Agroforestry Model designing for the Specific Areas

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The model has been proposed for the 10 ha of land in the mountain region of Nepal. This paper is divided into 5 sections. First sections provides the setting of the model development, which highlights gives the overview of the mountain region and scope for the implementation of the agroforestry model. Section two presents the need for the agroforestry model for the farmers on the basis of his land holding and other characteristics. Section three presents the approaches followed in model formulation and its objectives.

1. Background

The mountain region compromises land between 4,877 and 8848 m above the sea level in the Himalayan range, between 1500 and 3000 m above sea level in the Mahabharat Mountain, of the total land area, 147, 481 sq. km, 35 percent are in the mountains. Approximately 7.8 percent of the population lives in this area; Areas with less steep slopes and narrow valleys are used for cultivation in the mountains. The upper limits of cultivation are 4200 m elevations. These high regions can support only the crops like buckwheat, barley or potatoes a year or once every two years. High Himalayan areas are mostly rocky with snowfields and glaciers. Agricultures activities are limited to a minimal tilling of land. Raising of sheep, goats and yaks is common. Meadowlands in the area are used for grazing livestock. Rotational grazing is characteristics of the high altitude areas.

The per capita land of people in mountain area is also decreasing day by day. People are cultivating more land, and converting forest in agriculture land to ensure their food security. Due to the sloppy terrain, and improper cultivation practices the quality and productivity of land are also decreasing very rapidly. Forest areas are also under pressure due to the heavy dependency of people on forest for fodder, fuel wood, and timber. Number of cattle holding per household is also high and people use to leave their cattle in forest for grazing. The main livelihood source in high altitude is livestock rather than cultivation of crop. Decreasing availability and gradual deterioration of quality of fodder are the major problem associated with these people. Soil erosion is the another problem in these areas. To over come with these type of problems Agroforestry is the best option.

Agroforestry as a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. Agroforestry is a land use system that involves deliberate retention, introduction or mixture of trees or other woody perennials in crops/animal production to benefit from the resultant ecological and economic intersections (Nair, 1984). Actually Agroforestry is new name for a set of old practices. The major objective of agroforestry is to optimise production and economic returns per unit area, while respecting the principle of sustainable development. The main components of agroforestry systems are trees and shrubs, pasture and livestock, together with the environmental factors of climate, soils and landforms. There are a lot of models available, designed and developed by various institutions for the high altitudes regions based on land condition, climatic condition, elevation, and soil type etc. Agroforestry models are designed on the problem based like fodder, fuel wood, timber based or grasses based, and erosion control based, rehabilitation and reclamation models. Taking the above factors into accounts the agroforestry model was developed for the farmer for his socio-economic upliftment and livelihood enhancement of the farmer of the mountain region.

2. Designing Agroforestry Model

2.1 Characteristics of Farmer

2.1.1 Location

This model has been designed for 10 ha of land in the mountain region of Nepal. This model was developed for Mr. Ram Prasad, who is one of the progressive farmer in the village but due to various problems, he was not able to secure the food security of the family due to following regions. Box 1 below summarizes the overview of the model.

	Name of Farmer	**Ram Prasad**
	Location	Lalu VDC, Kalikot District, Far Western Development region, Nepal
	Area	10 ha
	Physiographic region	Mountain
	Farming system	Subsistence
	Model Designed for	Mr. Ram Prasad and family
	Designed by	Regional Agriculture Research Center

2.1.2 Land distribution of the farmer

Table 1: Land distribution

Land types	Area (ha)	%
Agriculture fields (plain)	3	30
Upland hills (Bari)	4	40
Forest land	3	20
Total	10	100

The different type of land holding of farmer is presented in table 1 below. The household and home garden area constitutes for the 1 ha. The agriculture fields is about 2 hours walk and covers the area of 3 ha from his home in the foothills of the valley. The upland area 4 ha and his private forest (2 ha) is about one hrs walk from his house in the uphill side. Total land area for the farmers is 10 ha of land.

2.1.3 Farming system

Livestock based farming dominates in the farming system. The basic unit of farming is the individual farm, the land he cultivates the livestock it holds and others available area that may include privately owned forests, pastures and other lands. The main cropping patterns are

Maize – Potato – Wheat
Crop – fallow – barley
Potato - Fallow

He is practicing the maize- potato-wheat in the low land areas and crop fallow barley and potato- barley in the high land areas. The forest is mainly used for the fodder and fuelwood purposes. The use of farmyard manure is quite common though chemical fertilizer is available at village itself. The cattle are mostly unproductive and are kept for the religo-cultural value. The farming system is oriented towards the subsistence level and productivity is declining day by day.

2.1.4 Existing agroforestry practices

The existing agroforestry practices the farmer is following are:

- Meeting the demand of the basic food requirement from the homestead farms.
- Few trees are planted in the bond and border of the agriculture field. The species mostly includes are *Alnus nepalensis*, *Juglance regia, Prunus persica Morus serrata etc.* These species are planted for the fodder and fuel wood purposes

The analysis of the existing agroforestry systems reveals that

- There is no agroforestry system practiced over the entire villages. People are following traditional agroforestry system to bet their livelihoods.
- The species planted are of less economic importance as well as low yielding capacity.
- The soil erosion is one of the major problems in the highland areas. People are not practicing any system and methods for the control of it.
- The forest is kept for the fuelwood and fodder purposes. No other activities are carried out for the improvement of the forest as well as generating income from it.

2.2 Need for agroforestry intervention

The major problems in the higher altitude have been generated by the high populations, which have exceeded the carrying capacity of the land in most parts of the region. The improper land use system, heavy pressure on forest, improper cultivation practices is the main problems of these areas. Some specific problems which the farmers are facing is:

- Dependency on national forest area for daily use needs like fuel wood, fodder and timber
- Poor productivity of the land as well as use of traditional crops in the regions
- Diminishing wood and forest resources, which has led to an acute shortage of fuel wood and other essential wood products. (80% of fuel used for cooking is normally from wood).
- Large number of cattle population and poor productivity of the cattle
- Shortage of fodder sources for livestock limits livestock integration.
- Land degradation, both in terms of loss of fertility and aggravated erosion
- Lack of income and employment opportunities
- Fragmented land holdings

Thus, there is the lot of scope for the implementation of agroforestry in the farmer's field.

2.3 Objectives of the model

The main objective of the agroforestry model is to optimize the production and economic returns per unit area while respecting the principle of sustainable development. Specifically this model intends to

- To meet the demand of the fodder, fuelwood and timber from their own land through the practice of agro forestry models hence reduce the pressure in the forests
- Increase the productivity of the land as well as cattle for the socioeconomic upliftment.
- Ensure the food security of the family
- To reduce the environmental hazards as erosions, landslides etc. by practicing the different agro forestry models

2.4 Approaches in designing model

In order the attain the above objectives, certain agro forestry models have been evolved and standardized combining optimal land use system with tee- agriculture – livestock production system to give maximum economic returns, simultaneously or sequentially. However, manner so as to make them technologically feasible, ecologically sustainable economically viable and socially acceptable. Conforming to the cultural ethos of the people existing agro forestry models must be given due considerations

2.4.1Technical Considerations for Designing of Agro forestry Systems

- Use of nitrogen-fixing trees or shrubs
- Use of fast growing and deep rooted trees or shrubs for nutrient uptake (nutrient pump)
- Plant trees or shrubs along the contours
- Hedge-row intercropping and synchronize the timing of tree pruning / lopping
- Practice crop rotation for the intercrops
- Plant cover crop or green manure crops in fallow areas

2.4.2 Approach

The 3 D approach was followed for designing the agroforestry model. The approach includes

Diagnosis	Diagnosis of the existing agroforestry practices, problems assessment, scope for future interventions
Design	Design of the agro forestry models and its expected return
Delivery	Delivery mechanism of the suggested model and impact assessment

The agroforestry models is designed in such a way that each model is

- Technically feasible
- Ecologically sustainable
- Economically viable
- Socially acceptable

The models was designed by giving due consideration to the following factors.

- **Culture specificity**: The value of the agroforestry model perceived by villagers depends upon his cultural beliefs, values, faiths into delivery system and their past experiences with the existing practices, certain values associated are functional value, futuristic value, social value and status value.
- **Need specificity:** The needs of various groups of people differ according to their demographic and socio-economic conditions. The needs of the landowners, cattle owners and daily wage earners have different emphasis.
- **Site specificity:** Different type of the site had different requirements of the crops and models. Thus, it must be proposed according with the site specification and site conditions giving due consideration of the ecological and Site condition.
- **Technology specificity**: Make the agroforestry activities, an economically viable and environmentally sound proposition, increasing cropping intensity both in space and time dimensions and adoption of multiple cropping, are being resorted to. The

tree crop interactions, design innovation and site capacity, phenological characteristics and management interventions are given due consideration while designing model.

2.5 Suggested agroforestry model

The agroforestry model suggested is as follows. This model has been suggested on the basis of land holding of the farmers and suitability with the local conditions giving due considerations of the need and requirements of the farmers. The specific designs for each type of models and details plans and cost layout are summarized in later sections. For the control of erosions hazards and landslides, no new models has been suggested as it is assumed that practicing these models will lead to the conservation of soil and moisture as well as erosion control.

Area	Model	Species
Forest	**Silvi-horticulture**	*Alnus nepalnensis* + apple/citrus/pineapple Quercus + Pineapple
	Agri-silviculture	*Celtis australis*/*Grevia optiva* *Schima wallichii* /Anlus+ Ginger/ Termeric/cardamom *Michelia champaca*/Quercus + Ginger/ Termeric
	Pure silviculture	Schima wallichii+ Alnus nepalensis Schima + Acasia mangium / A. meansii
Low land	**Agri-silviculture**	*Celtis australis*/*Grevia optiva* *Schima wallichii* /Anlus+ Maize, Millet, Wheat *Michelia champaca*/Quercus + Millet/ maize/cabbage
Upland	**Agri-silviculture**	*Celtis australis*/*Grevia optiva* *Schima wallichii* /Anlus+ Maize, Millet, Wheat *Michelia champaca*/Quercus + Millet/ maize/cabbage
	Agri-Silvi-pasture:	*Schima wallichii* + *Setaria aphacelata* (Nandi grass) *Alnus / Michelia champaca* + Setaria/ guinea /*Thysanolaena agrostis* (Broom grass)+ Maize, Millet, Wheat *Schima wallichii* + Setaria/ guinea /*Thysanolaena agrostis* (Broom grass) + Millet/ maize/cabbage

2.8 Suitable Species for Agroforestry

Anthocephalus chinensis	*Poplar*	*Erythriana poeppigiana*
Duabanga grandiflora	*Anlus nepalsis*	*Mimosa scabrella*
Aquilaria agallocha	*Gmelina arborea*	*Sesbania sesban*
Spondias axillaris	*Spondias axillaris*	*Trema orientalis*
Cedrela serrata	*Melia composita*	*Gleditsia triacanthus*
Terminalia myriocarpa	*Quercus serrata*	*Albibizia lebbeck*

Grass Species

Pospalam notatum	*Lespedeza striata*	*Cynodon dectylon*

Axonopus affinis	*Trifolium repens*	*Pospalam dilatatum*

Some Species for Agroforestry in High Altitude with specific uses

SPECIES	USES
Alnus nepalnensis	*Timber, Fuel wood, Soil conservation*
Juglance regia	Timber, Carving, fruit
Morus serrata	Fodder, Sports article, Furniture, Toys
Populus nigra	Timber, match wood, Pulp, Fuel wood, Ornamental
Prunus persica	Fruits, Timber, Fuel
Quercus incana	Agriculture implements, Fuel, Fodder, Tussar silk
Robinia psendoacasia	Fuel wood, Fodder, Soil Conservation
Salix alba	Bats, Match, Tools, Fuel wood, Fodder

The model was designed on the basis of the parameters discussed above.

3. Forest area

The models for the forest area have been suggested on the basis of following assumptions.

- Farmers are willing to manage the forest under the agroforestry system.
- There are no marketing problems of products, the farmer produces.
- All the materials and technology are available in the village itself.

Based on the following assumptions, three models has been suggested in for the management of the forest land.

3.1 Model overview

The model for plantation is summarized in table below. The total forest area is divided into three plots where three different models are followed for the better yield as well as for enhancing the productivity of the crops.

Table 3.1: Overview of the model

	Silvi-horticulture	**Agri-silviculture**	**Pure silviculture**
Location	Forest	Forest	Forest
Year of Plantation	1995	1995	1995
Area	0.75 ha	0.75 ha	1.5 ha
Combination	*Alnus nepalnensis* + apple/citrus/pineapple Quercus + Pineapple	*Celtis australis*/*Grevia optiva* *Schima wallichii* /Anlus+ Ginger/ Termeric/cardamom *Michelia champaca*/Quercus + Ginger/ Termeric	Schima wallichii+ Alnus nepalensis Schima + Acasia mangium / A. meansii
Purpose	Income and soil conservation	Income and soil fertility maintenance	Income, erosion control, soil conservation
Rotation	5 years of tress and no rotation for agriculture crops	5 years of tress and no rotation for agriculture crops	5 years
Felling system	Selection felling for trees	Selection felling for trees	Selection felling for trees

3.2 Management techniques

The plantation techniques for each type of the models are summarized in table 3.2 below. The trees already exist in the forests so; no methods for planting trees are suggested here. The planting techniques for the crops are dealt in this section.

Table 3.2: Management techniques

Name of Plantation	Silvi-horticulture	Agri-silviculture	Pure silviculture
Site preparation	Manually and plaguing upto 10 cm suitable for cultivation of crops	Manually and plaguing upto 10 cm suitable for cultivation of crops	None
Planting materials	Seedlings		
No of seedlings/stumps	500		
Espacement	2m * 2m		
Manureing	No use of organic fertilizer Use of chemical fertilizer during plantation only	No use of organic fertilizer Use of chemical fertilizer during plantation onlu	None
Pit size	45 cu. Cm	45 cu. Cm	
Pit preparation	Mechanical means	Mechanical means	
Lay out of plots	Row	Row	
Soil working	Upto the third year of plantation, deep mechanical ploughing	Upto the third year of plantation, deep mechanical ploughing	
Watering	Rainfed	Rainfed	Rainfed
Soil and moisture conservation	None	None	None
Weeding	As required based on weed growth	As required based on weed growth	None
Silviculture operations	None	None	None
Harvesting	Annual for crops and selection system for trees	Annual for crops and selection system for trees	Selection system for trees
Protection			
Grazing	Not allowed	Not allowed	Not allowed
Insect pest/diseases	Use of chemicals as and when required	Use of chemicals as and when required	Use of chemicals as and when required
Fire	Fire control lines e.g.	Fire control lines	Fire control lines

3.3 Cost of production

The cost of production and estimated return from each type of model is summarized in table 3.3 below. Site preparation includes the for initial preparation of the crops. The figures below are estimated figure calculated on the basis of production potentiality of site and estimated return. Input cost includes the price of seeds, chemical fertilizers, pesticides and insecticides cost. Labor cost is taken as the wage labor required for the different operations and tending activities. Net return from this model will be Rs 11,400 per annum where the domestic consumption is not taken into accounts while calculating revenue part.

Table 3.3 Estimated cost and return in Rs.

	Silvi-	Agri-	Pure	Total cost

	horticulture	silviculture	silviculture	
Costs				
Site preparation cost	1500	1000		3000
Inputs cost	500	700	200	1400
Labor cost	4500	4000	1500	11000
Marketing and transportation cost	500	800	2000	3300
Other cost	400	500	800	1700
Total cost	**7400**	**7000**	**4500**	**20400**
Crops	4800	4500	0	9300
Trees	5000	6000	10000	19000
Total	9800	10500	10000	28300
Return	**2400**	**3500**	**5500**	**11400**

Note: Estimated figure

4. Upland and low land area

Different models has been suggested for the upland and low land area. The model and species compositon will remain same for all the area except the plantation techniques for the tree. In the low land area, the trees are planted in blocks where as in upland area, the trees are planted in rows or in scattered way. Few fruit trees species as apple, citrus will be planted also.

Following models are suggested for the agriculture fields.

Low land	**Agri-silviculture**	*Celtis australis*/*Grevia optiva* *Schima wallichii* /Anlus+ Maize, Millet, Wheat *Michelia champaca*/Quercus + Millet/ maize/cabbage
Upland	**Agri-silviculture**	*Celtis australis*/*Grevia optiva* *Schima wallichii* /Anlus+ Maize, Millet, Wheat *Michelia champaca*/Quercus + Millet/ maize/cabbage
	Agri-Silvi-pasture:	*Schima wallichii* + *Setaria aphacelata* (Nandi grass) *Alnus / Michelia champaca* + Setaria/ guinea /*Thysanolaena agrostis* (Broom grass)+ Maize, Millet, Wheat *Schima wallichii* + Setaria/ guinea /*Thysanolaena agrostis* (Broom grass) + + Millet/ maize/cabbage

The plantation techniques, management interventions and expected return are summarized in following sections. This models has been suggested on the basis of following assumptions.

- Farmers is willing to practice this models and is economically feasible.
- The use of the tree species will help to reduce the soil erosions as well as grass species are used as soil binding as well as fodder for animal.
- There are no marketing problems of products, the farmer produces.
- All the materials and technology are available in the village itself

4.1 Overview of model

The model for plantation is summarized in table below. The total forest area is divided into three plots where three different models are followed for the better yield as well as for enhancing the productivity of the crops.

Table 4.1: Overview of the model

	Agri-silviculture	**Agri-silviculture**	**Agri-Silvi-pasture:**
Location	Low land	Up land	Up land
Year of Plantation	1995	1995	1995
Area	3 ha (0.5 ha tree and 2.5 crop land)	3 ha (0.5 ha tree and 2.5 crop land)	
Combination	*Celtis australis*/*Grevia optiva Schima wallichii* /Anlus+ Maize, Millet, Wheat *Michelia champaca*/Quercus + Millet/ maize/cabbage	0 *Celtis australis*/*Grevia optiva Schima wallichii* /Anlus+ Maize, Millet, Wheat *Michelia champaca*/Quercus + Millet/ maize/cabbage	*Schima wallichii* + *Setaria aphacelata* (Nandi grass) *Alnus / Michelia champaca* + Setaria/ guinea /*Thysanolaena agrostis* (Broom grass)+ Maize, Millet, Wheat *Schima wallichii* + Setaria/ guinea /*Thysanolaena agrostis* (Broom grass) + + Millet/ maize/cabbage
Purpose	Income and wind break, shelter belt,	Income and soil erosion control	Income, erosion control, soil conservation
Rotation	10 years of tress and no rotation for agriculture crops	10 years of tress and no rotation for agriculture crops	10 years of tress and no rotation for agriculture crops
Felling system	Selection felling for trees	Selection felling for trees	Selection felling for trees
Mode of regeneration	Coppicing and plantation	Coppicing and plantation	Coppicing and plantation

4.2 Management techniques

Following management interventions are suggested in the agriculture filed. In both the upland and low land area, there was no irrigation facility hence the irrigation is not mentioned here.

Table 4.2: Management techniques

Name of Plantation	**Agri-silviculture**	**Agri-silviculture**	**Agri-Silvi-pasture:**

Site preparation	Manually and plaguing upto 10 cm suitable for cultivation of crops	Manually and plaguing upto 10 cm suitable for cultivation of crops None	
Planting materials	Seedlings/stumps	Seedlings/stumps	
No of seedlings/stumps	4000	2000	
Espacement	3m * 3m	1.5m * 1.5m	
Plantation model	Block	Row	
Manureing	Use of organic fertilizer during planting in pits Use of chemical fertilizer during plantation only		
Pit size	45 cu. Cm		
Pit preparation	Mechanical means		
Lay out of plots	Row	Row and scattered	Row and scattered
Soil working	Upto the third year of plantation, deep mechanical ploughing		
Watering	Rainfed		
Soil and moisture conservation	None		
Weeding	As required based on weed growth		
Silviculture operations	Thinning and pruning in 2nd and 5th year	None	None
Harvesting	Annual for crops and clear felling system for trees	Annual for crops and selection system for trees	
Protection			
Insect pest/diseases	Use of chemicals as and when required	Use of chemicals as and when required	Use of chemicals as and when required
Fire	Fire control lines e.g.	Fire control lines	Fire control lines

4.3 Cost of production

The cost of production for the different models is summarized in table below. The return form the trees includes the fuelwood and fodder species obtained from the singling and thinning operations. The cost did not take accounts of the indirect benefits obtained from the practicing of models e.g. soil and moisture conservations. Tale 4.3 presents the cost and return from the models. The total return from the agroforestry will be Rs 10,600 per year.

Table 4.3 Estimated cot and return from practicing agro forestry in agriculture fields.

	Agri-silviculture	**Agri-silviculture**	**Agri-Silvi-pasture:**	**Total cost**
Costs				
Site preparation cost	2500	2500	3000	8000
Inputs cost	1500	2500	2500	6500
Labor cost	4000	5000	5000	14000

Marketing and transportation cost	1000	1500	1500	4000
Other cost	400	400	600	1400
	9400	11900	12600	33900
Return				
Crops (including fruits)	8000	12000	9000	29000
Trees	4000	3000	4500	11500
Animals			4000	
Total	12000	15000	17500	44500
Return	2600	3100	4900	10600

5. Homestead

No models have been suggested for the homestead farming. The farmer is practicing the multistorey crop composition and it is sufficient to meet his daily food requirements as well as household requirement of fuel wood, fodder along with the soil and water conservation. Thus, no models is suggested for the home stead farming

6. Arrangement/support mechanism

The farmer will be provided with following support for the initiation of the agroforestry in the village as the model farmers.

- Market linkages will be established to sell the products more easily and at competitive prices. This will help to enhance the income of the farmer.
- Coordination with different organizations working for agriculture, forestry, livestock, soil conservation etc. will be made such that farmer can get the required services at earliest as possible and at his door steps
- Materials inputs will be provided at subsidized prices at the door steps such that it create the incentives for other farmers to start agro forestry practices.
- Free technical inputs and extension facilities will be provided to the farmer by the research organizations such that farmer can always go for the better technology an cost effectiveness.
- Credit arrangements will be made if farmer desire for it at very subsidized rate from the agricultural and rural development banks.

Bibliography

Anthony, Y. 1989, Agroforestry for Soil Conservation. CAB International, International Council for Research in Agroforestry

Buck, LE. Lassoie, JP and Fernandes, ECM, (Eds) 1999. Agroforestry in Sustainable Agricultural Systems. Lewis Publishers London

Gholz, HL ed. 1987, Agroforestry: Realities, Possibilities and Potentials. Martinus Nijhoff Publishers in Cooperation with ICRAF

Khosla, PK. Puri, S. and Khurana, DK. 1986. Agroforestry Systems A New Challenge. Indian Society of Tree Scientiest.

Lecture notes on Agro forestry

Mac Dicken, KG. and Vergara, TN. 1990. Agroforestry Classification and Management. A willey interscience publication.

Nair, PKR. 1993 An Introduction to Agroforestry. In cooperation with International Centre for Research in Agriculture

Old as the Hills, May 2001 Down to Earth

Roy, MM Pathak, PS and Singh, P. (eds) ,1994. Agroforestry Systems for Sustainable Land Use Range management society of India