Banana plantation in the rehabilitated area (Kuenzang Nima)

Rehabilitation of Fallow Land Through Agroforestry (Bhutan)

Shing Tho Tsug Tey Zhing Tong Leg Choe (ཤིང་ཐོག་བསྒུག་རྟེ་ཞིང་སྟོང་ལེགས་བཅོས།)

DESCRIPTION

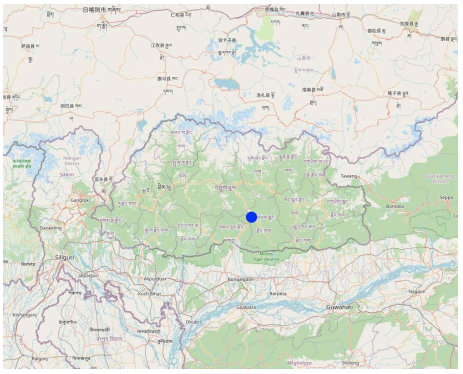
Fallow is arable land deliberately set aside due to challenges faced in cultivation. The rehabilitation of lands left fallow for decades through the adoption of agroforestry has been one success story of the Khengrig Namsum Cooperative in the central region of Bhutan. The integration of perennial trees (fruit and high-value trees) and seasonal crops creates environmental, economic, and social benefits.

Fallow land is the term for arable fields either partially or completely left unused and unproductive, owing to reasons such as labour shortages, lack of irrigation, human-wildlife conflict and/or the plots being far away from the settlements. Land rehabilitation is a promising approach towards mitigating the fallow land issue. Thus, the Khengrig Namsum Cooperative (KNC), a registered firm under the Department of Agriculture Marketing and Cooperatives, Ministry of Agriculture and Livestock (MoAL), Bhutan has ventured into rehabilitating 235 acres (94 ha) of fallow lands since 2016, through the adoption of agroforestry. The KNC was founded by Mr. Thinley Wangdi (the current chairman), with the motive of improving the livelihoods of the people of Zhemgang Dzongkhag through locally grown farm produce.

The KNC with funds from the Global Environment Facility - Small Grant Program (GEF–SGP) through the United Nations Development Program (UNDP), Bhutan, revived the fallow through agroforestry (intercropping of banana and bamboo plants). The KNC intervened in three strategic locations, benefitting 36 households. This particular agroforestry approach was not only aimed towards enhancing livelihoods but also to diversify production: through banana chips production and bamboo product development.

Upon securing the funds, implementation started with the procurement of planting and fencing materials, hands-on training, and then planting and fencing activities. Installation of electric fencing was done to reduce human-wildlife conflict. There was specific training on product development. Moreover, the KNC was able to link up with nearby schools for the school feeding programme, to supply fruits and vegetables. The cooperative demonstrates skills in processing its own products and enabling better access to renewable natural resources in the locality. On the contrary, not having proper cold storage facilities has negative impacts on processing units and has resulted in unreliable market coupling.

LOCATION



Location: Rebati Chiwog under Ngangla Gewog, Brumbi and Jiwongolia Chiwog under Trong Gewog, Zhemgang Dzongkhag, Bhutan

No. of Technology sites analysed: 2-10 sites

Geo-reference of selected sites
- -269.31295, 27.14889

Spread of the Technology: evenly spread over an area (0.95 km²)

In a permanently protected area?: No

Date of implementation: 2015

Type of introduction
- ☐ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☐ during experiments/ research
- ☑ through projects/ external interventions

CLASSIFICATION OF THE TECHNOLOGY

Main purpose
- ☑ improve production
- ☑ reduce, prevent, restore land degradation
- ☐ conserve ecosystem
- ☐ protect a watershed/ downstream areas – in combination with other Technologies
- ☑ preserve/ improve biodiversity

Land use
Land use mixed within the same land unit: Yes - Agroforestry

Cropland
- Annual cropping: cereals - maize, root/tuber crops - potatoes, vegetables - melon, pumpkin, squash or gourd, Ginger, turmeric

- ☐ reduce risk of disasters
- ☐ adapt to climate change/ extremes and its impacts
- ☐ mitigate climate change and its impacts
- ☑ create beneficial economic impact
- ☑ create beneficial social impact

- Perennial (non-woody) cropping: banana/plantain/abaca
- Tree and shrub cropping: avocado, citrus, tree nuts (brazil nuts, pistachio, walnuts, almonds, etc.)

Number of growing seasons per year: 2
Is intercropping practiced? Yes
Is crop rotation practiced? Yes

Forest/ woodlands

- (Semi-)natural forests/ woodlands: subtropical humid forest natural vegetation. Management: Selective felling, Non-wood forest use

Tree types (mixed deciduous/ evergreen): n.a.
Products and services: Timber, Other forest products

Water supply

- ☑ rainfed
- ☐ mixed rainfed-irrigated
- ☐ full irrigation

Purpose related to land degradation

- ☑ prevent land degradation
- ☑ reduce land degradation
- ☐ restore/ rehabilitate severely degraded land
- ☐ adapt to land degradation
- ☐ not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion, Wg: gully erosion/ gullying

soil erosion by wind - Et: loss of topsoil

biological degradation - Bc: reduction of vegetation cover, Bh: loss of habitats

SLM group

- agroforestry

SLM measures

agronomic measures - A1: Vegetation/ soil cover

vegetative measures - V1: Tree and shrub cover

TECHNICAL DRAWING

Technical specifications

The technical drawing shows the banana plant and bamboo intercropped.

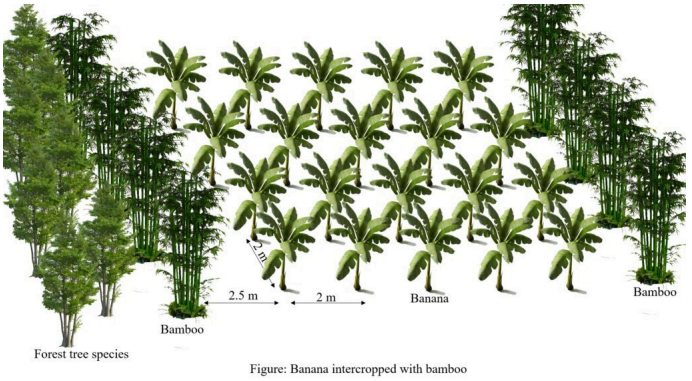


Figure: Banana intercropped with bamboo

Author: Ongpo Lepcha

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology area (size and area unit: **235 acres**)
- Currency used for cost calculation: **Ngultrum (Nu.)**
- Exchange rate (to USD): 1 USD = 80.0 Ngultrum (Nu.)
- Average wage cost of hired labour per day: Nu. 450

Most important factors affecting the costs

The most important factors affecting the costs while implementing this technology is land preparation and plantation of seedlings.

Establishment activities

1. Explored funds from UNDP through development of project proposal, led by the chairman (Timing/ frequency: 2016)
2. Forest clearing and development using tractor at Brumbi and Rebati (Timing/ frequency: December 2016 - November 2018)
3. Electric fencing (Timing/ frequency: February 2017 - May 2017)
4. Procurement of fruit seedlings (local banana and bamboo) from Bhur nursery, Sarpang Dzongkhag (Timing/ frequency: May 2017 - July 2018)
5. Hands-on-training on fruit tree plantations (KNC members and other farmers) and product development from bamboo (Timing/ frequency: May 2017 - November 2018)
6. Plantation of banana seedlings and bamboo (Timing/ frequency: June 2018)

Establishment inputs and costs (per 235 acres)

Specify input	Unit	Quantity	Costs per Unit (Ngultrum (Nu.))	Total costs per input (Ngultrum (Nu.))	% of costs borne by land users
Labour					
Labor	person days	1440.0	451.0	649440.0	100.0
Equipment					
Land preparation	Lumpsum	1.0	725432.0	725432.0	
Plant material					
Cost of seedlings (local banana and bamboo)	Lumpsum	1.0	979170.0	979170.0	
Construction material					
Electric fencing	Lumpsum	1.0	267410.0	267410.0	
Plantation of bamboo and banana	Lumpsum	1.0	231594.0	231594.0	
Other					
Project administration and participation	Lumpsum	1.0	182042.0	182042.0	
Project signboard and installation	Lumpsum	1.0	19500.0	19500.0	
Formulation of by-laws and agreements	Lumpsum	1.0	72301.0	72301.0	
Hands-on-training on plantations and product development	Lumpsum	1.0	100781.0	100781.0	
Total costs for establishment of the Technology				**3'227'670.0**	
Total costs for establishment of the Technology in USD				*40'345.88*	

Maintenance activities
1. Replacement of electric fence poles (Timing/ frequency: Every after three years (winter))
2. Replacement of solar batteries (Timing/ frequency: replaced once (1 battery))
3. Replacement of fruit plants (Timing/ frequency: Every season)

NATURAL ENVIRONMENT

Average annual rainfall
- [x] < 250 mm
- [x] 251-500 mm
- [ ] 501-750 mm
- [ ] 751-1,000 mm
- [ ] 1,001-1,500 mm
- [ ] 1,501-2,000 mm
- [ ] 2,001-3,000 mm
- [ ] 3,001-4,000 mm
- [ ] > 4,000 mm

Agro-climatic zone
- [x] humid
- [ ] sub-humid
- [ ] semi-arid
- [ ] arid

Specifications on climate
The rainfall data of 2017 was used
Name of the meteorological station: Station: Bhur, Type: Class A, Station ID: 23310046
The area falls under the warm and humid Subtropical zone among the six Agroecological zones of Bhutan.

Slope
- [ ] flat (0-2%)
- [ ] gentle (3-5%)
- [x] moderate (6-10%)
- [x] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

Landforms
- [ ] plateau/plains
- [ ] ridges
- [ ] mountain slopes
- [x] hill slopes
- [ ] footslopes
- [ ] valley floors

Altitude
- [ ] 0-100 m a.s.l.
- [ ] 101-500 m a.s.l.
- [x] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [ ] 1,501-2,000 m a.s.l.
- [ ] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

Technology is applied in
- [ ] convex situations
- [x] concave situations
- [ ] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [ ] shallow (21-50 cm)
- [x] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [ ] very deep (> 120 cm)

Soil texture (topsoil)
- [x] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- [x] coarse/ light (sandy)
- [ ] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Topsoil organic matter content
- [x] high (>3%)
- [ ] medium (1-3%)
- [ ] low (<1%)

Groundwater table
- [ ] on surface
- [ ] < 5 m
- [ ] 5-50 m
- [ ] > 50 m

Availability of surface water
- [ ] excess
- [x] good
- [ ] medium
- [ ] poor/ none

Water quality (untreated)
- [x] good drinking water
- [ ] poor drinking water (treatment required)
- [ ] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to: surface water

Is salinity a problem?
- [ ] Yes
- [x] No

Occurrence of flooding
- [ ] Yes
- [x] No

Species diversity
- [x] high
- [ ] medium
- [ ] low

Habitat diversity
- [x] high
- [ ] medium
- [ ] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] subsistence (self-supply)
- [ ] mixed (subsistence/ commercial)
- [x] commercial/ market

Off-farm income
- [x] less than 10% of all income
- [ ] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth
- [ ] very poor
- [ ] poor
- [x] average
- [ ] rich
- [ ] very rich

Level of mechanization
- [ ] manual work
- [ ] animal traction
- [x] mechanized/ motorized

Sedentary or nomadic
- [x] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

Individuals or groups
- [ ] individual/ household
- [ ] groups/ community
- [x] cooperative
- [ ] employee (company, government)

Gender
- [x] women
- [x] men

Age
- [ ] children
- [x] youth
- [x] middle-aged
- [ ] elderly

Area used per household
- [ ] < 0.5 ha
- [ ] 0.5-1 ha
- [ ] 1-2 ha
- [ ] 2-5 ha
- [ ] 5-15 ha
- [ ] 15-50 ha
- [x] 50-100 ha
- [ ] 100-500 ha
- [ ] 500-1,000 ha
- [ ] 1,000-10,000 ha
- [ ] > 10,000 ha

Scale
- [ ] small-scale
- [ ] medium-scale
- [x] large-scale

Land ownership
- [x] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [ ] individual, not titled
- [ ] individual, titled
- [x] Family land ownership

Land use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [x] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [x] communal (organized)
- [ ] leased
- [ ] individual

Access to services and infrastructure

health	poor ✓ good
education	poor ✓ good
technical assistance	poor ✓ good
employment (e.g. off-farm)	poor ✓ good
markets	poor ✓ good
energy	poor ✓ good
roads and transport	poor ✓ good
drinking water and sanitation	poor ✓ good
financial services	poor ✓ good

IMPACTS

Socio-economic impacts

Crop production

decreased ✓ increased

Crop production increased exponentially in Rebati, where crop production prevailed before the introduction of the agroforestry system. For the reverted fallow land in Brumbi and Jiwongolia, crop production increased by 100%. The abundant availability of bananas from the rehabilitated areas has greatly facilitated the cooperative employees in procuring a sufficient quantity of bananas for banana chip production. Previously, they had to embark on time-consuming journeys to various locations to source bananas, which not only proved laborious but also led to an increase in production costs.

crop quality

decreased ✓ increased

Quantity before SLM: Local varieties
Quantity after SLM: Improved varieties
The cultivation of enhanced banana varieties, including G9, Jaji, and Dosari, has resulted in a noticeable enhancement in quality

fodder production

decreased ✓ increased

Following the harvest of banana fruit, the stems and leaves are utilized as fodder for livestock

risk of production failure

increased ✓ decreased

The risk of production failure is minimized as the land users engage in agroforestry, diversifying their income sources. Their earnings do not rely solely on one crop; instead, they come from a variety of sources, including bamboo products, bananas, vegetables, and spices. Consequently, if one crop encounters difficulties or fails, the other crops can continue to generate income for the cooperative

product diversity

decreased ✓ increased

Agroforestry promotes the diverse cultivation of both forest and agricultural plants, resulting in a wide range of products. As an example, the land users are able to

produce bamboo products, spices, and banana chips due to the diversity of their cultivation practices

production area (new land under cultivation/ use)

decreased ✓ increased

The technology is implemented in the previously uncultivated land (fallow) leading to the increased production area.

land management

hindered ✓ simplified

The conversion of fallow land into cultivated land has enhanced land management and stewardship. This transformation involves the addition of manure and timely interventions, effectively reducing soil erosion and improving the overall care of the land

expenses on agricultural inputs

increased ✓ decreased

There are increased expenses on agricultural inputs. However, the increased expenses are compensated by the income generated from the farm.

farm income

decreased ✓ increased

Quantity before SLM: Nu. 23,00,000/- annual income
Quantity after SLM: Nu. 55,00,000/- annual income
The ready availability of bananas as a raw material has significantly boosted the production of banana chips and led to a substantial increase in the annual revenue of the cooperative. Furthermore, land users supplying bananas to the cooperatives have also experienced a rise in their annual income

diversity of income sources

decreased ✓ increased

The KNC has diverse value-added products and natural products such as watermelon, bamboo products, and homemade pickles diversifying their income sources.

workload

increased ✓ decreased

Reduced workload due to increased availability of raw materials for banana chip processing.

Socio-cultural impacts

food security/ self-sufficiency

reduced ✓ improved

The staff of the KNC is food secure due to increased income generated from the cooperative. Likewise, the land users supplying raw materials are also meeting the food security from the income generated by supplying raw materials to the KNC. The land users are self-sufficient in bananas, bamboo and some spices.

health situation

worsened ✓ improved

The land users shared that the improved annual income is directly related to improved health and well-being of the family/community.

cultural opportunities (eg spiritual, aesthetic, others)

reduced ✓ improved

Their venture into such activity has added value to the community, where the community has been recognized as one of the successful pilot sites for rehabilitating fallow lands. Moreover, external visitors are attracted to witness the success of the community.
Also, the community bond has been strengthened, through an approach like labour sharing practised during the implementation of the technology.

SLM/ land degradation knowledge

reduced ✓ improved

Before, the land users' knowledge about SLM technologies was confined to a few technologies. Now they have realized that SLM is a holistic approach involving different technologies. Therefore, the understanding and knowledge of agroforestry as one of the SLM measures has been enhanced.

situation of socially and economically disadvantaged groups (gender, age, status, ehtnicity etc.)

worsened ✓ improved

Disadvantaged families constrained by poor market access benefited from this technology.

Ecological impacts

vegetation cover

decreased ✓ increased

The plantation of banana plants and bamboo has covered a wide range of land, leading to better vegetation cover.

biomass/ above ground C

decreased ✓ increased

The increased vegetation cover by different fruit, bamboo, and vegetables leads to increased above-ground biomass.

beneficial species (predators, earthworms, pollinators)

decreased ✓ increased

Agroforestry harbours various plant species attracting diverse beneficial insects that feed on these plants.

habitat diversity

decreased ✓ increased

The destruction of natural habitats has been decreased due reduced dependency of land users on wild bamboo products.

landslides/ debris flows

increased ✓ decreased

The risk of surface erosion has been mitigated due to improved ground cover.

wind velocity

increased ✓ decreased

Cultivation of bamboo species reduces wind velocity reducing surface erosion.

Off-site impacts

Biological diversity conservation

Decreased ✓ Increased

Biological diversity increased due to the cultivation of different plant species which also act as a habitat for different insects and birds.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns: very negative ✓ very positive

Long-term returns: very negative ✓ very positive

Benefits compared with maintenance costs

Short-term returns: very negative ✓ very positive

Long-term returns: very negative ✓ very positive

The agroforestry with banana and bamboo plantations has been advantageous with both short-term and long-term benefits. For instance, banana gives fruiting in less than a year (9 months) after plantation.

CLIMATE CHANGE

Gradual climate change

annual temperature increase: not well at all ✓ very well

annual rainfall decrease: not well at all ✓ very well

Climate-related extremes (disasters)

local rainstorm: not well at all ✓ very well

local thunderstorm: not well at all ✓ very well

heatwave: not well at all ✓ very well

extreme winter conditions: not well at all ✓ very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- [ ] single cases/ experimental
- [ ] 1-10%
- [ ] 11-50%
- [x] > 50%

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- [x] 0-10%
- [ ] 11-50%
- [ ] 51-90%
- [ ] 91-100%

Number of households and/ or area covered

36 households and one cooperative (KNC)

Has the Technology been modified recently to adapt to changing conditions?

- [ ] Yes
- [x] No

To which changing conditions?

- [ ] climatic change/ extremes
- [ ] changing markets
- [ ] labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- Increased production area. The reversion of fallow land through agroforestry significantly increased the production area for the land users.
- Increased income. The easy access to the raw materials for KNC and easy market access for the land users leads to improved income for the KNC staff and land users supplying bananas to the cooperative.
- The technology is easy to implement as bananas and bamboo are perennial providing continuous income to the land users with little maintenance required. The land users need not be involved in agronomic practices such as land preparation and sowing every year.

Strengths: compiler's or other key resource person's view

- Restoration of cultivable land lost to forest encroachment.
- Loss of cooperative members due to better opportunities, which ultimately would affect sustainability. Provide timely incentives and adequate facilities.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Youths do not prefer to work in agriculture as it is viewed as laborious. Introduce fully mechanized and smart farming systems to attract youth.

REFERENCES

Compiler
Nima Dolma Tamang

Editors
Tashi Wangdi

Reviewer
William Critchley
Rima Mekdaschi Studer
Joana Eichenberger

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Resource persons

Dawa Zangpo - land user
Tashi Wangmo - land user
Pema Wangmo - land user
Tshering Dolkar - land user

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_6839/

Linked SLM data

n.a.

Documentation was faciliated by

Institution

- National Soil Services Centre, Department of Agriculture, Ministry of Agriculture & Livestock (NSSC) - Bhutan

Project

- Strengthening national-level institutional and professional capacities of country Parties towards enhanced UNCCD monitoring and reporting – GEF 7 EA Umbrella II (GEF 7 UNCCD Enabling Activities_Umbrella II)

Links to relevant information which is available online

- Rehabilitation of fallow land through agroforestry, UNDP, 2020: https://www.undp.org/bhutan/stories/rehabilitation-fallow-land-through-agroforestry
- Background on Fallow Land Bank, NLCS, n.d.: https://flb.nlcs.gov.bt/index.php/background-on-fallow-land-bank/
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