

Reclamation of flood-damaged areas through community-based agro-forestry: A case study from Nepal

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Abstract

More than 400,000 ha of land have been damaged by rivers in Nepal. Agro-forestry practices have been launched in those areas with the twin objectives of countering land degradation problems and meeting the demands of local people for fuelwood, fodder, and small timber. This study assessed the effectiveness of such practices in the riverside areas of the middle hills region in reclaiming the flood-damaged lands, considering vegetation establishment, land productivity and control of weed infestation (*Imperata cylindrica*, *Saccharum munja*) as the bases for evaluation. Data were gathered from the field measurements and observations. Results of two years' study showed that *Dalbergia sissoo* could be successfully intercropped with *Zea mays*, *Solanum tuberosum*, *Cajanus cajan* and *Phaseolus vulgaris* in flood-affected areas. There was no significant difference in growth performance of *Dalbergia sissoo* planted in river-affected areas and unaffected areas. Yields of various crops have also been documented. Species composition was found to have changed in silvipasture plots. The study reveals that agro-forestry practices have been effective in reclaiming the flood-damaged areas.

Key words: Agro-forestry, land reclamation, silvipasture, inter-cropping, middle hills region, Nepal.

Introduction

In Nepal, indiscriminate felling of trees and clearing forest areas for agriculture have given rise to the scarcity of the essential needs of rural people such as fuelwood, fodder and small timber. These activities, along with population pressure and improper land-use patterns, have led to serious environmental degradation. As a result, natural calamities like landslides in the hills, flooding in the foothills and the *Terai* and drought in most of the areas of the country have frequently occurred. Most of all, flooding has become a major cause of land degradation leading to the poor socio-economic conditions and the deterioration of the natural ecosystems.

More than 400,000 ha. of land have been damaged by rivers in Nepal (LRMP 1986). The Shivalik hills and middle mountainous regions are highly vulnerable to soil erosion (Dregne 1982). The extent and severity of damage have increased year after year due to the frequent changing nature of mountain rivers. Farmlands near river banks are washed away by flooding, crops are ruined and widths of river widen every year during the monsoon. Nepal's rivers carry around 336 million tons of soil per year to the main river systems entering India (Brown 1981). The bed level of *Terai* rivers is rising by 35-45 cm annually (Dent 1984). The productivity of riverside lands has been seriously affected by silting, flooding and deposition of pebbles. Furthermore, the flood-damaged areas of middle mountains of Nepal suffer from excessive grazing pressure of domestic animals. Pioneer plants, which are indicator species for degraded lands such as *Imperata cylindrica*, *Saccharum munja* and *Cassia occidentals*, have colonized such areas. The natural succession has been inhibited by excessive grazing pressure as well as flash floods during the monsoon.

Land degradation can be due to one or more causes: physical, chemical, or biological degradation of soil (Lal and Stewart, 1992; Sing et al. 1994; Sanchez et al., 1994). Physical degradation includes soil compaction and erosion whereas chemical degradation involves a significant increase in soil acidity and decline in available soil nutrients. Biological degradation involves the loss of soil microorganisms, organic matter and increase in weed encroachment. Among the many approaches to restore degraded lands, agro-forestry is often considered to be the most suitable strategy (Uhl et al. 1990; Robinson and McKean 1992; Serrao and Homma 1993). The main reasons given are that agro-forestry most closely resembles the land by retaining and recycling nutrients protecting the soil from erosion and providing sustained yields (Uhl et al., 1990). Singh et al. (1994) have stated that agro-forestry has much to offer in checking land degradation trends on one hand and in providing much needed products viz. food, fiber, fodder, fuelwood, timber, medicines etc. on the other.

A number of agro-forestry systems have been launched in the middle hills region of Nepal with the twin objectives of countering the problems of land degradation and meeting the demands of the local people for fuelwood, fodder and small timber. The present study looks at the effectiveness of such activities in reclaiming the river damaged areas of the midhills region.

Particularly, the objectives of this study were:

1. To compare the growth performance of trees between river affected and unaffected areas.
2. To analyze crop production and to identify the effectiveness of agro-forestry activities in river damaged areas.

Study Area

This study area is situated in a subtropical region on the eastern bank of the Andhikhola river in Syangja district of Middle hills region, Nepal. It is 32 kilometers south-west of Syangja bazaar, the district headquarters and lies at an altitude of about 500 m above msl. The annual average rainfall

is 1462 mm, most of which falls between May and September. Temperatures range from 14.3°C-26.2°C.

Based on the existing land type situation, the study site was categorized into three land categories, viz: land type A (LTA), land type B (LTB) and land type C (LTC). LTA includes the area affected by the river in the past with little chance of getting affected again. This area lies farthest from the river bank and is dominated by sandy soils with very low moisture content. *Imperata cylindrica*, *Saccharum munja* and *Cassia occidentalis* are the dominant plants found in the area. LTB involves the areas affected by flash floods during monsoon that remain dry for the rest of the period. This is a lower area compared to LTA and has higher soil moisture content. Soil in this area was dominated by sandy-clay, however, there were boulders and pebbles in the lower portion. *Imperata cylindrica* was the dominant ground flora which is very difficult to uproot even in the summer season. LTC included the area which was under water during monsoon. This area largely consisted of rocks stones, pebbles and sands. There was no vegetation in this zone.

The study area, which was good agricultural land before, has remained fallow for the last twenty to twenty five years. The reasons behind this were:

1. Heavy decrease in land productivity due to washing away of top soil by flooding,
2. Risk of reoccurrence of flooding,
3. Demarcation of the river-damaged land is difficult
4. Land preparation is costly because of the presence of *Imperata cylindrica*, *Saccharum munja* and other grass species and boulders and pebbles
5. Difficult to protect crops from domestic animals because of excessive grazing pressure in the area.

All the river-damaged areas on the site are owned by the people residing in nearby villages. After loosing the good agricultural land some owners, who were fully dependent on those areas, left their villages and migrated elsewhere. Some others who had 'Pakho bar' (un-irrigated upland agricultural areas where crops other than rice and wheat can be cultivated) invested their efforts and resources on it.

Methods

Vegetation establishment, land productivity and control of weeds were the three parameters taken into consideration as the bases for land reclamation. For this, growth performance of trees as well as production of agricultural crops was measured. In order to measure tree heights and diameters, direct field measurements were done, whereas data pertaining to crop yield were gathered through interviews with the concerned farmers. Crop yield data were compared with the production of undamaged cropping field nearby. There were altogether 33 households directly involved in agro-forestry activities. Therefore, an observation of all the 33 direct beneficiaries was done. The major agro-forestry systems practiced in the area are shown in table 1.

The procedure of overall intervention has been given in the box below.

Box 1
Procedure of the project intervention

- Step 1. Site selection (Technical, social, economical considerations)
- Step 2. Community Rapport Building (Interaction with VDC/ward officials, farmers who have lands in the riverside area, willingness of planting trees and crops, economic status etc)
- Step 3. Detailed baseline survey (economic, ecological and technical aspects of the site)
- Step 4. Land categorization and Designing the agro- forestry models in association with the local farmers and agro-forestry experts of the project.
- Step 5. Implementation of the project
- Step 6. Monitoring, Evaluation
- Step 7. Result analysis, Verification and Replication to other areas

Results and Discussion
Growth Performance of Trees

Growth and mortality of tree plantings of four tree species were recorded (Table 2). The growth performance of *Dalbergia sissoo* was the highest among the four. Moreover, growth performance of *Dalbergia sissoo* under different schemes (Figure 1) shows that LTA-intercropping is the most suitable scheme for seedling growth. The growth performance of tree seedlings in the 'block plantation' was slightly lower than the other two schemes. This was because of higher seedling density. The spacing of tree species in the 'multi-tree crop intercropping scheme' was 2.58 m whereas it was 1.1 m in farm forestry blocks and 2.58 m in the two-crop intercropping. Among the four species, *Tectona grandis* was found to have poorest growth performance.

Table 1: Agro-forestry Systems Practiced in the Area.

Agro-forestry practices	Local examples
1. Agri-silviculture - single crop intercropping - double crop intercropping - multi tree-crop intercrop.	<i>D. sissoo + Zea mays/Eleusine coracana/Solanum tuberosum</i> <i>D. sissoo +Cajanus cajan+Zea mays/Eleusine coracana/Phaseolus vulgaris</i> <i>D.sissoo+L.leucocephala+T.grandis+ Mangifera indica + Eleusine Coracana./Zea mays/Solanum Tuberosum/Sesamum indicum/ Fagopyrum spp./Phaseolus vulgaris</i>
2. Silvipasture	<i>D.sissoo+A.catechu+local grasses</i>
3. Farm forestry (block)	<i>D.sissoo;Acacia catechu;Tectona.grandis; Fraxinus floribunda; Cassia siamea; Alnus nepalensis; Michelia champaca (Randomized Complete Block Design)</i>

The terminologies 'single crop intercropping', 'double crop intercropping', and 'multi-tree crop intercropping' may arise some confusion. The term 'single crop intercropping' here is used to mean that a single agriculture crop species planted tree rows at a particular time. Whereas 'double crop intercropping' implies the technique in which two agriculture crop species are planted along with the rows of single tree species at the same time. Similarly, 'multi-tree crop intercropping' refers to the agricultural crops planted with the tree rows of different species. The objective of 'multi-tree crop scheme' is to get fuelwood, timber, fodder and fruits from the same patch of land without hampering the overall production.

Table 2: Average growth performances of different species in 'block plantation' after two growing seasons.

Tree species	Height (m)	dbh (cm)	Mortality (%)
<i>Acacia catechu</i>	2.73±0.50	4.10±0.9	15
<i>Tectona grandis</i>	1.97±0.43	2.27±0.5	18
<i>Alnus nepalensis</i>	2.73±0.61	2.40±0.4	19
<i>Dalbergia sissoo</i>	3.78±0.60	3.23±0.5	12

Values are mean ± SD

The mortality percent of *Dalbergia sissoo* was highest (16%) in the inter-cropping of LTB (Table 2). *Dalbergia sissoo* and *Acacia catechu* showed good performance in both the height and dbh growth in the block plantation. Moreover, there was no significant ($P=0.05$) difference in the height growth of *Dalbergia sissoo* planted in the flood-affected area and the area unaffected (Table 3).

Agricultural Crop Yield

Several agricultural crops were intercropped with *Dalbergia sissoo* at the tree spacing of 2.5x10m. They included maize, millet, potato, pigeon pea, oil seed (sesame), and bean. These crops were planted on the same plot at different seasons of the year. Maize, pigeon pea, and bean were cultivated at the same time whereas millet was planted at the time of maize cultivation. The maize production was 1.92 ton/ha which was quite good if compared to its production from the usual agricultural land which is 24.57 Qtl./ha (TU/IDRC 1995). Production of potato, millet, bean, oilseed and pigeon pea has been calculated (Table 4). However, the crop yield decreases as the canopy cover increases. Kafle (1994) also reported the shading effect of trees on rice and mustard production. The reduction of grain yield due to tree shading can be reduced by growing shade-tolerant crops under tree shade, increasing spacing between planted trees, managing the canopy especially lower branches and using any other techniques to increase the amount of light getting on to the crops (Kafle 1994).

Effect of agro-forestry practices on Weeds

The presence of *Imperata cylindrica* and *Saccharum munja* grasses have made soil preparation for agricultural practices costly. These are regarded among the ten world's worst grass species which acidify and further degrade the soil. However, these species are suitable for protecting soils from erosion and for cattle feeding. The roots of these grass species are long and form a web-like structure on the ground surface which cannot be penetrated by wooden ploughs. Use of power tiller or pesticides to prevent growth of these species, from the economic point of view, is not always possible. The growth condition of these grass species were observed in three different plantation regimes; namely, intercropping area, silviculture and block plantation of tree species.

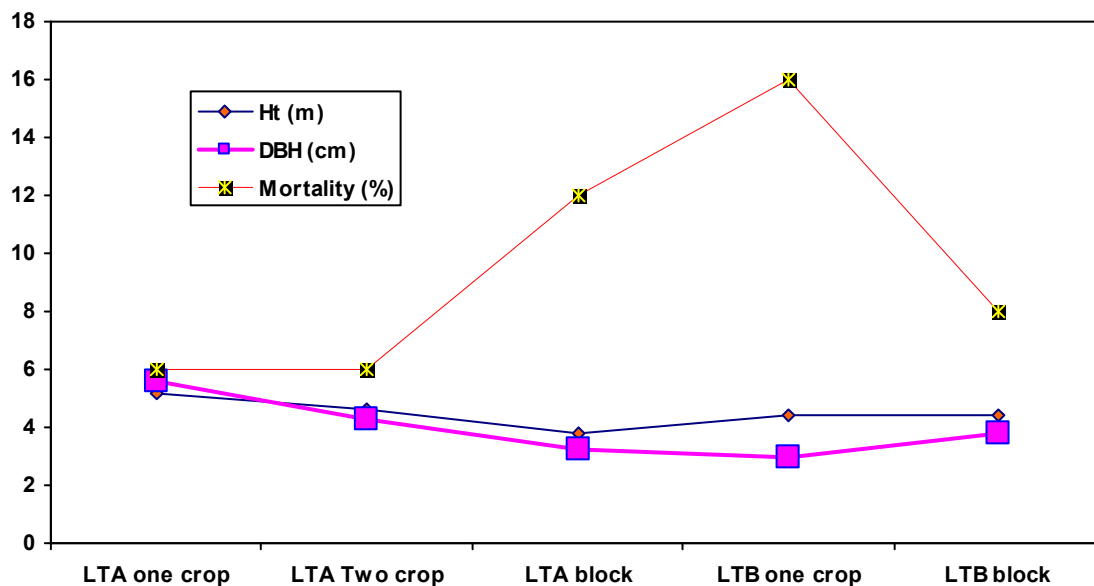

 Figure 1. Growth performance of *Dalbergia sissoo* under different agro-forestry schemes

 Table 3: Growth of *Dalbergia sissoo* under flood-affected and unaffected sites (Block plantation)

Locations	Avg.Ht.(m)	Avg.dbh (cm)	Mortality rate (%)
Present Study Area (river-affected-LTB)	4.39±0.88	3.80±0.7	8
Agriculture land (undegraded)	4.80±0.65	3.94±0.5	12

($p=0.05$)

Table 4: Yield from agricultural crops

Crops	Production (Qtl./ha/year)	Per unit price at market price (Rs/Kg)	Total income (Rs/ha)
Maize	19.2	6.00	11520
Millet	4.0	4.00	1600
Potato	20.0	5.00	10000
Pigeon pea	1.6	18.00	2880
Oilseed	0.8	30.00	2400
Bean	2.0	15.00	3000
Grand Total			31400

In the intercropping area, power tillers were used in order to prepare the land for cropping for the first time, and local wooden ploughs were used afterwards. In such areas, the *Imperata* grass was completely eradicated. In the silvipasture blocks, where *Dalbergia sissoo* and *A. catechu* were planted at a spacing of 5x5 m, the composition of grass species was noticed to have changed. New species appeared such as *Saccharum munja*, *Phaspalum sp.*, *Phragmites sp.*, and *Setaria sp.* These newly appeared species were more palatable to cattle. After protecting the area from grazing, *Cassia occidentalis* was seen to have disappeared. Whereas in block plantation areas, growth of *Imperata cylindrica* and *Saccharum spp.* was completely stunted. Most probably, the reason was due to shading. The growth of grass species was seen to have prevented during second rainy season. In this area, *Imperata* and *Saccharum* grasses were dying in all the blocks regardless of tree species planted.

Conclusions

Agro-forestry systems, especially *Dalbergia sissoo* intercropped with the local agricultural crops such as beans, finger millet, pigeon pea, maize and potato, are suitable for land reclamation. Block plantation of various MPTS is also useful in this regard. However, farmers prefer planting *Dalbergia sissoo* along with agriculture crops instead of planting trees alone. Protecting grass lands and planting *Dalbergia sissoo* and *Acacia catechu* result in a change in the vegetation composition leading to increased plant diversity.

Decrease in productivity and difficulty in land preparation are two most serious problems faced by the farmers while cultivating the flood-damaged areas. Agro-forestry practices with judicious selection of species and designs can help overcome both of these problems. However, efforts should be made towards mitigating the impact of future floods using bioengineering designs such as vegetative spurs and check dams. In addition, dense plantation of *Acacia catechu* and *Dalbergia sissoo* will be helpful in protecting the land from flash floods. Further studies regarding crop yield, diversity of grass species and appropriate tree management techniques for agro-forestry are recommended.

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