Chapter 5
Social-Ecological Transformation Through Planting Mixed Tree Species on Abandoned Agricultural Land in the Hills of Nepal

Bishnu Hari Pandit, Netra Kumari Aryal, and Hans-Peter Schmidt

Abstract A project entitled, "**B**uilding villag**e** e**c**onomies t**h**rough clim**a**te farmi**n**g & forest **g**ard**e**ning" (BeChange) was implemented in four municipality areas of the Tanahun and Lamjung districts of Nepal from May 2015. In order to assess changes in the social-ecological system that result from this project targeting abandoned agricultural lands, this case study was conducted using various methods: triad grouping, GPS point surveys, household surveys, focus group discussions (FGDs), field observation and reports. A participatory approach in reforestation on abandoned agricultural land with introduction of carbon credits has become a new livelihood strategy for local communities. It has not only attracted domestic and international tourists, but also helped to conserve biodiversity and local ecology. This activity also united village women and indigenous communities as triad groups for collaborative outcomes. A total of 42,138 seedlings of mixed tree species such as *Michelia champaca*, *Elaeocarpus ganitrus*, *Bassia butyraceae*, *Bauhinia purpurea*, and *Cinnamon tamala* were planted by 276 families on abandoned agricultural land between May 2015 and July 2018. However, as of 2020, this range has expanded to include 635 families with plantations of more than 65,000 seedlings. The set-up and maintenance of these forest gardens were financed with advanced payments for the carbon sink services of the planted trees. Farmers who succeeded with tree survival rates above 80% received an additional yearly carbon sink payment. The outcomes of the project show significant improvements in food security and tree biodiversity in the project villages. Of the total sampled households, almost half (45%) were under extreme poverty and had food sufficiency for only 3 months/year before the project.

B. H. Pandit (✉)
Kathmandu Forestry College, Koteshwor, Kathmandu, Nepal

Ithaka Institute for Climate Farming, Tanahu, Nepal
e-mail: bishnu@kafcol.edu.np

N. Kumari Aryal
Krishiban Prabhardan Nepal, Koteshwor, Kathmandu, Nepal

H.-P. Schmidt
Ithaka Institute Ancienne Eglise 9, Arbaz, Switzerland

M. Nishi et al. (eds.), *Fostering Transformative Change for Sustainability in the Context of Socio-Ecological Production Landscapes and Seascapes (SEPLS)*,
https://doi.org/10.1007/978-981-33-6761-6_5

With the project, this percentage dropped to 22%, signals the emergence of seeds for transformative change.

Keywords Ecological transformation · Carbon sink · Forest garden · CO_2 certificate · Food security · Abandoned agricultural land · Triad group

5.1 Introduction

Nepalese people have practiced organic agriculture for hundreds of years across the country's hills. Terraced slopes and water channels were made manually. Farmers allowed trees to grow on the terrace faces and edges, in a system that has been well described in many studies (Malla 2000; Regmi and Garforth 2010; Pandit et al. 2018). The typical Nepali trees growing in farmlands were mainly fodder trees for livestock. The resulting manure and forest litter were then used as mulching material to maintain soil fertility. Farmers cultivated rice, maize, wheat, millet and vegetable crops on their farms that were commonly terraced and bounded with trees. However, these terraces have been largely abandoned over the last decade. Studies indicate that on average 37% of arable land is abandoned in Nepal (Paudel et al. 2014; Ojha et al. 2017). Increasing land abandonment in Nepal poses multiple threats related to food insecurity, loss of rural livelihoods, reduction in crop production, loss of biodiversity and soil productivity, and damages to the ecological landscape. The implications of agricultural land abandonment are not limited only to the household level, but also extend to impacts on the national economy. For example, the GDP contribution of the agricultural sector was 33% in 2011, though this figure decreased to 26% in 2018 (CBS 2018), showing agricultural land abandonment as a major problem for the people, economy, and environment (Basnet 2016; Ojha et al. 2017). As a result, 42 of the total 75 districts are reported to be food insecure (FAO 2010). This indicates that there is significant room for improvement in the contribution of tree growing on such land (Schmidt et al. 2017). Furthermore, it is important to create jobs in rural areas in Nepal in the wake of COVID-19, as migrant youths are returning and searching for new jobs.

In recent decades, terms such as social-economic transition, societal transformation, ecological transformation, green economy and sociotechnical transition have increasingly been discussed (McDowell 2012; Brand and Wissen 2017). Social-ecological transformation is an umbrella term which describes political, socioeconomic, and cultural shifts resulting from attempts to address the socioecological crisis (Brand and Wissen 2017). Social-ecological transformation is a systemic approach applied to broad-based change in social-ecological systems that catalyses rapid shifts in the mental constructs inhibiting solutions to complex problems of the socio-ecological landscape that prevent it from realising its full potential (Walker et al. 2004; Brand and Wissen 2017). There is an urgent need to change our society, particularly because of impending and potentially catastrophic climate disruption and degradation of ecological life-support systems (Butzer 2012; Pearson and

Pearson 2012). In addition, transformation requires proactively changing structures and processes when conditions make the existing social-ecological system untenable (Butzer 2012; Pearson and Pearson 2012).

The life-support systems in the landscape of this study area have been affected adversely, hindering people's ability to sustain their livelihoods and exacerbating the poverty level. A fundamental shift in human behavior is required, to live more ethically and efficiently and to radically rethink the concept of progress and economic development in our societies. We are all part of one planet; our wellbeing depends on working together for a sustainable, more equitable society. Transformational change is a formidable challenge but is necessary. In an effort to improve understanding of socio-ecological transformation, this study examines whether a project conducted in a rural area of Nepal has the potential to become the seeds of transformative change. The "**B**uilding villag**e** e**c**onomies t**h**rough clim**a**te farmi**n**g & forest **g**ard**e**ning" (BeChange) project planted trees on abandoned farmlands to improve environmental and livelihood benefits. This project could be assessed for its potential to serve as the seeds of social-ecological transformation.

5.2 Methodology

5.2.1 Study Site

The study site is located in middle hill region of Nepal (Fig. 5.1). Four municipalities, two each from Tanahun and Lamjung Districts within Gandaki Province, were selected before project intervention. From each of the four municipalities, one focus village was selected purposively for this case study. The total area of the four municipalities is 47,200 ha, and the population is 103,680 (Table 5.1). This area is connected by the Prithibi Highway, some 130 km away from Kathmandu, the capital city of Nepal. Of the four municipalities, Bhanu is situated in between the other three (Bandipur, Rainas and Madya Nepal) (Fig. 5.1). The geographic coordinates are 28° 1′ 48.0004″ N, 84° 26′ 24.0072″ E, and the altitude of the study area ranges from 418 m to 2320 m above mean sea level. The climate is of the humid subtropical type across all four municipalities. The mean temperature at the lower hills is 16 °C. The winter is cool and dry.

Rainfall data shows that the area receives more than 80% of its annual rain within the short period of 15 May to 15 September. The monsoon starts in the beginning of May and continues until September, while the remaining months remain generally dry. The average annual rainfall ranges from 2000 to 2500 mm. There is general decline in soil quality with rising elevation. The soils of the upper elevation are medium to light-textured, highly permeable, acidic and of low to medium fertility. The hill slopes tend to lose their top-soils, owing to erosion caused by their steepness and periods of intensive rainfall. The soils of the lower elevation are of better quality and fine textured.

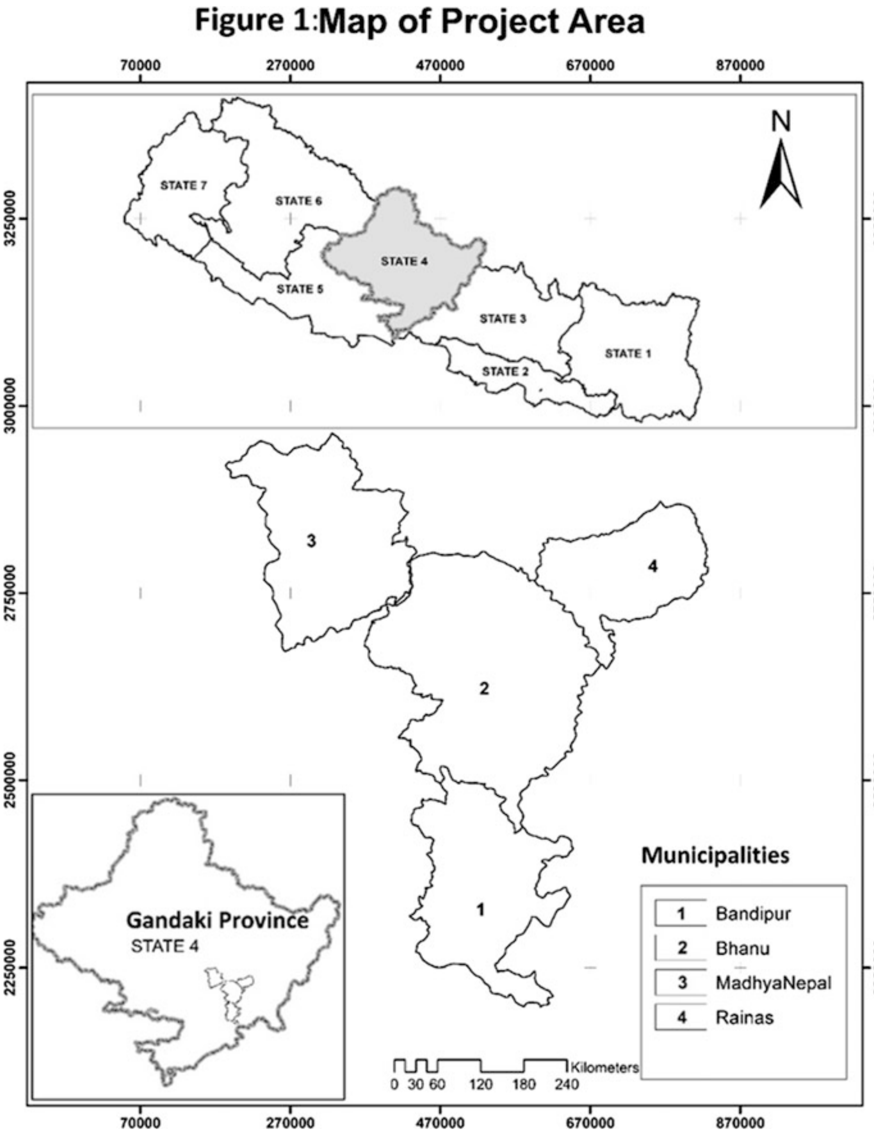

Fig. 5.1 Map of project area. The location of the study area is also shared at the google map link below. https://www.google.com/maps/d/edit?mid=10dFDhfUPe3wOIwHAuVcpZpHcjVg-ipWD&usp=sharing

The vegetation is characterised by open, mixed *Shorea* and *Schima* forests. *Shorea* (commonly known as sal trees) forest is found along the foothills and lower parts of the hill slopes. *Schima wallichii*, *Castanopsis indica*, and *Eugenia jambolana* are the typical tree species found in forests. *Emblica officinalis* and *Terminalia* species are the dominant tree-based non-timber forest product (NTFP)

Table 5.1 Basic information of the study area

Features of study area	Description
Province	Gandaki
District	Tanahun and Lamjung
Municipalities	Bandipur, Bhanu, Madya Nepal, Rainas
Size of geographical area (hectare)	47,200
Number of indirect beneficiaries	103,680
Size of the case study/project area (hectare)	42
Number of direct beneficiaries	276
Number of respondents	121
Dominant ethnicity(ies), if appropriate	Gurung, Magar and Chhetri/Brahmin
Geographic coordinates (latitude, longitude)	28° 1′ 48.00″ N; 84° 26′ 24.00″ E

species, among others such as *Bassia butyraceae*, *Myrica esculenta*, *Terminalia balerica*, *Eugenia jambolana* and *Dandrocalamaus strictus*, that are generally grown on farmland terraces. Rice is grown on the terraces of lower hills, and while maize and millet are cultivated in the uplands. These are supplemented by fields grown with vegetables and good quality upland crop terraces. Farmers have been increasingly compelled to keep their land fallow or abandoned in this area, as the current level of returns from cropping does not meet the cost of cultivation. Of the total agricultural land, farmers have kept more than half of their land fallow. This proportion is even higher in the areas where tree planting is not carried out. It is for this reason that the forest gardening project was initiated.

5.2.2 *Methods*

To assess the impact of the project, the following methods were applied throughout the project: process documentation by forming triad group, GPS mapping, household surveys, focus group discussions (FGDs) and examining the results of carbon accounting through tree planting.

5.2.2.1 Establishment of a Triad System and Carbon Crediting

The project applied a triad system in which three families formed a group. Each family in the group was responsible for planting and growing trees on their land. Families communicated and shared the recurrent tasks amongst themselves, frequently patrolling the plantations of each family, determining failure rates, and replanting together. Each member of the triad was responsible for the other two partners as well. Only when all three families could show tree survival rates of 80% or higher, were they entitled to receive the carbon premium. If, for example, one family reached 97%, another 83%, but the third only a 72% tree survival rate, then the triad as a whole failed and none of the families earned the premium. If all three partners within the triad surpassed the 80% mark, each one of them received the carbon bonus in accordance with the number of trees grown on their own terraces. Triads that did not reach the 80% mark had to pay for new seeds themselves, but after successful replanting were paid the carbon premium in the total amount of 60 NPR/tree (digging pit = 20 NPR + irrigation and management = 20 NPR + final payment = 20 NPR) for the number of trees that survived.

At least 15 tree species were planted based on farmers' preferences. These include: *Artocarpus lakoocha*, *Morus alba*, *Melia azedarach*, *Bassia butyraceae*, *Michelia champaca*, *Emblica officinalis*, *Cinnamomom tamala*, *Choerospondias axillaris*, *Terminalia bellirica* or *chebula*, *Paulownia tomentosa*, *Citrus limon*, *Leucaena leucocephala*, *Flemingia congesta*, *Pinus* spp. and *Sapindus mukorossi*. Of the total species, two-thirds (10 out of 15) were local and indigenous. Biochar-based fertilisers (1 part feedstock—*Euphatorium* biomass: 1 part urine: 4 part cow-dung mix) were applied to these plantations. The results of biochar application were highly effective.

5.2.2.2 GPS Mapping and Tree Growth Measurement

Every certified tree was accurately mapped and dated with a GPS-based smartphone application, and plot-wise mapping was also performed. In each plot, the number of trees planted was recorded and verified. At the end of the first (2015/16) and second year (2016/17), tree height and trunk diameter at 10 cm above ground were measured. After the third year, trunk diameter was measured at breast height (150 cm above the ground), the tree's general vigour and health were rated on a scale from 1 to 10, and a picture of each tree was taken. This monitoring system has served to ensure that CO_2 certificates were issued only for trees that were actually growing well. Customers who bought CO_2 certificates issued by the Ithaka Institute for Carbon Strategies could then know where "their" trees were, how well they were growing, and how the biomass carbon was eventually sequestered. The goal is that CO_2-subscribers based in Europe (Example: Eubenheimer Manufaktur UG, Email: info@eussenheimer-manufaktur.de) are able to follow the growth of the forest garden online in order to reclaim their CO_2 emissions and to know which family does the work for them, forming a virtual alliance.

5.2.2.3 Survey on Food Security in Households

In order to assess the impacts of the forest gardening project on food security and poverty alleviation, a sample of 121 household heads among a total of 276 were interviewed. These were households that had planted trees during the year 2018/19. However, the total households that planted trees as of the end of 2019 scaled out to 635. A range of 40–60% of households were sampled from the four villages (Table 5.2). This survey mainly identified the priority activities of farmers across

Table 5.2 Sampling of households

Village/ municipality	Brahmin/ Chhetri	Indigenous (Gurung, Magar and Tamang)	Dalit (shoe maker, iron smith and teller)	Total HHs	Sample HHs
1. Ratanpur, Bhanu Municipality	89	38	22	149	59 (40%)
2. Bandipur Rural Municipality	2	82	2	86	39 (45%)
3. Rainas Municipality	20	4	1	25	13 (50%)
4. Madya Nepal Municipality	13	2	1	16	10 (60%)
Total	124	126	26	276	121

each of the ethnic groups. This was helpful to investigate which households suffered food insufficiency and had fallen into a poverty trap at the end of the project intervention.

5.2.2.4 Focus Group Discussions (FGDs)

In each of the four target villages (Fig. 5.1), at least one FGD was conducted. FGDs helped in classification of households in terms of their focused activities such as (1) gender sensitisation and tree planting for increased productivity and carbon sequestration, and (2) increased sustainable income through agroforestry, ecotourism for food security and poverty reduction.

5.2.2.5 Setting Indicators for Assessing Social-Ecological Transformation

As per the project goal, four objectives and 11 key indicators were set for measuring the success of the project (Table 5.3). These indicators were assessed with different tools, mainly household surveys and FGDs, discussed above.

5.3 Results

5.3.1 Tree Planting by Triad Family Groups

One year after the initial forest gardens were planted, the results were quite variable. While some families had kept 95% of their trees alive, less than 30% trees survived

Table 5.3 Indicators for success (2015/16 to 2018/19)

Objectives	Objectively verifiable indicators
1. Increase water availability and water retention capacity	1. At least 75 households at both upstream and downstream watershed have secured drinking water source
	2. At least 25% of participating farmers have access to irrigation water in dry season
	3. Agricultural productivity increase of 25% for all participating farmers after application of biochar-based organic fertiliser
2. Improved biodiversity and ground cover change	4. At least 22 ha of abandoned agricultural land of 100 households covered by multiple tree species plantation
	5. Plantation area increased by 50% at the end of the project period
	6. Participating farmers earn additional income from sales of agricultural products from abandoned land
3. Increased productivity of cash crops income and food security for the poor	7. Income of at least 20 poor and socially excluded families (more than 50% women) in upstream and downstream areas increased by 25%
	8. Cash crops (vegetables and spices) increased by 50% for 10 water users in lower hills and 15 poor and socially excluded families
	9. Food security level of participating farmers increased by 25% at the end of the project
4. Policy and institutional transformation	10. Policy feedback available for change in the private forest rules and regulations/carbon payment at both local and national levels
	11. Incentive mechanism created for trees planted on abandoned agricultural lands at local level

for other families. The average survival rate was only 60% during the first year (Table 5.4). This year was the most challenging, and farmers with low survival rates replanted the trees on their own to compensate the carbon sequestration rates for payment. Most plantings reached success rates of 60–70%. Although this figure is more than twice the rate of other reforestation projects in Nepal, there was certainly much room for improvement.

Since the summer of 2015, a total of 42,502 trees have been planted in cooperation with 276 farming families (Table 5.4); 49 ponds have been put into place; and four villages are now housing tree nurseries. While only 60% of the planted trees survived the first year, with 60 tons of CO_2 extracted from the atmosphere, the survival rate for the second and third years reached 70.25% and 77.5%, respectively. The introduction of triads improved the success of the plantings. However, this system worked well only when the community households were located close to each other.

Table 5.4 Number of villages, beneficiary households and total trees planted and survived by year

	First two-year period				Second two-year period			
	2015/16		2016/17		2017/18		2018/19	
Village/ municipality	No. of villages	No. of HHs	No. of villages	No. of HHs	No. of villages	No. of HHs	No. of villages	No. of HHs
Ratanpur, Bhanu	1	40	2	66	8	143	2	149
Bandipur	0	0	1	20	1	75	1	86
Madya Nepal	0	0	0	0	0	0	1	25
Rainas	0	0	0	0	0	0	1	16
Total	1	40	3	86	9	218	5	276
Trees planted (survival rate)	10,442 (60%)		9838 (77.5%)		11,946 (87.6%)		10,276 (53%)	

5.3.2 *Carbon Credits*

In the carbon calculation, we used a wood density database reference from the google sheet for each of the species planted. When farmer families in Nepal plant 583 trees on a hectare of abandoned rice terraces, CO_2 removal would be 336 t over 20 years. For example, over a period of 20 years, a cinnamon tree extracts 70 kg, a *Michelia champaca* 380 kg, and a frequently coppiced *Melia* tree 557 kg (Table 5.5). A bio-diverse mix of 583 trees per hectare results in 336 t CO_2 being pulled from the atmosphere over the course of 20 years. Therefore, one tree sequesters CO_2 equivalent to 576 kg (336 t/583 trees). Besides the carbon sequestered in trees, about 80% of the biochar carbon applied to the soil is stable for a period of hundreds of years (Lehmann et al. 2015; Zimmerman and Gao 2013). The invasive species *Eupatorium odoratum*, locally called *banmara* (meaning "forest killer plant"), was used as a main feedstock for making biochar. This species is abundantly available in forests and has a high regeneration capacity. Therefore, there is no problem with the ecological integrity of use of *Eupatorium* feedstock. The application of biochar to agricultural crops has proven to be very useful for enhancing crop productivity. Examples from the project site demonstrated a fourfold increase in pumpkin yield and doubled the yield of cabbage and cauliflower inside forest gardens. On an average there has been at least a 25% increase in crop yield. Carbon sequestration potential has also been increased by 50% in trees planted with the use of biochar, which is not currently accounted for in carbon payments.

The carbon calculation here is based on seven out of 58 important tree species from the catalogue of carbon fixation by trees (Table 5.5). The rate of carbon per ton sold in Europe was 35 EUR and in the United States was 12 USD in volunteer markets. This covers the costs of seedlings, digging pits, planting, irrigation and management. On top of this, at the end of each of the 3-year periods, farmers were paid 20 NPR per survived tree as a reward. After 3–4 years, farmers were supposed

Table 5.5 Carbon fixation by trees planted in Bandipur hills for 20 years

Tree species	Stem volume (πr2*Ht*.5)/4	Wood density kg/m^3	Trunk biomass	Branch biomass (44%)	Root biomass (12%)	Leaf biomass (12.5%)	Total biomass over 20 year/tree (kg)	Total C/Tree (kg)	CO2 removal/tree (kg)	No of tree/ha	Total C t/ha
Pinus roxburgii	0.707	327	231	102	28	29	389	183	671	400	268
Michelia champaca	1.202	400	481	212	58	60	810	381	1396	278	388
Melia azedarach	1.256	560	703	309	84	88	1185	557	2042	400	817
Cinnamomum tamala	0.188	510	96	42	12	0.0	150	70	258	625	161
Emblica officinalis	0.097	680	66	29	08	08	111	52	191	625	120
Ficus benjamina	0.721	490	353	155	42	44	595	279	1026	156	160
Saraca ashoka	0.188	496	93	41	11	12	157	74	271	1600	434
									Total (avg)	583	336

to earn from the sale of tree products and other associated activities, such as selling honey and earning from homestays and ecotourism.

5.3.3 Impacts on Food Security of Households

Of the total 65 indigenous (Gharti, Gurung/Magar) and Dalit households sampled, almost all, or 54 households (83%), had food sufficiency for less than 3 months/year prior to the start of the project (Table 5.6). This figure dropped to 34 households as of the end of the project, of which 14 households shifted to 4–7 months and six households to 8–12 months food sufficiency level. If the impact on Dalit families is looked at alone, of the total 18 Dalit families that were under extreme poverty (food sufficiency for only 3 months), six households shifted to the next level (4–7 months), and two households shifted to the third level (8–12 months) (Table 5.6). These improvements are attributed mainly to goat and fodder tree support, ecotourism and homestay programmes.

5.3.4 Level of Impact as Shown by Changes in Indicators

Assessment of progress on the 11 indicators showed significant impacts except for Indicator 2 (Table 5.7). The inadequate availability of irrigation water to collect from water sources in winter is thought to be the cause for lack of progress on this indicator. An investment in technology that captures rain water in the winter is required. To address this issue, a dew collection net was set up in one of the villages, but this method also did not perform well. While every household now has safe and secure drinking water, they do not have enough water for irrigation in both the upper

Table 5.6 Outcomes achieved through implementation of priority activities by caste and ethnicity

Activity	Ethnicity	Food sufficiency in households (HHs)					
		Up to 3 months		4–7 months		8–12 months	
		Pre-project	Post-project	Pre-project	Post-project	Pre-project	Post-project
Gender sensitisation and tree planting for increased productivity and carbon sequestration	Brahmin	24	19	9	4	5	1
	Chhetri	10	7	4	2	4	1
	Sub-total	34	26	13	6	9	2
Increased sustainable income through agroforestry and ecotourism for food security and poverty reduction	Gharti	7	3	1	3	1	1
	Gurung/Magar	29	21	4	5	2	3
	Dalit	18	10	2	6	1	2
	Sub-total	54	34	7	14	4	6
Total		88	60	20	20	13	8

Table 5.7 Progress on indicators

Indicators set before project (2015)	Present level of progress on indicators (2020)
1. At least 75 households at both upstream and downstream watershed have secured drinking water	A total of 79 households have secured drinking water
2. At least 25% of participating farmers will have access to irrigation water in dry season	Only 11% of farmers have access to irrigation in dry season
3. Agricultural productivity increase of 25% due to application of biochar	Agricultural productivity increased by more than 25%
4. At least 22 ha of abandoned agricultural land of 100 households covered by multiple tree species	68 ha of land belonging to more than 200 families was converted into forest gardens and three new indigenous species regenerated
5. Plantation area increased by 50% at the end of project	Plantation area increased triple-fold
6. Participating farmers earn additional income	Increase in additional income (Table 5.5)
7. Income of at least 20 poor and socially excluded families (more than 50% women) increased by 25%	20 poor and Dalit families shifted from low food security level to high security level (Table 5.6)
8. Cash crops (vegetables and ginger) increased by 50% for 10 water users in lower hills and 15 poor and socially excluded families	All targeted (10+15) farmers have cultivated vegetable and cash crops in winter
9. Food security level of participating farmers increased by 25% at the end of the project	32% of households shifted from low food security to high food security level
10. Policy feedback available for change in the private forest rules and regulations/carbon payment at both local and national levels	Carbon payment is provisioned in the new Forest Act-2019
11. Incentive mechanism created for trees planted on abandoned agricultural lands at local level	Municipality created funds to support tree planting on abandoned agricultural land

and lower watershed of the landscape. Because of biochar application, the fertility level of soil is believed to have increased by 10%, and the impact of which has been food sufficiency level also increasing by 31%. Plant diversity level has also increased significantly. Some indigenous species such as *Schima wallichii*, *Syzygium cumini*, *Ficus religiosa*, and *Ficus bengalensis*, which were not seen before, have now started to regenerate themselves inside forest gardens. The income level of participating farmers also increased and positive policy feedback has been evident. The local government and divisional forest office are now actively involved in rehabilitation of the landscape and co-funding.

5.3.5 Stakeholders' Roles in Achieving Multiple Benefits from SEPLS

This project has identified the various stakeholders directly or indirectly involved in providing multiple benefits to the SEPLS. The most important stakeholder group encompasses local farmers including women, indigenous people and Dalit (Indicator 7), who were actively involved in planting trees on their land in small groups, called triad groups, and also benefited from the activities. The community forestry user group (CFUG) also provided assistance to its members through promotion of tree nurseries and tree planting activities (Indicator 4). A local implementation committee was formed for monitoring and evaluation of the success of the project. This committee included a representative from the local school, a member from local government (municipality), a women's group leader, a retired school teacher and the CFUG committee chair. Actors with policy knowledge and values involved the divisional forest office (DFO) staff, the agriculture knowledge centre and the municipality head. DFO and the Municipality jointly cofounded this initiative (Indicator 11). Staff from the Forest Research and Training Centre (FRTC) under the Ministry of Forests and Environment (MOFE) provided time-to-time follow up and technical support in assessment of the effects of insect pests and diseases emerging in the forest garden. All of their actions and cooperation helped the project to ensure multiple benefits for the landscapes.

5.3.6 Scaling Out and Scaling Up

To address climate related risks and biodiversity loss, and to enhance the livelihoods of people living in the landscape, this project has already involved 276 households in the planting of more than 40,000 trees on abandoned agricultural land. We observed that many other local and indigenous tree species have regenerated inside the forest gardens. This project has been scaled out in two more communities in two other districts in the province (Pokhara and Gorkha). Pame village of Ward 24 of Pokhara Municipality has initiated a programme with at least 20 farmers and one farmer-managed commercial nursery. Activities have been continued by the local communities even after the project ended, and the number of forest garden promoters has reached 635, with 65,000 seedlings planted on their farms as of 2020.

5.4 Discussion

5.4.1 Success of Tree Planting and Transformation

A good number of trees from the first plantation campaign have already grown so much that some species (*Cinnamomum tamala* and *Morus alba*) are now at the harvesting stage. The visible excitement of the farmers over witnessing the fruits of their labour and how the landscape has changed over such a short time span is a great success of this project, and also serves to motivate farmers toward new steps and trials to promulgate our findings. Over time, the outcomes and successes (Table 5.7) can be used to attract migrant youths to return. Mainly two aspects of the project have motivated the communities to continue the forest gardening activities on their land. The first is project assistance to protect drinking water sources and distribution systems. The second is payment for carbon credits. Likewise, at present homestays and ecotourism are associated with the motivation of local people to make these changes.

5.4.2 Impact of Carbon Credits

Carbon credits and carbon markets are a component of national and international attempts to mitigate the rise in concentrations of greenhouse gases in the atmosphere. A carbon credit (carbon offset) is a credit for greenhouse emissions reduced or removed from the atmosphere by an emission reduction project, which can be used by governments, industry, or private individuals to compensate for the emissions they generate elsewhere. Offsetting one metric ton of carbon means that there will be one less Mt of carbon dioxide in the atmosphere. In our case, one tree sequesters an average 28.8 kg of CO_2 eq per year (Table 5.5), which means 42,000 trees have sequestered more than 1200 tons of carbon annually. The payments received by farmers cover the cost of seedlings, pitting, and management, as well as 20% as a reward to the farmers at the end of each year. Besides these economic benefits, farmers get benefits from tree products: fruits, nuts, medicines, essential oils, silk, perfume, honey, timber and animal fodder, including other added values such as organic matter increase, biodiversity, erosion control, and water retention.

5.4.3 Opportunities for Increasing Income Through Value-Added Products

In the southern lowlands of Nepal bordering India, fertilisers, pesticides and machines are cheaper, and market access is easy. By contrast, in the poorly accessible hills of Nepal, where no fertilisers and pesticides can be purchased and most of the soil is degraded, biochar-based fertiliser can be helpful. On the steep terraces, it is not profitable to grow grain beyond that needed for personal nutrition. The villages are too far away from the marketplaces, the roads are bad, and it is nearly impossible to mechanise production. All of these impediments can be overcome if higher-value crops are planted and processed on-site. With local value addition, the durability of the goods increases, the transport volume decreases, and marketing becomes economically viable. In this manner, silk or tea from mulberry and moringa leaves can be produced and sold instead of rice; essential cinnamon oil instead of corn; nuts instead of potatoes; and dried banana or papaya chips instead of millet, providing direct income through value addition.

However, there are other income sources which have indirectly benefited participant farmers, such as cultural ecotourism and biochar fertilisation. The inclusion of a cultural tourism component in the tree planting project provided another innovative solution to diversify the income of the villagers while creating seasonal jobs for the village youth. It also offered opportunities for the villagers to learn new skills and motivated them to gain specialised education related to tourism and hospitality. The biochar fertilisation on the other hand has increased the fertility level of soil, which in turn increased the yield and biomass of both crops and trees that are being sold. The use of biochar fertiliser not only increases the crop yield, but also provides an alternative to scarce and costly chemical fertiliser that is imported from India.

5.4.4 Project Scaling Out and Up Is Possible

As a scaling up activity, this project secured co-funding from the Bhanu Municipality to pay for nursery operator at Ratanpur. Similarly co-funding from Ithaka Foundation Switzerland helped to develop a soil organic matter assessment laboratory at Ratanpur, Tanhu, and a knowledge hub centre at Satungal, Kathmandu. Over the last 2-year period (2019–2020), this project has been scaling out its activities to more than 635 households in five to six local government areas of four districts and has planted an additional 200,000 seedlings. This is a very important innovative activity to motivate farmers to proactively participate and expand the volume and quality of activities.

5.5 Lessons Learned and Conclusions

5.5.1 Lessons Learned

- The established forest gardens have created a new environmental balance by bringing back trees on degraded and barren land.
- Tree planting on abandoned agricultural land has been proven successful in reducing the concentration of atmospheric carbon dioxide, a leading cause of

global climate change, and at the same time providing economic benefits to the farmers.

- This type of project can provide a diverse array of value-added products that have high market potential.
- The use of biochar-based fertilisers for tree planting boosted the growth of both the trees and the crops cultivated between and under the trees, and could replace expensive chemical fertiliser.
- The inclusion of ecotourism as a component of the project has helped to diversify the income of the villages. The forest gardening project can be further scaled out in the context of the post-Covid-19 situation.

5.5.2 Conclusions

With the development of the forest garden system, this project has been successful in motivating a large number of farmers to undertake activities to sustain their livelihoods. Income from the sale of carbon credits is enough to establish forest gardens and to get additional income to buy food. The creation of value-added products such as essential oils, biochar, fruits, nuts and other agricultural products would be very effective to further promote tree planting on the degraded hills of Nepal. Working on value chains with renewable energy, such as post-harvest value-adding of forest products like drying and distillation, would help to increase the shelf-life and decrease the cost of transport. These value-adding processes, which include indirect drying of fruits by hot air in solar dryers that retain nutrients, make forest products lighter and of lesser volume to transport. Heat recovery devices used for essential oil production while making biochar have been very effective, which could also be promoted at a wider level. In the wake of Covid-19, many Nepali people are migrating back home and mass unemployment has already begun. This type of project could help these people to develop sustainable agroforestry practices on abandoned agricultural land and lead the path towards social-ecological transformation.

References

Basnet, J. (2016). *CSO Land reform monitoring report*. Kathmandu, Nepal: Community Self Reliance Centre.

Brand, U., & Wissen, M. (2017). Social-ecological transformation. In D. Richardson, N. Castree, M. F. Goodchild, A. Kobayashi, W. Liu, & R. A. Marston (Eds.), *International encyclopedia of geography: People, the earth, environment and technology* (pp. 1–21). Hoboken, NJ: Wiley.

Butzer, K. W. (2012). Collapse, environment, and society. *Proceedings of the National Academy of Sciences, 109*, 3632–3639.

CBS. (2018). *Agriculture statistics*. Thapathali, Kathmandu, Nepal: Department of Central Bureau of Statistics.

FAO. (2010). *Assessment of food security and nutrition situation in Nepal (An input for the preparation of NMTPF for FAO in Nepal)*. Pulchowk, Nepal: Food and Agriculture Organization of the United Nations.

Lehmann, J., Abiven, S., Kleber, M., Pan, G., Singh, B. P., Sohi, S. P., & Zimmerman, A. R. (2015). Persistence of biochar in soil. In J. Lehmann & S. D. Joseph (Eds.), *Biochar for environmental management* (pp. 235–299). London: Routledge.

Malla, Y. (2000). Farmers' tree management strategies in a changing rural economy, and factors influencing decision on tree growing in Nepal. *International Tree Crops Journal, 10*, 247–266.

McDowell, G. (2012). The role of bridging organizations in facilitating socio-ecological transformation: A case study of the Great Northern Landscape Conservation Cooperative. MSc thesis, Environment Change Instititute, University of Oxford, UK.

Ojha, H. R., Shrestha, K. K., Subedi, Y. R., Shah, R., Nuberg, I., Heyojoo, B., Cedamon, E., Rigg, J., Tamang, S., Paudel, K. P., Malla, Y., & McManus, P. (2017). Agricultural land underutilisation in the hills of Nepal: Investigating socio-environmental pathways of change. *Journal of Rural Studies, 53*, 156–172.

Pandit, B. H., Nuberg, I., Shrestha, K. K., Cedamon, E., Amatya, S. M., Dhakal, B., & Neupane, R. P. (2018). Impacts of market-oriented agroforestry on farm income and food security: insights from Kavre and Lamjung districts of Nepal. *Agroforestry Systems, 93*, 1593–1604.

Paudel, K. P., Tamang, S., & Shrestha, K. K. (2014). Transforming land and livelihood: analysis of agricultural land abandonment in the mid hills of Nepal. *Journal of Forest and Livelihood, 12* (1), 11–19.

Pearson, L. J., & Pearson, C. J. (2012). Societal collapse or transformation, and resilience. *Proceedings of the National Academy of Sciences, 109*, E2030–E2031.

Regmi, B., & Garforth, C. (2010). Trees outside forests and rural livelihoods: a study of Chitwan District, Nepal. *Agroforestry Systems, 79*, 393–407.

Schmidt, H. P., Pandit, B. H., Kammann, C., & Taylor, P. (2017). Forest gardens for closing the global carbon cycle. *The Biochar Journal, 2017*, 48–62.

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society, 9*(2), 5.

Zimmerman, A. R., & Gao, B. (2013). The stability of biochar in the environment. In N. Ladygina & F. Rineau (Eds.), *Biochar and soil biota* (pp. 1–40). Boca Raton: CRC Press.