limited the use of forest resources and incentives for sustainable use and cooperative management. After the failure of the governmental forest management system and the revival of common-based management systems, local communities have taken back these rights to use and manage their forests and formed institutions called forest user groups (FUGs). Therefore, in the 1970s, local users' participation in forest management was reconsidered by the government after recognizing the effectiveness and benefits of common property management [9].

Conference organized by the Department of Forest in 1975 focused on the role of community in forest management. It helps in the emergence of community forest management till 1978 and further development occurs till 1993 [8]. Community forestry management was initiated on an experimental basis in the 1980s which decides to provide power and authority over resource use to the community level and return property rights to communities. Projects were initiated by the governmental institution with the support of policymakers, field staff of the forest department and project staff of the national community forestry workshop. Eventually, community forestry was legally implemented with the 1993 Forest Act and the 1995 Forest Rules with the support of local users and forestry staffs [10]. The responsibility of protection of CF is taken by local forest user groups while forestry staff plays the role of supervision [10].

The need of community involvement was identified in the National Forestry Plan after the deterioration of hill forests. After the National Forestry Plan, two amendments were made in Forest Act in 1977 and 1978, and the handover of forests has started gradually. World Bank, Australia and Britain also need changes in the forestry sector in the 1980s, and community forestry management was introduced in various policies. Decentralization Act in 1982 focused on forming the community forestry management committees for forest management, and the concept of forest user groups was introduced. To provide subsistence needs of people, the

Seventh Periodic Plan (1985–1990) gave priority to people's participation in forest management. As a second major milestone, the master plan for the forestry sector declared to handover forests in the Middle hills to FUGs by following the outcomes of first the National Community Forestry Workshop in 1987. For the reorientation of DoF staff towards this new priority, 47% of investment within the forest sector was invested in support of community forestry programmes for the new role of facilitation. Democracy in 1990 helps to form FUGs the important unit of community forestry management and a strong independent legal institution [8].

Analysts have delineated three phases of forestry development in Nepal—privatization (before 1957), nationalization (1957 to the late 1970s) and decentralization (the late 1970s onwards) [11]. Before the state took control of forests in late 1950s, most forests in rural Nepal were controlled and managed by local communities. When the government identified the need of active co-operation of local forest-dependent citizens, participation of local people in the forest management began in the late 1970s. In the history of Nepal, state was controlled by the Shah or Rana families before the democracy in the 1950s, the 1990s and after 2006. The control of forest resource and economic surplus flowed from general people to the ruling elites [11].

Before the establishment of community forestry, government of Nepal assumed that transferring forests from private groups to the state would enhance people's access to forest resources but the state imposed regulations to exclude people from controlling forest resources [11]. To mitigate deforestation and forest degradation and to address the negative impacts on rural livelihoods, community forestry management (CFM) was established as an important forestry policy in the late 1970s. It plays an important role in forest management by linking agriculture, livestock rearing and the forest [12]. It focuses on avoiding deforestation and forest degradation by implementing protective measures [13]. Involvement of local people in forest protection and management became an important policy in the forestry sector in the hilly region due to the failure of states to mitigate deforestation and forest degradation [13].

CFM has been promoted as an important step in common property resource management in Nepal [14]. To mitigate the growing deforestation and deterioration of the forest, government of Nepal made a policy based on the 1976 National Forestry Plan to involve local communities in forest management [8]. Many communities in developing countries are successful in transforming natural forests from the deteriorating state to the sustainable state. Community-based forest management is an approach to mitigate increasing deforestation and forest degradation to address the negative impacts on rural livelihoods. In Asia, this management approach quickly became widespread in different forms of community involvement in forest management and protection [8]. China Collective Forest, India Joint Forest, Philippines Community-based Forest and Nepal Community Forest are some of the examples of community managed forest. In a time duration of more than 10 years, CFM had a great role in forest conservation. Management of forest by local users and supervision by local forestry staff make CFM more successful, which is a successful example of decentralization and empowerment of local people [8].

A group of households wishing to form a CFUG should prepare an operational plan under the provisions of the Forest Act of 1993 and submit it for registration at the local District Forest Office (DFO). To prepare an operational plan for forest management, CFUG should take

technical assistance from forest officials and non-governmental organizations (NGOs). There is no any legal limit for the area and size of the CFUGs as it depends on the willingness and ability of the community to manage a forest. CFUG may include all members of a village, a selected group of households, people from different village and district without any administrative boundaries. It is inclusive of households in the village and all households of one or more villages become members of a CFUG, representing diverse interest in forests. CFUG is a perpetually self-governed institution with rights to manage and fix the prices of forest products. Forest use is not restricted in legal framework and practice, but CFUGs have to pay taxes to the government for selling any forest products outside CFUG. The state retains ownership of forests but communities hold the rights to use the forests and make management decisions. With the help of operational plan, CFUGs set the price of various products, collect revenue and mobilize income for community development activities [11].



Figure 3. General meeting of CFUG members. (Source: Author).

CFUG members can participate in decision-making process through role-based meetings, executive committee involvement, annual assemblies and forest management plans formulation as shown in **Figure 3** and **Figure 4**. Each CFUG prepares its own constitution and operational plan, registers and approves from DFO, defines the social arrangements, responsibilities and rights of the group and makes arrangement for forest management. The strategy, constitution and operational plan are prepared by following standard guidelines and norms but varies from group to group to adapt local traditions and practices. Each CFUG elects a

specified number of members to an executive committee for a period of 1–3 years to carry out day-to-day decisions about forest management [11].



Figure 4. Checklist and feedback collection from CFUG. (Source: Author).

Community forestry management in Nepal is successful in providing important rights, including decision making, empowerment over forest management and use, and access to forest resources at the community level. Community forestry policy and institutional innovations contribute to improved welfare and livelihood security in Nepal by increasing access of CFUG to forest products and by providing positive impacts on income, employment and entrepreneurial opportunities, livelihood diversification, and broader community development activities. The role of CFM to overall livelihood security is critically important in Nepal because more than 70% of Nepal's population depends on agricultural livelihoods that encompass complex interactions between agriculture, forestry and livestock systems [11].

Up to date, a total of 1,798,733 ha of community forest is handed over to 18,960 community forest user group throughout the country [15]. The trend of conversion of public forest into community forest is increasing rapidly with the need and interest of local community in conserving forest.

1.2. Role of CFM in biodiversity conservation

Different life forms or varieties of life are called biodiversity, and care and management of biological materials are called biodiversity conservation [16]. It is categorized as species diversity, ecological diversity and genetic diversity [17]. Due to the unique geographical loca-

tion with diverse climate and altitude, Nepal has great diversity of flora and fauna [16, 17]. Nepal consists of 0.1% of the terrestrial area of the earth with 118 ecosystems, 75 vegetation types and 35 forest types [17]. It consists of 5000 species of flowering plants, 2252 species of moths, 635 species of butterflies, 185 species of fishes, 844 species of birds and 181 species of mammals. For the conservation of biodiversity, there is provision of protected areas, zoo, different types of law, conventions, non-governmental organizations (NGOs), local and national authorities and national and international organizations [16].



Figure 5. Scenic beauty of forestry combined with water. (Source: Author).

Community forestry is successful in decreasing resource degradation and helpful in the conservation of biodiversity [18]. Implementation of community forest management has improved the forest condition and biodiversity in the hills of Nepal as compared to degraded forest in the past. It could be a suitable option to conserve biodiversity, but it focuses on sustainable forest product and keeping biodiversity conservation in less priority. Its aim is to supply forest products to local users rather than to conserve biodiversity [19]. There is a considerable role of community forestry in biodiversity conservation of Nepal. The impacts on biodiversity of plant species are clear but it is less obvious in the case of faunal biodiversity. Community forestry had protected or re-established habitat and helpful in the survival of birds and animals. Operational plans also include prohibitions against hunting at the request of local people [20]. For the conservation of forest and its biodiversity, CFUGs are voluntarily involved in fencing, planting and meetings. It is helping in carbon sequestration and increasing the forest cover by controlling deforestation and forest degradation [1].

Various studies have demonstrated a significant increase in forest condition under community forestry showing that it is a proven model for controlling deforestation and forest degradation.

CF helps in supporting livelihood in hilly area by providing necessary forest products, such as fodder, firewood, timber, leaf litter and agricultural tools. CFM also helps in conservation of flora and fauna. There is a growing concern that CF is prioritizing only towards sustainable management of forest resources and less towards biodiversity conservation. The aim of community forestry is to supply forest products to local users rather than to conserve biodiversity. Currently, there is evidence that CFUGs are slowly moving towards active forest management. Effective management of CF leads to sustainable production and sustainable harvest of forest resource. Sustainable harvest of forest resource helps to fulfil forest product needs and also helps in livelihood enhancement of local people [18].

CF has been successful to provide forest resource need of people by enhancing the forest cover. Forest enhancement is increasing ecological services of forest, water resource management, biodiversity conservation, carbon stock, greenery enhancement and air quality management, as shown in **Figure 5** [12]. In actual fact, CFM provides win-win situation in atmospheric carbon dioxide mitigation and biodiversity conservation in global scale; and livelihood enhancement and greenery enhancement in local scale are shown in **Figure 6**. Community forestry also had co-benefits of reducing poverty, addressing social exclusion and creating rural employment [21].

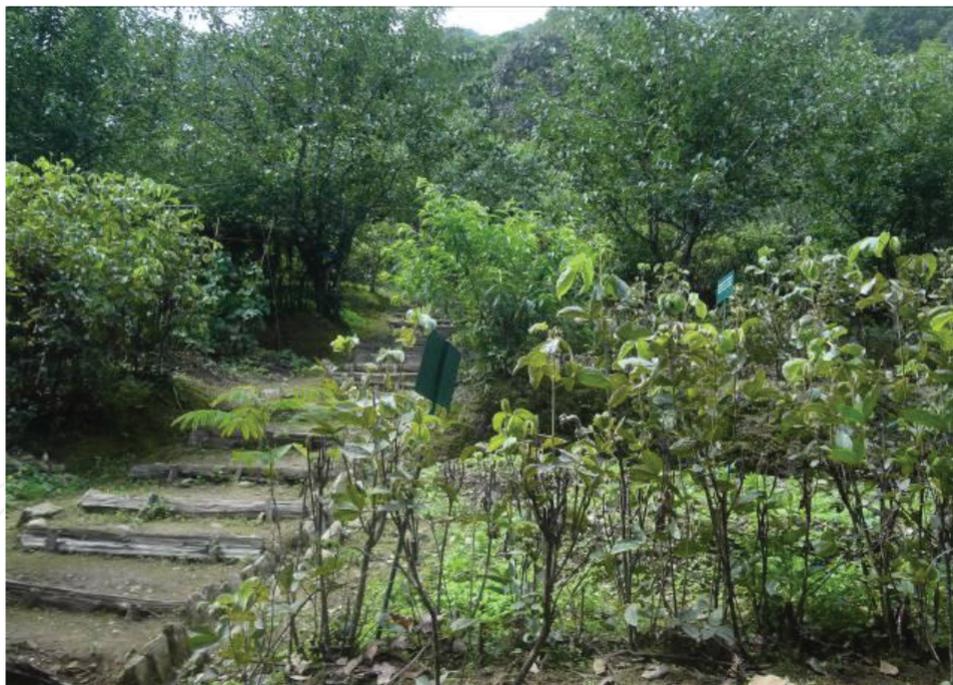


Figure 6. Agroforestry system practiced in CF area. (Source: Author).

In Nepal, local communities have come a long way in conserving forest ecosystems and nurturing local institutions for democracy and social justice. The historical context for the emergence of community forestry in Nepal dates back to the 1950s, when the Government of Nepal nationalized all the forests hoping to optimize the use of natural resources and conserve it sustainably. Communities were totally excluded from the forest management process

threatening the livelihood of the rural people. This exclusion led to massive deforestation and degradation of natural resources solely because the community viewed the state as an enemy causing destruction of forest. The situation of environmental crisis had emerged due to lack of participation of community in management of forests. By the late 1970s, Nepal had lost almost 2.2 million hectares of forest cover resulting in serious downstream flooding. In the Kavre and Sindhupalchok districts of central Nepal, a study found that shrub land and grass land have been converted into productive forests increasing the forest area from 7677 to 9678 ha [11, 22]. Three different studies conducted in mountain ecosystem for a time period of 25 years (1976–1989–2000) showed that forest cover had increased as compared to the past. Due to the increase in forest cover, small patches were merged into larger ones decreasing their number (from 395 to 175) and increasing forest area (794 ha). Thus, there is an overall improvement in forest protection contributing to local environmental conservation and increased greenery [11, 23].

2. Methodology

Different research studies are conducted by different researchers to assess the role of community forest in biodiversity conservation in Nepal by applying different methodologies. Issues raised by researchers in their research studies were reviewed to find out tools and techniques applied by them. It would support the researchers to identify the subject of research with appropriate tools and techniques. It would make the new researchers easy and simple to select appropriate literature necessary for them. This chapter provides the location, aim and methodology of different research studies throughout the world.

With an objective to examine the impacts of forest management on biodiversity in Nepal, Acharya [19] conducted a study on two CFUGs in the Mid-hill region of Parbat district in Nepal. The study area was selected on the basis of similar socio-economic, ecological conditions, area, forest types and biophysical factors. Forest biodiversity information was collected using six transects walk at three different altitudes in the east-west and north-south directions in each of the CFUGs with the help of informal interviews with CFUG members by applying tools and techniques of participatory rural appraisal (PRA).

Thoms [24] conducted a study to examine whether community forestry is elite dominated and not successful in livelihoods improvement of CFUGs. For this purpose, primary data were collected from 6 months of field research between October 2002 and April 2003 in four hill districts and two Terai districts. Data were collected from 2871 household surveys selected through multi-stage area probability sampling.

With an aim to compare land use changes between village development committees (VDCs) with and without community forests, Gautam et al. [25] conducted a study in the Roshi watershed of Kabhrepalanchok district in the Middle Hills of Nepal. Spatial analysis was based on two land use data sets, 1978 data compiled by the land resource mapping project (LRMP) and 1992 data compiled by Survey Department of His Majesty's Government of Nepal (HMGN).

With an aim to evaluate forest condition in community forests, national forests and protected areas in the Nepal Terai, Nagendra [26] conducted a study in three International Forestry Resources and Institutions (IFRI) research sites in the Chitwan district of Nepal. The site was selected to cover the east-west range at an altitude of 195–425 m above the sea level in *Shorea robusta* dominated tropical moist deciduous hardwood forests. Assessment of forest condition was carried out through the use of forest plots evaluation by a professional forester and interviews with the local communities depending on forest.



Figure 7. Measurement of diameter of tree inside CF. (Source: Author).

Adhikari et al. [18] studied the relationship between key household characteristics and common property resources in eight community forest of two districts, Kabhre Palanchok and Sindhu Palchowk, in the mid-hills of Nepal. The study was based on information collected through a household survey. A total of 20% stratified sample of households from each income group was chosen by compiling a census of village households with participatory rural appraisal (PRA) techniques.

With an aim to assess success of restoration in community forest using a reference of semi-protected natural forest, Baral and Katzensteiner [27] conducted a study in CF and better protected municipality owned forest (MF) in similar topographic positions in Dhulikhel of Kavrepalanchowk district. The diversity of vascular plants and forest structure was compared with the help of primary data of tree height, diameter at breast height (DBH) and crown width with the help of transect survey, clinometers and diameter tape.

To assess improved condition of forests by collective action of local communities, Shrestha and McManus [28] conducted a study in three CFUGs of Nepal. Data collection was directly carried out by rapid forest assessment (RFA), household questionnaire interview (HQI), group discussion, participant observation and informal talks. Rectangular plots were established in each community forest of size 100 m² (10 m 10 m) to capture plantation in a recently harvested site and dense forest with mature trees and to represent the diversity of forests within the sample plots.

To identify the role of community forests in the conservation of faunal diversity of Satbariya Range Post of Dang district, Pokhrel and Shah [29] conducted a study with the help of questionnaire survey, group discussion and line transect methods. They collected data of faunal diversity, abundance and distribution pattern of the wild animals and wildlife-people conflict.

To estimate the climate change mitigation potential from carbon stock of the forest, K. C. et al. [14] conducted a study in Ghwangkhola Sapaude Babiyabhir Community Forest (GSBCF) in Syangja district of Nepal. Their study was based on carbon stock measurement and review of past studies.



Figure 8. Measurement of height of tree inside CF. (Source: Author).

With a special focus to study the impact of forest resource use on carbon stock of forest, Paudel and K. C. [30] conducted a study in Kafle Community Forest of Lalitpur district in Nepal. To conduct carbon stock measurement, focus group discussion and key informant interview, field

visit was conducted in different time of year in 2012 and 2014. Biomass measurement was conducted directly in the field for trees and sapling by following national guideline as shown in **Figure 7** and **Figure 8**. Twenty composite samples of leaf litter, herbs, grasses and soil collected in the field were brought to the laboratory for detailed analysis of biomass and carbon stock.

With a special focus to study the feasibility of community forest management, K. C. and Manandhar [31] carried out research on GSBCF of Syangja district in Nepal. Their study was based on carbon stock measurement, household survey, focus group discussion, key informant interview and review of past studies.

3. Role of CFM in conservation of flora

As stated in the introductory section, CFM had a great role in the conservation of flora and fauna. To identify the status of community forest, findings of different research studies are documented below.

Gautam [32] conducted a study to assess the carbon sequestration rate of the agroforestry system, natural forest and annual cropping system in the Terai region of Nepal. Natural forest had the highest carbon stock of 98 ton/ha. Carbon stock in the annual cropping system ranges from 33.2 to 55.5 ton/ha while that of orchard plantation ranges from 35 to 74.6 ton/ha. Similarly, soil organic carbon (SOC) in natural forest, vegetable field and streamside were 53.2, 52.6 and 3.6 ton/ha, respectively.

Acharya [19] observed that active management by CFUGs contradicts with biodiversity conservation. Forest types are slowly converting to monoculture from mixed, shrub and tree diversity is decreasing gradually, and shrub land areas are gradually converting to high forest land. Active forest management favouring specific useful plant may introduce more homogeneity into the forest structure with consequent loss of biodiversity. It will lead to the modification of forest types and ecosystem in the mid-hills of Nepal affecting ecological functions and services of forests.

Thoms [24] concluded that community forestry is quite successful in terms of forest protection and management but at the cost of the poorest households. Community forestry is fairly successful in conservation but not in improving rural livelihoods.

Gautam et al. [25] observed that VDCs having community forests before 1992 sustained less total loss of forested area (1.9%) than VDCs without community forest (9.9%). High forest area was six times higher in VDCs with community forests (77%) than the VDCs without community forests (13%). Loss of shrub land in VDC with community forest was 50% greater than that of VDCs without community forest.

Nagendra [26] observed that vegetation density and species diversity were highest in national park forest, followed by national forest and community forests. Community forests were significantly poorer as compared to national forests in species richness and Shannon species

diversity of tree; sapling density, sapling diameter, sapling richness, sapling Shannon species diversity, sapling girth and sapling height. Trees located in community forests were significantly taller with high density than those within national forests, but there was no difference in tree size (diameter). Community forests have significantly low species richness, low Shannon species diversity and smaller diameter saplings as compared to national park forest. There was low level of grazing, low tree lopping but proper fencing in community forest as compared to the national forest.

Adhikari [33] tried to examine the contribution of community forestry to household-level income with particular emphasis on group heterogeneity and equity in benefit distribution. The household level benefits suggest that poorer households are currently benefiting less from community forestry. But, poor are not more dependent than the rich in community forest. Regression analysis shows that socio-economic conditions and ownership of private property are directly related to revenue generated from community forest. Households having more land and livestock get more benefits from community forest. Educated people and female-dominated household get less benefit from forest resources.

Bhatta [34] conducted a study in mixed broad leaved forests of Phulchowki watershed, Lalitpur. The carbon stock in above ground in natural forest and community forest ranges from 91.89 to 112.79 and 55.30 to 67.04 ton/ha, respectively. Similarly, the carbon stock in soil in natural forest and community forest ranges from 195 to 223 and 150 to 160 ton/ha, respectively.

Shrestha and McManus [28] observed that local communities are effectively protecting the forest through direct efforts of users or through forest watchers or sometimes both. Improvement in forest condition was seen by reversing degradation and regenerating degraded areas but not ideally for biodiversity conservation. The forests have low species diversity as the trees and poles are dominated by few species promoted by the FUG for their social, economic and political values.

Dahal [35] conducted a study in Sunaulo GhampaDanda CF in Kathmandu. The biomass organic carbon in pine forest and mixed broad leaf forest was 116 ± 16.39 and 25.95 ± 8.09 ton/ha, respectively. The soil organic carbon in pine forest and mixed broad leaf forest was 10.12 ± 1.03 and 24.62 ± 1.18 ton/ha, respectively. The carbon sequestration status in pine forest and mixed broad leaf forest was 1 and 2.95 ton/ha per year, respectively. The additional benefit to CFUG by carbon trading was \$ 563.15 per annum.

Karky [36] conducted a study in three community forest of Manang, Lalitpur and Ilam district in Nepal. From measurement of carbon stock, it was observed that the carbon stock of community forest with SOC up to 1 m depth (without leaf litter, herbs and shrubs) was 138 ton/ha or 504 ton CO₂/ha in three districts of Nepal. He found that the annual incremental rate for carbon sequestration in forest under CFM was 1.92 and 7.04 ton/ha per year excluding soil organic carbon. He also found that when CFUGs are permitted to use forest resource, the breakeven price for per ton CO₂ is \$0.55 for Ilam, \$3.70 for Lamatar and \$2.30 for Manang.

Baral and Katzensteiner [27] observed that maximum tree height (13.5 m) and the maximum DBH (29.5 cm) were observed in managed forest (MF). Trees with higher diameters have a higher basal area in MF, but 5–15 cm DBH trees have higher a basal area in CF. CF management

activities have affected plant community composition, species richness and distribution, and age class distribution of the trees. CF was less diverse with uniform stands of tree species compared to MF. Overall diversity of vascular plants was maintained by providing proper niches for rich under storey vegetation.

Gurung [37] conducted a pilot study in western Terai and had estimated the average forest carbon stock to be around 231 ton/ha. The carbon stock in trees above ground, below ground and in soil organic carbon (SOC) had been estimated to be about 68, 18, and 143 ton/ha, respectively. This clearly indicates that the share of SOC was almost 60% of the total forest carbon stock.

Thagunna [38] conducted a study in Bailbanda Buffer zone CF, Kanchanpur. The total carbon stock of CF was 78.46 ton/ha. The benefit from carbon trade was \$ 57,640 at the rate of \$ 12.5/ton C.

Aryal [39] conducted a study in Toudol Chhap CF, Sipadol, Bhaktapur. The total carbon content of pine forest and mixed broad leaf forest were 167.04 and 101.91 ton/ha, respectively.

Bhusal [40] conducted a study in Nagmati watershed in Shivapuri National Park. The SOC and total carbon content in the sampled area (14 ha) were found to be 9782.11 ± 25.18 ton/ha corresponding to a total of 167442.26 ± 42076.82 ton carbon content in the Nagmati watershed (1406 ha). The total carbon content of Shivapuri National Park (5860.8 ha, i.e. 40% of the total area of park which is forest) excluding soil was 699961.20 ± 175894.32 ton.

Dhakal [41] measured the total carbon stock in Pashupati Community Forest, Sarlahi district of Janakpur zone. The total carbon stock was found to be higher in naturally regenerated forest i.e. 181.83 ± 26.34 ton/ha followed by planted forest with 159.49 ± 31.96 ton/ha. The recent amount of total carbon stock of 133.65 ± 37.05 ton/ha was found in enriched forest.

ICIMOD, ANSAB and FECOFUN (2010) had performed baseline study in 104 community forests (CF) of three watershed areas of Nepal; Kayarkhola of Chitwan district, Charnawati of Dolakha district and Ludhikhola of Gorkha district. Analysis of the DBH distributions of all strata follows a left-skewed trend, indicating most of the trees in all the strata were younger, and there was potential to enhance forest carbon stock by encouraging tree growth. Forest carbon stock in dense and sparse strata of Kayarkhola, Charnawati and Ludikhola watershed were 296.44 and 256.70, 228.56 and 166.75, 216.26 and 162.98 ton/ha, respectively.

Mishra [42] conducted a study in Chapako CF, Kathmandu. The biomass carbon and soil organic carbon (SOC) of CF were 119.742 and 32.29 ton/ha, respectively. There was potential of storing and sequestering carbon in the CF.

Community forest user groups are giving less attention to biodiversity, ecosystem functions and services due to short-term economic motive, elite sanction and knowledge gap. They are unaware about maintaining biodiversity, ecosystem services and sustainable forest management. Monoculture of high economic valuable species and greenery of the forest are prioritized rather than the natural forest. Seedling plantation, wildlife hunting control and regulating forest encroachment assist biodiversity conservation but species selection, remov-

al of unwanted species and traditional knowledge depletion have negative impact on biological diversity [43].

The study reveals that the carbon stored in the forest soil is almost double than the biomass carbon [44]. The biomass in the Gwangkhola Sapaude Babiyabhir community forest, Syangja, Nepal, was found to be 164 ton/ha, with yearly increment of 0.95 ton/ha. The total carbon stock of the forest was 122.29 ton/ha, including soil organic carbon and below ground carbon of 45.18 and 12.85 ton/ha, respectively. The forest was dominated by *Schima wallichi*, *Castanopsis indica* and *Pinus roxburghii* [45].



Figure 9. Increase in forest cover and leaf litter in CF. (Source: Author).

K. C. et al. [14] measured the biomass in above ground shoot and below ground root of trees, shrubs, leaf litter, herbs and grass (LHG) in community forest of Syangja district in Nepal. It was observed that above ground biomass of trees was highest (126.3 ton/ha) followed by below ground biomass (27.34 ton/ha), sapling biomass (2.88 ton/ha) and leaf litter, herbs and grass biomass (7.54 ton/ha). Carbon stock in forest (122.29 ton/ha) was increasing at the rate of 0.45 ton/ha per year. Atmospheric carbon dioxide (CO₂) was mitigated by the forest at the rate of 1.64 ton/ha per year. The species diversity of *Schima wallicchi* was highest followed by *Castanopsis indica*.

K. C. and Manandhar [31] observed the total carbon stock of 155.04 ton/ha with soil organic carbon of 50.15 ton/ha in the forest. The more number of trees below 20 cm DBH shows that the forest is conserved after handing it to CFUG and newly grown plants are increasing thereafter. Above ground tree carbon had increased from 59.36 to 80.09 ton/ha while soil organic carbon had increased from 45.18 to 50.15 ton/ha from 2011 to 2014. The carbon stock

of *Schima wallichii*, *Castanopsis indica* and *Pinus roxburghi* was gradually increasing from 2011 to 2014.

Paudel and K. C. [30] observed that community forest management had helped in conservation of plants and animals as forest is getting denser than past, as shown in **Figure 9** and **Figure 10**. Carbon stock in all forms of plants as measured in 2014 was higher than that of 2012 with an annual carbon sequestration rate of 1.52 ton/ha. The forest was dominated by *Schima wallichii*, *Castanopsis indica*, *Alnus nepalensis* and *Pinus roxburghi*.



Figure 10. Researcher conducting study inside dense CF. (Source: Author).

4. Role of CFM in conservation of fauna

There are very few research studies conducted to assess the role of CFM in fauna conservation of Nepal. Some of the research studies conducted on the concerned topics were reviewed and documented below.

Paudel and K. C. [30] observed that carbon stock in all forms of plants as measured in 2014 was higher than that of 2012 with an annual carbon sequestration rate of 1.52 ton/ha. Community forest management had helped in conservation of plants and animals. Wild animals such as leopard, porcupine, monkey and other birds were increased in the forest and were frequently seen nearby the forest destroying the crops of people. The forest is becoming denser than past according to the view of local people.

To find the condition of animals in the Setidevi community forest and Gyaneshwar community forest, camera trapping technology was used. In the forest area of 500 ha, 181 animal species including one-horned rhino, Royal Bengal tiger and python have been observed. Among these 125 bird species and 19 mammals have been spotted [46].

Pokhrel and Shah [29] observed the increased frequency and movement of wild elephant and blue bull due to the establishment of community forests. Twenty-five mammals, 16 herpetofauna and 163 bird species were recorded in their study area indicating availability of suitable habitat for the species. In the study of 10 transects, they encountered 251 different signs of the wild fauna. Local people had suffered from economic loss of crop damage and livestock due to the increasing number of wildlife in the community forest.

5. Conclusions

Community forest management is an approach to mitigate increasing deforestation and forest degradation to address the negative impacts on rural livelihoods. Studies have demonstrated a significant increase in forest condition under community forestry showing that it is a proven model for controlling deforestation and forest degradation. It has co-benefits of reducing poverty and addressing social exclusion by creating rural employment. It is contributing to livelihood promotion such as fulfilling the basic needs of local communities investing money in supporting income generation activities of the poor people and providing access to the forestland for additional income or employment.

Different research studies are conducted by different researchers to assess the role of community forest in biodiversity conservation in different study areas of Nepal by applying different methodologies. Researchers had focused on analysis of biomass, carbon stock analysis, calculation of biodiversity index, change in land use and land cover, spatial analysis of forest resources, camera trapping of wild fauna and socioeconomic analysis by using different primary and secondary data collection techniques. They are using national guideline and their own derived methodologies for assessing biomass, carbon stock, measurement of biodiversity index and analysis of flora and fauna.

It was concluded that community forestry management had a great role in biodiversity conservation in Nepal. Biomass, carbon stock, growing stock, soil organic carbon, forest cover, forest products and benefit from forest resource had increased due to CFM as compared to past. The number and density of trees of highly productive plant had increased while the number and density of less productive shrubs and bushes had decreased. Forest biomass and carbon in different form of plants, above ground tree biomass, above ground sapling biomass, leaf litter herbs and trees and underground biomass had increased gradually after CFM implementation. Wild animals such as leopard, porcupine, monkey and other birds were increased in the forest and were frequently seen nearby the forest destroying the crops of people. The forest is getting denser and providing habitat to the wild animals as compared to past according to the view of local people.

As community forestry management had great role in biodiversity conservation of Nepal, there is a need of more funding for its sustainable management. Local people are working hard and devoting their time voluntarily for sustainable harvest of forest resource and conservation of flora and fauna. If they do not get adequate benefit of forest resource and monetary benefit from job employment and other income-generating activities, they will start using forest

products for sustaining their livelihood and fulfilling their day-to-day need. It would cause utilization of more forest resource and decrease in biodiversity of plants and animals. It is recommended to provide skill development trainings, income-generating activities, high yield forest resource and non-timber forest products and also provide financial support for the installation of renewable and alternative energy technologies to minimize the use of forest resources. In addition, more research studies on assessing the role of CFM in biodiversity conservation should be carried out to find out the feasibility of CFM in the Nepalese context for biodiversity conservation.

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