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Opportunities and Impediments of Carbon Sequestration Projects: A Feasibility Study from Humbo, Southern Ethiopia

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Abstract— Forest resources now a day have attracted widespread interest of global communities to enhance carbon storage. Community Assisted Natural Regeneration (CANR) is a simple, low-cost forest restoration method that can effectively convert deforested lands to more productive forests. Thus, this study was conducted to evaluate opportunities and impediments of carbon sequestration project in Humbo CANR project. The necessary data for the research was collected by using questionnaire, focus group discussions and key informants interviews. A sample of 120 was selected randomly from residents participating in CANR. Then, descriptive statistics were computed and statistical tests such as chi-square test, Likert scale and correlation coefficient were used for data analysis. In addition, the study applied Econometric model to identify determinants of forest regeneration in the study area. It revealed that the project provided an economic incentive to the community to conserve the forests, apart from carbon storage. The project offered opportunities to enhance biodiversity, mitigate GHG emissions and enabled adaptation to climate change. The study also identified potential hurdles to project execution like lack of wide-ranging knowledge, illegal logging, lack of good governance and frequent attacks from wild animals. The logistic regression model pointed out that educational status, sex, age, home-forest distance, HH size, income, land holding size and skill training opportunities determined community involvement in forest protection, resource utilization, and decision-making. Thus, international stakeholders should make greater efforts to invest more while the hosts need to improve institutions for natural resource governance and build institutional capacity in order to attract more carbon investments.

Keywords— Climate Adaptation, Mitigation, Community Assisted Forest Regeneration, Carbon Sequestration, Humbo

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1 Introduction

CHANGES to the Earth's surface that are caused by human activity can have significant effects on ecosystem composition and function. Forest resources now a day; have attracted the attention and interest of global communities for their services of supporting welfare and regulating global ecosystem. World Bank [1] indicated that forests contribute to the livelihoods of more than 1.6 billion people around the world. For millions of people living in poverty around the world, forests not only provide food, fuel for cooking and heating, medicine, shelter and clothing, but they also function as "safety nets" during emergencies [2]. In this regard, studies [3] [4] [2] indicated that forest products and cash incomes generated from them facilitate adaptation of rural households to stresses and shocks such as drought. The sector also plays a crucial role in mitigating global climate change through carbon sequestration, biodiversity conservation, and ecotourism promotion.

The examination of carbon sequestration and emissions requires an analysis of changes in both land use (for example, conversion of forest to agricultural land) and land cover (for example, harvesting trees on a parcel used for forestry).

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Changes in forest ecosystem have occurred as a result of climate changes and these have been documented by various researchers. The levels and trends of forest changes have also been aggravated by the increase in human population around the forest ecosystem. Parts of the forest have been converted to agricultural activities and settlement leading to a net loss of the natural forest area. Coupled with land degradation, climate change is also exacerbating environmental problems in Ethiopia [5] [6]. Deforestation, degradation of native grasses and conversion to cropland have prompted losses of biomass and soil carbon of 450–800 Gt/CO2 – equivalent to 30–40 percent of cumulative fossil fuel emissions [7] [8]. Emissions from conversion from forests to cropland or other land use have dominated carbon losses from terrestrial ecosystems [9] , but substantial amounts of carbon have been lost from biomass and soils of grassland systems as well [10]. Much of the carbon lost from agricultural land soil and biomass pools can be recovered with changes in management practices that increase carbon inputs, stabilize carbon within the system or reduce carbon losses, while still maintaining outputs of fibre and forage.

On this basis, there is now significant agreement among policymakers in many countries that carbon capture and sequestration (CCS) has a vital role to play in the overall efforts to reduce GHG emissions worldwide. Carbon sequestration projects may provide a win-win between environmental conservation and increased opportunities for economic development in poor countries [10] [12]. The move to bring the forest

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under rehabilitation through active involvement of the community is envisaged to trap many local socioeconomic and environmental benefits and ecological stability. Ethiopia needs more investment to support poverty alleviation and economic development. Accordingly, efforts to mitigate climate change through carbon sequestration projects can regenerate natural resources while raising local incomes [13]. In addition, though the estimates of the biological and economic potential of forest management practices for controlling the concentration of carbon dioxide in the earth's atmosphere are highly speculative [14] [15] roughly estimated that economically viable forest management practices could conserve and sequester1gigaton of carbon per year (GtC/yr) worldwide; the marginal cost of implementing these options is estimated to be 10$/tC. It is also believed that re-vegetated systems with appropriately and sufficiently diverse species were able to recruit other native flora and fauna to sustain the system [16]. Thus, understanding the value of carbon sequestered in forests is important in addressing the risk of global climate change that has presented a profound challenge to the international community.

Hence, Humbo community assisted natural regeneration (CANR) was introduced by World Vision Australia in partnership with World Bank in 2006 as one of carbon sequestering project [17]. The initiative introduced was to restore degraded communal forestland and thereby generate income for local communities through the sale of carbon credits. Hence, it is a simple, inexpensive, and effective technique for converting areas of degraded vegetation to more productive forests [18]. Logging followed by drought resulted in the replacement of forest with farm land, and the recent combination of increasing stress from extensive overgrazing has limited tree regeneration in the study area. Consequently, high dependence on land and forests for subsistence lead a growing threat to widespread natural resource degradation in study area. In addition, the socio-economic status of local community have significant influence on determining the types of activities they are engaged in, as well as the impact on different types of interactions toward their natural resources. As a result, understanding the socio-economic factors affecting people dependence on natural resources remains an essential element to conserve natural resources. Thus, this study was conducted on Southern Ethiopia with the aim to evaluate opportunities and challenges for carbon sequestration project. Therefore, the study provided valuable feedback to all those who are involved in environmental services such as carbon sequestration project.

2 Materials and Methods

2.1 The Study Area

The Humbo CANR project is located in Wolaita, Southern Ethiopia and surrounded by seven rural Kebele administrations namely Abella Longena, Hobicha Badda, Bolla Wanche, Hobicha Bongota, Abella Gefeta and Abella Shoya. The forest enclosure has a total area of 2,728 ha. The project is designated as a carbon sequestration project where its day-to-day management is entrusted to the local community living in the seven kebeles. Topographically, the area extends from 1300 to 2400 meters above sea level. It consists of undulating rocky hills and plateaus while relatively flat areas extending to Lake Abaya. The annual rainfall in the area ranges between 700 and 1000 mm. Rainfall variability in the area has been reported as major problem in recent years. Temperature also varies according to the season and elevation, and generally it ranges between 12 up to 24^{0}C with an average temperature of 18^{0}C [19]. Farmers of the district practice a mixed farming system in which crop and livestock husbandry being largely practiced. Apart from farming, some households practice off-farm activities such as petty trade, handicrafts, and seasonal migration to supplement their incomes. There are also some segments of local community whose livelihood is predominantly dependent on the sale of wood and charcoal gathered from the woodland. Local communities living close proximity to project site have close attachment to woodlands now demarcated as a reforestation site. Historically, they have used the woodland as major source of fuel wood, farm tools, construction material, and source of fodder for livestock. Currently, communities living in the seven Kebeles have established Forest Development and Protection Cooperatives on voluntary basis and formulated their forest management by laws.

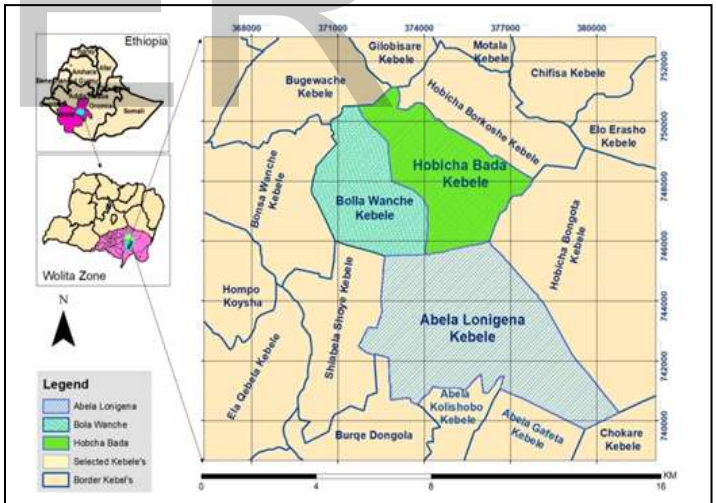

Fig.1. Map of project sight (Source: Humbo CANR Project, 2018).

2.2 Methods

In order to undertake this study, a mixed research design combining quantitative and qualitative approaches was employed. The necessary data for the research was collected by using questionnaire, focus group discussions (FGD) and key informants interviews (KII). To collect primary data, questionnaire that relied on semi-structured questions was used to get the relevant data. Secondary sources of data were accessed from policy documents, reports and forest development researches from websites. Out of seven *kebeles* which are found close proximity to the project site, Bolla Wanche, Abala

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Longena and Hobicha Bada were selected randomly. Sample size was determined from the total households who are participants from the three *kebeles* proportionally based on the Kothari (2004) formulae. A sample of 120 has been selected randomly from residents participating in community assisted forest regeneration available at each cooperative.

Methods of Data Analysis

Both quantitative and qualitative data were generated by the study. The data generated from questionnaires was ordered, coded, categorized, classified and labeled as per the themes and objectives of the study. The qualitative themes were then connected together in the form of key relationships to triangulate data. The SPSS.v20 was used to analyze the quantitative data. Then, descriptive statistics were computed and statistical tests such as Chi-square test and correlation coefficient were used for data analysis. In addition, the study applied Likert scale as the best measures for ordinal data analysis based on the mean range developed by [20] as follows:

Table 1: Five Scaled Likert's Criterion (**Source:** Al-Sayaad *et al.* 2006)

No.	Mean Range	Response Options
1	[1.00, 1.80]	Strongly Disagree
2	[1.80, 2.60]	Disagree
3	[2.60, 3.40]	Neutral
4	[3.40, 4.20]	Agree
5	[4.20, 5.00]	Strongly Agree

Econometric model was also used to study the relationship between variables empirically. Binary logit regression model was used to analyze determinants of community assisted forest development in the study area. According to [21] the logit model could be written in terms of the odds ratio and log of odds ratio, which enable one to understand the interpretation of the coefficients. In this study, the odds ratio is the ratio of the probability that the participation on forest development (Pi) to the probability that he/she was contributed (1- Pi). Generally the logistic regression model is explained as follows:-

$$Y_i = \ln\left(\frac{P_i}{1-P_i}\right) = \alpha + \sum_{i=1}^{k}\beta_i X_i + \mu_i \qquad (1)$$

Where, Y_i is our dependent variable either the community participated or not in the forest development. K is the number of explanatory variables included in the model. X_i is a vector of all explanatory variables. β_i is the coefficient or the parameter to be estimated in the model. P_i: is the probability that the youth is employed in the labor market. 1-P_i: is the probability of failure or the probability that the youth is unemployed. U_i: is the disturbance (error) term showing the effect of other variables (other than the included variables) on our dependent variable. Therefore, the odds ratio is the factor by which the odds of participation on forest development per unit change in the i^{th} independent variables, controlling the effects of other variables.

3. RESULT AND DISSCUSSION

3.1 Socio-Demographic Characteristics of Respondents

The sample households in this study represented both gender while males households dominating. This was expected because of patriarchal system of life, where a husband (usually men) is the head of household. The majority (68.3%) of sample respondents' fall under the age of above 30. This implies that the majority of respondents are in productive age group. As far as education is concerned, 17.89% were never attended formal education while 41.05% attended primary level and 22.12% have received vocational training diploma. This may have significant impact on individual's or a group's awareness, knowledge, attitude and skill in environmental management. The majority of respondents (81.0%) were farmers and involved mainly in mixed farming such as crops and livestock. This shows how closely the livelihood conditions of the households in the study area are reliant upon the natural resources.

3.2 Opportunities of the project at local level

Impacts on the Natural Capital (HC)

The project has impacts directly or indirectly on the two main livelihood assets (natural and human capitals) in the study area. Thus, the evaluation of the impact of carbon sequestration on the local community environmental resource management (natural capital) is indicated in the table below by using Likert scale analysis as follows.

Table 2: Impact of the project on local community in terms of natural capital (NC)

Indicators	Statistics				
	N	Min.	Max.	Mean	Std. Dev.
The project showed significant increase in the forest cover in the protected area.	120	1	5	3.81	.7348
The emergence of new plant species that were not seen before has increased after the project.	120	1	5	4.01	.7483
The number and types of small and large animals has recently increased.	120	1	5	3.81	.7348
There is increase in the amount and frequency of rain in the local area.	120	1	5	2.81	.6483
The volume of springs and rivers has increased since the project is implemented.	120	1	5	2.88	1.189
Flooding from runoff, rain water and its risk has decreased after the project.	120	1	5	4.21	.7348
Overall	**120**	**1**	**5**	**3.68**	**1.784**

As indicated in table 2, the project has resulted in the forest regeneration with the highest mean value of 3.81. Regarding to the emergence of new plant species that were not seen before the project implementation, the majority of the respondents have agreed, as indicated by their higher mean scales of 4.01. In addition, FGD participants in the study sites acknowledged the resto-

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ration of grass to the forest floor and hillsides. Thus, the survey result was in agreement with Grieg-Gran *et al., (*2005) that enhancement of biodiversity, emergence of new plant species, and increased stocks of timber and non-timber forest are potential positive outcomes and impacts of carbon projects for natural capital.

Concerning the number and types of small and large animals, they witnessed as it has increased with the mean value of 3.81. Accordingly, the mean value falls on the response scale of agree level. So, it implies that most members of respondents believe on after the implementation of the project the number and types of small and large animals has recently increased. However, the FGD participants stated that there is difficulty in raising livestock and crops around the forest due to frequent attacks from wildlifes like hyenas, pigs, hedgehogs, monkeys, leopards, and some bird species. This is evident from the detrimental impacts of initial area enclosure and the later increasing attack from wild animals on agricultural produce and livestock of households closer to the forest.

Thus, it needs awareness creation among the society in making the project site the eco-tourism attraction. It was also witnessed that flooding from runoff and its risk has decreased after the project implementation and has the mean value of 4.21. In relation to this, key informants and participants of FGD agreed on the increment in rainfall duration, improvement in soil moisture retention capacity, reduction of soil erosion, and improvement in local micro-climate as key environmental benefits resulting from the project. One of the key informants from Bolla Wanche observed improvements in rainfall conditions as follows:

The volume and time of rainfall in our vicinity is gradually restoring back to the condition that existed in our fathers' days (as the time when the area was covered by dense forest). In 2017 we received first autumn (Belg) rain in mid of April. In 2018 we received it around March 11 and in this year we may receive it even earlier. Furthermore, we get sporadic rainfall even in January and February, which was uncommon in the last decades. This is due to the area closure and forest regeneration established by this project.

Thus, the evidence shows the existence of perceived improvement in rainfall conditions due to the restoration of vegetation in the area. However, these perceived changes in the microclimatic conditions of the areas require further comprehensive studies in order to establish a causal relationship.

Impact on the Human Capital (HC)

As can be seen from table 3, the project invested more training on carbon project management and has the mean value of 3.6 with a standard deviation of .6782. According to Fifth-Scaled Likert's Criterions of Al-Sayaad et al. (2006) of Table 1, the mean value falls on the response scale of agree level. So, it implies that most members of cooperatives believe on the project provide training in conservation of the forest. The results obtained from the survey agree with [22] that carbon projects typically contribute to the development of knowledge, skills, and capacity of individuals through trainings in forest project management. Thus, the carbon revenue invested in trainings has contributed to human capital.

The inquiry extended to the importance of the existing trainings to carbon management. The majority of the respondents agreed that the trainings that have given to them were important to develop their knowledge which indicated in mean value of 3.4. The survey results agree with [23] that the existence of sufficient access in building the capacity of cooperatives provides them with high opportunity to have good performance though there is little evidence to date whether new knowledge and skills are gainfully applied in practice.

Table 3: Evaluation of carbon sequestration project on local community for human capital

Indicators	Statistics				
	N	Min	Max	Mean	Std Dev
There is more training in carbon project management skills	120	1	5	3.6	.678
Does it existing trainings are important for carbon development	120	1	5	3.4	.668
Trainings enabled cooperatives to identify new carbon management skills	120	1	5	3.6	.678
Cooperatives have been benefited from skills developed through trainings	120	1	5	3.8	.734
Overall human capital	120	1	5	3.6	.6898

On the other hand, the trainings enabled person to identify new forest management skills has the mean value 3.6. So, it implied that most members of cooperatives believe on the trainings enabled people to identify new forest management opportunities. In the inquiry made to assess whether the skills are applied in practice in forest management or not, the survey result provide evidence, that the majority of the respondents have agreed implemented the skills in their management activities which indicated in mean value of 3.80.

In this regard, Key informants from the selected local communities indicated that continuous training enhanced awareness of local communities about the importance of forest. Thus, a key informant from Aballa Longena indicated that:

Training changed initial negative attitude of some of our community members towards conservation of the forest. In fact, not only the knowledge gained from training, but also the perdiem allowances we received during training sessions were meaningful to convince us. Most importantly, the training equipped our community members with basic skills on how to restore the forest and manage it.

Community members mentioned gains in knowledge about the importance of the forest, as well as enhanced awareness of associated with forest management. Key informants also mentioned that they have gained skills through various training workshops on nursery establishment, bee keeping and so forth. Thus, access to training reduced initial resistances to protection of the forest land by raising awareness of community members. From this, it is evident that the project has built the institutional capacity of the local community, which in turn positively contributes to the sustainability of forest management. This finding agrees with [24] where it was indicated that a small carbon forestry project in the state of Chiapas, Mexico contributed to strengthened local ca-

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pacities and leadership and to reinforcing community based natural resource management across the region.

In this study, the researcher used Pearson's coefficient of correlation, because it is the most widely used method of measuring the degree of relationship between two variables. This coefficient assumes that community assisted forest development has very strong relationship with both Natural capital (NC) and Human capital (HC) contribution with correlation coefficient of .909, .829 respectively at 0.01 level of significance. Turning to the findings from the correlation analyses, the highest correlation score between natural capital (FC) and Human capital (HC) was seen and found highly significant at the 0.01.

3.3 Impediments to carbon project implementation

Any measures to reduce deforestation will inevitably affect the flexibility of landowners to use their land since a large percentage of people make their living from the land. As local people do not possess formal land titles, there are strong concerns in the area that the project may threaten eviction of people who depend on the area for farming, collection of timber and cattle grazing If carbon sequestration projects are taken up where property rights are unclear, it is also possible that more powerful people may take control over the land and poor people who may have been occupying it not only will not receive any benefits from carbon sales but could even end up losing their access to the land (25]. While most of the project activities are supervised by World Vision at the moment, the long-term sustainability of the project will depend upon how well cooperative union (the local institutions) can take responsibility for managing these activities. Despite women play a major role in carbon project activity particularly in the area of tree nursery and other important activity, they still need to be integrated into the project activities as well as have a representation in the institutions to have any formal say in the project of both villages.

On the other hand, an increase in density of forest cover may also increase the number of wild animals in the area, which are already perceived as a major threat by most people since the wild animals started destroying crops on the farm. Similarly, in all of the study sites participants mentioned the difficulty of raising poultry due to rampant attacks from wild animals that have been returned the area due to forest restoration. Moreover, forest fire and drought are also the other threats to the project sustainability. In terms of forest protection, it was learned that both communities have been effective in dealing with wildfires but were less successful in combating illegal logging. Furthermore, participants of FGD in Hobicha Badda, explicitly disclosed the difficulty of practicing cattle fattening due to a severe shortage of fodder due to area closure. They also perceived that conflict also emerged due to increased competition among community members and the perceived lack of fairness in the selection of participants in the project. From this it can be argued that some skill training has not thoroughly foreseen the feasibility of and potential hurdles for application the project among the communities.

A key barrier to project execution is also lack of wide-ranging knowledge on the impacts of forest management in most of the study area. Despite a large estimated potential in the short run, the respondents were possibly overlooking to build or rebuild soil carbon stocks and enhance forest productivity. Although organizations like UNDP and UNEP are already involved in capacity building initiatives, much remains to be done in terms of capacity building as an integral component of carbon project. The country also faces political volatility and unpredictable governance systems making carbon sequestration investments a risky proposition. Considering that most carbon sequestration projects have a long gestation period, any investment is liable to be risky unless backed by long-term economic and political stability. Therefore, in order to attract and sustain international carbon projects, it is essential to have good governance practices at national and local levels.

3.4 The factors affecting the implementation of community assisted forest development

Based on the binary logistic regression analysis, among 10 determinant factors considered in the model, 8 were found to have a statistically significant impact in determining community assisted forest development in the study area. The statistically significant factors that were identified were educational status, sex, age, home-forest distance, HH size, income, and land holding size and awareness and training. Conversely, residence-market distance and marital status were not found statistically significant (Table 5). The detail contribution for each of these factors is presented below.

Table4. The factors which affect the CANR (N = 120)

Variables	β	S.E	P	Z
Sex	−.380	.356	.013**	-1.63
Age	−.536	.238	.024*	−2.25
Educ. Status	.653	.182	.050*	0.032
HH size	.298	.021	.012**	0.994
Income	1.05	.59	.001**	1.12
Land hold size	−.230	.149	.003*	-0.719
Home-forest distance	.330	.252	.000	.136
Awareness and training	.225	.302	.000**	.045
Constant	2.542	3.055	0.01**	8.10

*−2 Log-likelihood function = 111.85; X^2 = 8.309; d.f. = 1; Constant = 1.529; Cox and Snell R square = .426; R square = .782; ** = P < 0.01 highly significant * = P < 0.05 significant*

The result indicated that age positively affects CANR at 1 percent significance level. The coefficient (β= -0.536) implies that keeping the influences of other factors constant, for each year increase in age of youth, log-odds of being participating in forest development decrease by 0.536. Thus, age older may not be interested because they may not have the energy to participate in doing physically hard works. So, age is a determinant factor for the level of the participation in community assisted forest development activities. There was a highly significant difference between males and females on the level of participation in terms of community assisted forest development. It needs more work to integrate women into forest development, and that increased gender equity could improve natural resource management adoption and implementation in the study area. Its coefficient β= -3.80 indicates that log odds of being unemployed for married youth decreases by 1.63 compared to single youths holding other factors remain constant. HH size is one of the important demographic factors that

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affect the level of participation of community within community assisted forest development. Thus, larger family sizes are likely to provide surplus labor and increased likelihood to engage in physically demanding activities such as forest development and management to livelihood improvement. Hence, the regression result was highly significant at 5% significance level which was 0.012.

Educational status of an individual could be most significant factor that affects forest management in the study area. As the level of education increases, the probability of unemployment decreases. It was found to be statistical significant with positive effect on forest development at 1% level. The coefficient β=-0.653 indicates that keeping the influences of other factors constant, as educational level of a person increase by one level the log odds of protecting forest increase by 0.653. This implies that increasing additional years spent in school is likely to increases the awareness of forest development and management of the community.

The regression results indicate that decreasing landholding size by one unit, community assisted development contribution to livelihood improvement will decrease approximately with a factor of .23 (Table 5). The result implies that households cultivating small land are more dependent on forest products than households cultivating large farmlands. This is related to the argument of the subsistence model and circles of poverty and forest management, in which poor households tend to clear forest due to absence, fragile and scarce resources rather than sustainably managing the forest. This study was in agreement with [26] argued that land scarcity and ambiguous property rights contribute to destruction and power struggle particularly when forests contain valuable resources. Distance from residence to forest is a variable that has a negatively significantly affect at ($p < 0.05$) on forest development and management (Table 5). The model result implies communities in close proximity to the forest can better participate in forest development and management due to convenience and effective use of extra time and energy. The result is in line with some studies that suggest the relationship between distances from residence to local forests and community involvement in forest protection, resource utilization, and decision-making was found to be negative [27].

As it's indicated in the above table, if training and awareness increase by one unit, it contributes to livelihoods improvement will increase approximately by a factor of (β=.225). This implies that an increase in training and awareness of the respondent helps to increase the participation of people in forest management practices. This result corroborates with the findings of [28] which suggests that awareness creation contributes to the understanding of the importance of forests users since it encouraging community members to participate in forest management actively. Similarly, the majority of respondents in this study indicated that a lack of training and awareness is one of the problems at the community level that leads to obstacles for successful forest management.

4. Conclusion

The study indicated that many activities that have been implemented through forest regeneration program provide an array of benefits including enhancement of biodiversity, habitat for wild animals, stocks of timber and carbon while increasing the ability of the forest to adapt to changing conditions. Apart from reducing carbon emissions related to deforestation, it also provides an economic incentive to the community to conserve the large tracts of forests. Although carbon investments cannot fulfill all investment needs of these communities, nevertheless they can make significant contribution towards sustainable development in the region. Hence, the large populations who depend directly on forests tend to be poor and vulnerable to climate variability and climate change. Implementing practices to rebuild carbon stocks in forest lands could lead to considerable mitigation, adaptation and development benefits. As a policy implication, the project offered opportunities to enhance biodiversity, mitigate GHG emissions and enabled adaptation to climate change. Therefore, priority should be given to investments in sustainable land management practices that develop incentives that foster sustainability of existing resources like soil, water, air and labor. It's also imperative to incorporate human-wildlife conflict intervention into project management and support the project with research and education on best practices for maintaining forest development.

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