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RESEARCH ARTICLE

Effectiveness of Community Forest Management as an Ecosystem-Based Adaptation Strategy in the Context of Nepal

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Abstract

Objectives: This study attempted to explore the effectiveness of community forest (CF) management as an ecosystem based adaptation (EbA) strategy in combating and adapting with the climate change impacts upon local ecosystems and communities. **Method:** In order to identify EbA options, effectiveness, efficiency, sustainability, governance and socioeconomic function of CF were analyzed. Effectiveness and sustainability were examined and compared through Land Use Land Cover (LULC) database during 1996 and 2021. Efficiency was explored through the economic valuation of provisioning and cultural services, using economic approach–revealed price (market price) method. Socioeconomic functions and governance were examined through the existing plans/policies and secondary data review. **Findings:** CF is effectively and sustainably managing the available resources. It has increased forest cover, water body, grassland and remarkable decline in bush and sand area. Bush area (79.25 ha in 1996) dropped (to 6.52 ha in 2021) while forest cover increased from 340.46 ha to 375.54 ha. Waterbody (pond or lake area) was limited to 0.88 ha that expanded to 5.04 ha in 2021 due to the conservation oriented management practices. Meanwhile, economic value of provisioning services is USD 7182 accounting wood and timber the highest (average annual USD 4800) among the provisioning services while average annual value of firewood and poles is USD 1367 and NTFP (fish and rubber) is USD 1015 whereas the economic value of cultural services is USD 18803. **Novelty:** The novelty of the research work lies in the unique methodology and the selection of CF for the EbA case study, which is least explored. By exposing the integration of ecological and socio-economic considerations, this research underscores the significance CF as EbA option in shaping sustainable development pathway in Nepalese context.

Keywords: Ecosystem Services; Ecosystem Based Adaptation; Community Forest; Nepal; Land Management

1 Introduction

Climate change refers to the enduring alteration in weather patterns spanning from tropical to polar regions, posing pervasive global threat in diverse fields [1]. World temperature has been increasing gradually by 1°C with additional decadal warming of 0.2° C since pre-industrial era to now. Global warming is predicted to continue by 1.5°C by 2030-2050 [2]. Climate change is likely to result in wide range of environmental impacts, more specifically in the Himalayan countries like Nepal. The maximum annual temperature trend of Nepal is remarkably increasing between 1971 and 2014 (0.056 °C) [3]. Meanwhile, the annual mean temperature is predicted to increase by 0.9-1.1°C during 2016-2045 and 1.3-1.8 °C during 2036-2065 [4].

Nepal is among the most vulnerable countries in terms of climate induced hazards and risks [5] which is ranked in the 4th position in the climate change vulnerability index in 2017 [6]. Nepal has been witnessing climate induced disasters particularly hailstorms, avalanches, cold waves, wind storms, erratic rainfall and landslides in the later years. Climate induced disasters have claimed significant number of lives and property. Estimated average annual economic loss during 1971-2019 is 2778 million Nepali rupees [7]. Extreme climatic events are expected to be more frequent and severe which in combination with degrading ecosystem and biophysical processes will result in catastrophic shocks in the future days to come [8]. These changes may have severe impacts to humanitarian crises, increased societal vulnerabilities and multi-hazard scenarios [5]. Harsh impacts of climate change in Nepal are inclusive of reductions in agricultural production, food insecurity, damaged infrastructure, and reduced water supply [9].

Adaptation strategies are imperative in the least developed countries to effectively channel climate financing and enhance support for impoverished vulnerable households [10]. Among different approaches to climate change adaptation, Ecosystem based adaptation (EbA) is the one that refers to the utilization of biodiversity and ecosystem as the part of adaptation strategy which is believed to adapt with the harsh climate change impacts thereby reducing the socio-environmental vulnerability. EbA benefits the community by offering several ecosystem services (ES) and sustainable ecosystem management during climatic extremes [11]. It intends to incorporate sustainable practices for managing, conserving and restoring ecosystems that takes the diverse social, economic and cultural benefits into account for the local communities [12]. Further, it targets to harness the socioecological services for climate change adaptation and growing attention globally [13].

Studies have explored EbA approach in several scenarios within Nepal such as: the potential of ecosystem-based solution for urban disaster reduction of Kathmandu valley [14]; implementation of EbA intervention in watershed restoration of Lamjung during 2014-2018 [15]; role of fungi on EbA in the Himalayan region of Nepal [16]; EbA approach to disaster risk reduction in the mountain systems of Nepal including Uganda and Peru [17]; ecosystem-based flood risk mitigation and socioeconomic diversity in the Terai region of Nepal [18]. Similarly studies also have highlighted on climate change mitigation and adaptation potential of forest [19]; climate resilient forest management strategies [20]; local collective actions in forest transition [21]; status of community forests of Nepal [22,23] and the climate change adaptation strategies by Nepalese farmers [24–26].

Exploring EbA intervention in the local level is essential for the wider socioeconomic and ecological understanding of the local institutions. There is the potentiality of EbA intervention in community forest operational plan however investigation and evidence is lacking [27]. There is the dearth of studies that explore the effectiveness of community forest (CF) management as an EbA option in Nepal. Based on this knowledge gap, this study aims to answer the following research questions: How is CF management enhancing ecosystem resilience? What are the socio-economic benefits and adaptation strategies that the CF management is offering? This study paves way to the planners and policy makers to institutionalize the EbA interventions in minimizing the climate induced risks and build climate resilient socioeconomic and ecological systems.

2 Methodology

2.1 Study area

We have selected Jamunbari Community Forest (JCF) for the case study-which is geographically located within 87°534' E to 87°56' E longitude and 26°39' N to 26°40' N latitude covering 434.19 ha area (Figure 1) of which 26.54 ha is managed as wetland and ecotourism area. Administratively, it is located within Kankai Municipality ward no 1 and 2 of Jhapa district, Nepal. The forest has been under the community management since 1995. Maximum average temperature in 1989 was 29.72 °C which had increased to 31.4°C in 2016 while the minimum temperature was 17.54 °C in 1989 and increased to 18.49 °C during 2015. Similarly, the average annual rainfall of nearby Damak station was 277.5 mm in 1988 which declined to 152.75 mm during 2015 [3]. Changing climate along with urban sprawl have been adversely pressurizing the natural resource of the study area where local institutions such as community forest user's groups (CFUGs) are anticipated to function in combating with the climate change impacts.

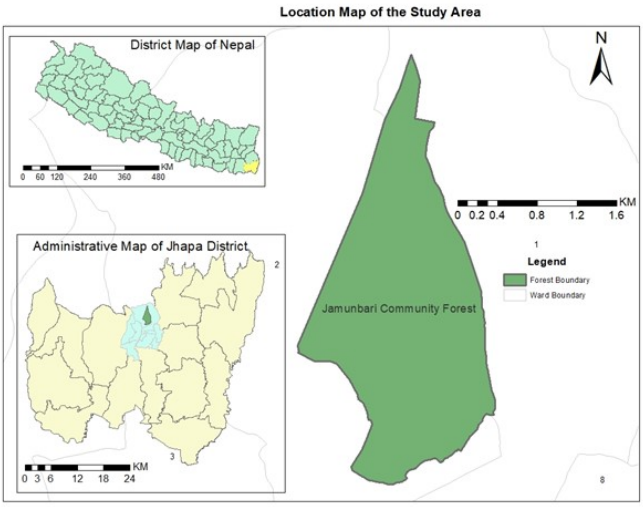

Fig 1. Location Map of the study area

2.1.1 Data Collection an Analysis

In order to identify EbA options in CF management, specific criteria were generated (Table 1), based on literature review: effectiveness, efficiency, sustainability, governance and socioeconomic function of CF in the local level.

To examine the effectiveness in ecosystem management, Land use land cover (LULC) management practice of the forest before and after the handover to the CF were examined. LULC analysis for the years 1996 and 2021 were conducted using Topographical Map prepared by Department of Survey, Government of Nepal[28] and Landsat satellite OLI (operational land imagery) collected from United States Geological Survey (USGS) https://earthexplorer.usgs.gov, respectively. Subsequent verification, image classification and accuracy assessment were based on Global Positioning System (GPS) derived field data, topographical map by Government of Nepal and Google Earth image. In order to verify the classified LULC data, 180 sample points with 20 points per each class were randomly collected using GPS. The sustainability of ecosystem management is evaluated by comparing the LULC change during 1996 and 2021.

Obtained images were projected in UTM Zone 45 N and were processed in ENVI environment. SRTM (Shuttle Radar Topographical Mission Digital Elevation Model) of 30×30 m spatial resolution were obtained for the slope verification and image registration. For the accuracy assessment, overall accuracy (OA), user's accuracy (UA) and producer's accuracy (PA) were calculated.

Table 1. Criteria to examine the effectiveness of EbA intervention

Criteria	Target	Tools
Effectiveness and Sustainability in ecosystem management	To examine land management practice and restoration of ecosystem To monitor ecosystem to ensure sustainability	LULC database
Efficiency	To evaluate economic benefit generated by ES	ES valuation
Governance and institutional arrangement	To identify integration of EbA in policy level	Plans and policy review
Socioeconomic development and livelihood diversification	To explore the impacts of EbA intervention in local community	Secondary data, plans and policy review

To explore the efficiency, two major ES: provisioning (wood, poles/firewood and non-timber forest products (NTFP) and cultural service (ecotourism and recreational service), were evaluated using economic approach–revealed price (market price) method. This method estimates the lower value of goods or services in comparison to the actual market price[29,30]. The defining criteria for ES valuation was prepared based on the framework developed by Acharya et al.[29]. The economic value of goods and services was calculated by multiplying the average quantity of goods and services by the local market price of the product. The market rate of goods and services is presented in the supplementary table 1 (S1). Input data for the revealed price method were entry fees, parking fees, recreational and activities charges. The number of annual visitors during 2009/010-2021/022

(Supplementary table -S3), and available auditor's financial reports during fiscal years 2009/010 to 2020/021 were collected. Obtained data, official financial records and reports were desk reviewed and analyzed. The information was triangulated through the review of operational plans and tourism development master plans. ES based spatial attributes collected during the field visit were mapped using Geographic Information System (GIS) tools.

To explore the governance and institutional arrangements of CF in terms of resource management and the EbA options, operational plans and tourism development master plans were reviewed. To assess the impact of EbA intervention in local community, management practices and community based activities on livelihood enhancement and capacity buildings were examined based on the office records, reports and operational plans.

3 Results and Discussion

The study has explored the effectiveness, efficiency, sustainability, socioeconomic and livelihood diversification role along with governance and institutional mechanism of the CF as EbA option through the robust methodology by selecting a case study from Nepal.

3.1 Effectiveness and sustainability in Ecosystem management

Sustainability and effectiveness of CF in management was evaluated through the LULC data prepared by using satellite images and topographical data. The overall accuracy for LULC database of 1996 was 94% and 2021 was 87%.

The LULC analysis shows that the CF witnessed increased forest cover, waterbody, built-up, grassland and remarkable decline in bush and sand area. Bush area which occupied 79.25 ha in 1996 dropped to 6.52 ha while forest cover increased from 340.46 ha to 375.54 ha by 2021. Waterbody (pond or lake area) was limited to 0.88 ha that expanded to 5.04 ha in 2021 due to the conservation oriented management practices (Table 2Figure 2). Infrastructure here refers to the physical attributes within the ecotourism and wetland area. Similarly, grassland areas are managed as garden and recreational zones (Figure 2 b, Figure 3).

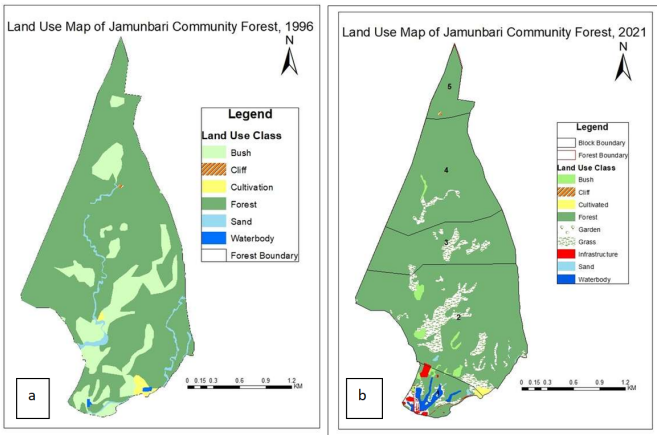

Fig 2. LULC Map of JCF during 1996-2021

Until 1994, under the national governance, the forest was subject to encroachment, pressurized due to the increased population growth and urbanization along with the changed climatic condition. The water cover area confined, ponds converted into other land use and forest cover degraded posing serious threat to natural environment thereby impacting the local livelihood[31]. However, under community management, forest has been attempted to manage sustainably under five strata: Block I (26.54 ha)-ecotourism and wetland area (Figure 3), Block II- rubber plantation area (211.69 ha), Block III (93.95 ha)-mixed shorea robusta forest, Block IV (78.11 ha) and Block V (23.91 ha)- mixed natural shorea robusta forest[32] (Figure 2 b,Figure 3).

The results of forest and water cover restoration under community management is comparable with the outputs of other studies. In 79 community forests of Charnawati and Kayarkhola watershed of Nepal, forest cover increased remarkably during 1988-2016 under community management[33]. In Kalika CF of Jhapa district, forest cover increased by 8.6% during 1990-2019[30]. In Tanahun district of Nepal, forest cover increased at the annual growth rate of 0.68% during 1976-2015[34]. In sharp contrast to our results, in Ajei watershed CF of Cameroon, forest cover declined by 240 ha in 30 years where deforestation rates ranged between 1.49% to 1.83%. During the period, bare soil and sparse vegetation increased at the cost of dense forest and

Table 2. Land use land cover change of JCF during 1996-2021

Land use class	1996 (Area in ha)	2021 (Area in ha)	Change during 1996-2021
Bush	79.25	6.52	-72.73
Cliff	0.19	0.09	-0.1
Cultivation	3.64	1.54	-2.1
Forest	340.86	375.54	34.68
Pond or lake	0.88	5.04	4.16
Grass	0	39.52	39.52
Sand	9.37	0.71	-8.66
Built-up	0	3.19	3.19
Garden	0	2.04	2.04
Total	**434.19**	**434.19**	

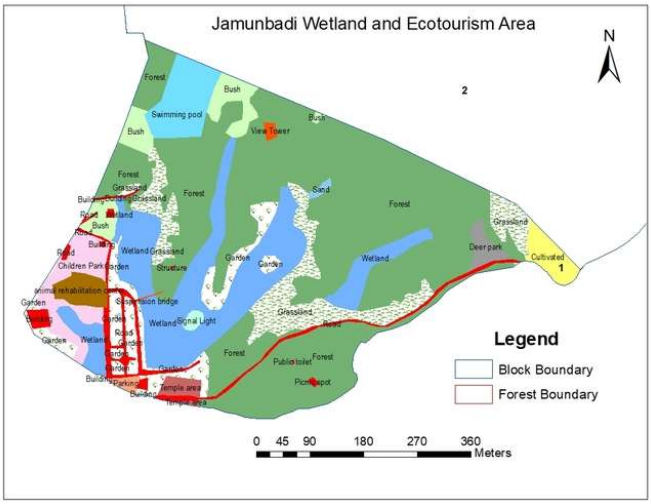

Fig 3. Jamunbari Wetland and Ecotourism area within JCF

savanna[35]. Apart from the success and failure cases, sustainability of CF confronted several internal challenges and depended on other institutional and political influences[36].

3.2 Efficiency

Community forest has been efficient in delivering various ES and this study has evaluated the major provisioning (timber and NTFP) and cultural services (Ecotourism and recreational service) applying market price-reveal price method. Households need timber for house and shed construction, grass and bedding materials for livestock and firewood for cooking and CFUG collects revenue from the products. The average annual economic value of timber and wood services since 2009/010 to 2021/022 is USD 4800 whereas it is USD 1366.92 for firewood and poles. The revenue collected from the timber products is increasing gradually over the years. The average annual supply of grass is 10410 *bhari* (approx.1 *bhari*= 40 kg) and bedding materials is 8842 *bhari*[32]. Similarly, the economic value of NTFP (rubber and fish) is 1014.87 per annum in average (Supplementary file S2 a-b and Figure 4).

Ecotourism has been an integral part of JCF. The average annual income of ecotourism and wetland area during 2010 to 2021 is USD 30784.39. Of the services, boating service has the highest economic value (8708.73 USD). Pandemic affected the service delivery and revenue generation. The details for the economic valuation of ES is presented in **Supplementary table 2 (S2a-b).**

Forest based ecotourism has been the recent popular trend particularly in the developing countries[37] as it uplifts the economic base of local people[38]. Contribution of forest based ecotourism of JCF in the local economy is comparable to the other regions Cambodia[39]; Kalika CF of Jhapa[30]. However, the results also contrast with the results of some regions. In sub-Saharan African countries, CF lags in terms of benefit sharing, product and resources management[40]. It is also claimed that

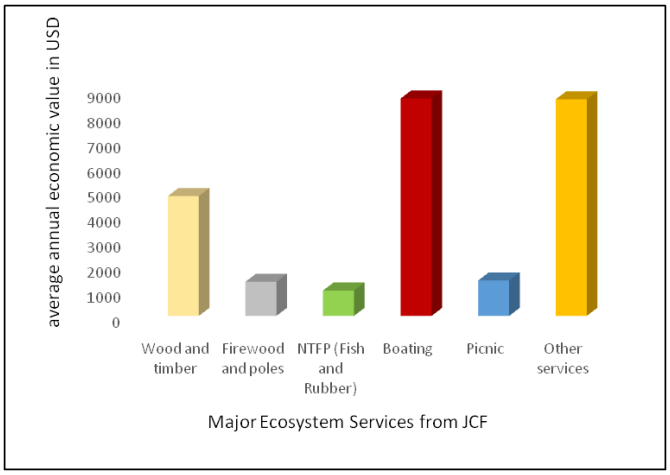

Fig 4. Economic values of major ES within JCF

CF, without external subsidies cannot function for the effective societal goals[41].

3.3 Socioeconomic development and livelihood diversification

CF prioritizes socioeconomic development and income diversification options. The CF invests in infrastructure development such as gravelling of the road, drinking water supply, river embankment, school buildings, electrification which again create employment and income opportunities to the locals. Ecotourism and wetland area alone has provided direct employment opportunity to 147 people, management and conservation (20), tourism and transportation (57), and business (70)[31].

A total of 35% of the collected revenue is used to enhance the financial condition of the under-privileged and marginalized people, 35% is used for income generation of member households and 25% of the budget is utilized for forest conservation and management. Income related programs (such as tailoring and knitting trainings, empowerment programs, commercial vegetable farming, animal husbandry and leasing certain area for farming to the deprived households) for livelihood of low income and marginalized are provisioned in operational plan (Chapter 8 operational plan). Diversification, biodiversity conservation and natural resource management (section 13 of action plan) and special forest based skilful programs to women and pro-poor (section 12.5) are prioritized. Annual reports show that JCF has been investing USD 15182.62 for community development, USD 2767.98 for poverty alleviation and community service, USD 3414.68 for forest development and USD 85083.46 for wetland development and management (Supplementary table S4, a-b).

To minimise the dependency upon CF for forest products, agro-forestry is promoted and alternative energy such as distribution of bio-briquette, improved stoves, biogas plants are subsidized. Auditor's report show that the average annual subsidy to install biogas plant is NRs 91000. Meanwhile, JCF has prioritized wild life conservation- threatened and troubled wild lives are rescued and rehabilitated.

The results are comparable to the other regions. CF program has substantially enhanced livelihoods, demonstrating significant positive impacts on various aspects including household conditions, income sources, savings, education, and community trust and cooperation in Srilanka[42]. Granting local forest ownership in Mount Oku region enhanced transparency, stability and enhanced livelihoods, but requires bolstered capacity-building and improved stakeholder communication for sustained conservation and livelihood benefits[43].

3.4 Governance and Institutional arrangements

Operational plan[32] and wetland and ecotourism management plan[31] have provisioned the conditions to manage, monitor and utilize the resources which can be indirectly dealt as EbA options. The degraded forest and wetland which was at the verge of extinction were preserved and managed as wetland in the active participation of the user's households thereby establishing JCF as ecotourism hotspot of the region. Sustainable forest management, plantation programs (section 9.4.), specific silvicultural criteria for the extraction of the forest products (chapter 3) and management activities such as monitoring, conservation and prevention measures (Chapter 4) are aimed to minimize the harsh impacts of climate change. Haphazard extraction of forest products, encroachments, smuggling, harming biodiversity and use of pesticides are restricted. However, apparent integration

of EbA options in forest management is not incorporated in the operational and master plans.

National Adaptation Plan of Action (NAPA) failed to incorporate how EbA can uplift ecological and economic system[44]. REDD+ strategy 2018[45] has indicated that EbA can be an option in improve forest management however, its implementation is not highlighted. Local Adaptation Programme of Action (LAPA) emphasizes on the localized institutional arrangements in combating with the climate change impacts however has failed to address how EbA can be instrumental in it[46]. Climate Change Policy, 2019[47] regards EbA suitable for vulnerability reduction however EbA financing and integration in mainstream plan and policy is lacking. This study indicates the need of EbA inclusion in operational plans of the CFUGs.

4 Conclusion

The findings of this study undersocre the effectiveness of CF management as an EbA strategy in mitigating and adapting to the impacts of climate change on local ecosystems and communities. Through a comprehensive analysis of various parameters including LULC changes, economic valuation of ES, and examination of governance structures, this research has demonstrated the positive outcome of CF management. The significant increase in forest cover from 340.46 ha to 375.54 ha, water bodies from 0.88 ha to 5.04 ha and notable declines in bush and sand areas reflect the successful conservation-oriented management practices implemented by local communities. This has led to significant improvements in ecosystem health and resilience over the study period. The quantification of economic values of ES sheds light on the tangible benefits of CF management, further emphasizing its role as a viable EbA option in the Nepalese context. It underscores the importance of empowering local communities in the management of natural resources and emphasizes the need for policy support and institutional frameworks to ensure the continued success and sustainability of CFs as EbA strategies.

Still, there exists research gap about people's perception in terms of EbA adaptation options. Ecotourism activities within the forest area contain multiple challenges including human-wild life conflict, and declined biodiversity which can be investigated in the further research works.

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