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Use of multipurpose trees in hill farming systems in Western Nepal

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Abstract. A large number of multipurpose trees and shrubs are deliberately retained or incorporated on farms in the subsistence farming systems on the steep slopes in parts of Nepal. Woody perennials are maintained in contour strips across the slopes and around the fields. The contribution of these trees is the production of fodder and firewood and their protective function in reducing the erosion hazards and thereby making crop production possible in those steep slopes where profitable cropping would otherwise be extremely difficult. Based on a case study in two villages of the Western Development Region, this paper presents some data on basic farm management aspects, production of crops and other components, etc. of the system. The performance of the system is assessed and its merits and weaknesses highlighted.

Although the hill farming system extends over quite a large area and accounts for a large number of Nepal's population, it has not received any research attention nor benefitted by any scientific innovations. Improvement possibilities in terms of component technologies as well as farming systems including the incorporation of the several locally available medicinal plants are indicated.

1. Introduction

Nepal, located on the southern slopes of the Himalayas, extends from the Gangetic plain in the south, and occupies one-third of the entire length of the Himalayan range. The country has a rectangular shape, approximately 830 km long (east-west) and 200 km broad (north-south) and has a total land area of 147,141 km^2. Within this short span of distance are remarkable altitudinal variations which range from a mere 150 m a.s.l. at the southern foot hills to well over 8,000 m a.s.l. at the northern crest line. The monsoonic pattern which indicates the total precipitation of the country clearly differentiates the east Himalayan region with the heavily rained forest from its western relatively scanty rained dry forest. More than 15 million people of different ethnic origin live in this Hindu Kingdom.

Nepal is divided into five administrative units or Development Regions,

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viz., Far Western, Mid Western, Western, Central and Eastern Region. This paper is based on a survey of existing agroforestry systems of the hills of the Western Development Region. However, among the different Development Regions, there are many similarities in terms of land-use patterns and socio-economic characteristics, the site-specific variations being brought about by local factors such as aspect of slope (north- or south facing), foot hill (deep soil) vs hill-top (shallow, poor soil), altitude, etc. Therefore the system/practice described here can be taken as fairly representative for over 50% of the area of Nepal.

2. General description of the area

The Western Region extends from the Terai lowland (150 m) to the Himalayas (Annapurna, Dhaulagiri – 8172 m). The system described here are found in 500–2500 m altitude range. The climate is warm temperate with heavy monsoon rains between June and September, when 80–90 percent of the annual rainfall is received. The total quantity of rain varies widely depending on altitude and topography, ranging from 1000 to 2000 mm per annum in areas of about 1000 m altitude.

The soils, developed from a complex jumble of phyllites, shists, quartzites, granites and limestones are generally poor for agriculture. They are deeply weathered, containing only little organic matter and having a very low capacity to retain moisture and nutrients. In addition, they are prone to serious erosion hazards if not managed carefully: an annual soil loss of more than $12\,t\,ha^{-1}\,yr^{-1}$, equivalent to 0.8 mm of the top soil, has been estimated (Tinau Watershed Project – TWP Management Plan).

Climax vegetation also varies according to altitude and topography: in the lower sites (less than 1000 m) mixed, evergreen broadleaved forests of the *Shorea robusta*-type prevail; at higher elevations, broadleaved or pure coniferous forests are found with *Pinus roxburghii* as the predominant species. Figure 1 shows the relationship between altitude, ecology and land use patterns. In general, the steeper the slopes, the more the proportion of forests preserved; the higher the rainfall, the more the agricultural activity. Data on land use pattern for Palpa District of Western Region show the following figures:

irrigated (*bari*) land – 6.2%
non-irrigated (*khet*) land – 26.0%
grassland – 3.2%
forest – 37.7%
scrub and bush – 24.4%
other forms of land use – 2.5%

An eye-catching characteristic of the foothills and gentle slopes are the terraces dug with untold difficulty by the farming families. Slopes too steep for terraces show a dense network of tree strips with sloping fields in between.

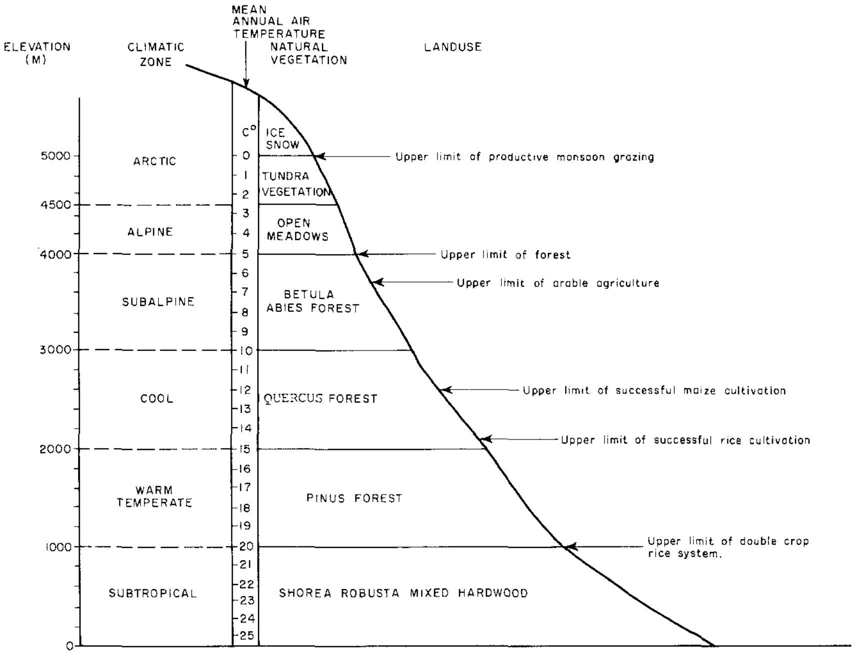

Figure 1. Interrelationships between altitude, mean annual temperature and land use limits in Western Development Region, Nepal.

Figure 2. Photograph giving a general view of the landscape of the study area.

Communal grazing land is also found on land of low productivity but close to villages. Very steep slopes, tophills and areas away from settlements are stocked with forests most of which have been highly degraded. Figure 2 gives a general view of the landscape.

Despite its relatively inhospitable conditions, the area is densely populated, with more than 100 persons per km^2 and an annual population growth rate of more than 2.5%. Ninetythree percent of the people have to make their livelihood from agriculture and related activities.

The agroforestry practices that are commonly found in the area are use of shrubs for live fences around farmlands, pasture (grazing) in forest area and use of strips of multipurpose trees and shrubs around sloping (40–70% slope) fields. This last-mentioned practice of incorporations of multipurpose trees and shrubs is the subject of further description in this paper. The data presented here are based on a case study conducted by E. Oberholzer in two representative villages in Palpa District.

3. Structure of the system

The main components of this land-use system are field crops, trees/shrubs and animals.

3.1 *Crops*

Major crops are maize (*Zea mays*), various pulses (*Phaseolus* spp., *Vigna unguiculata, Glycine max*, etc.), finger millet (*Eleusine coracana*), vegetables, rape seed (*Brassica napus*), wheat (*Triticum aestivum*), barley (*Hordeum* sp.), and buckwheat (*Polygonum* sp.). Around the houses, various vegetables and banana are grown, mainly for household consumption.

3.2 *Trees/shrubs*

Several trees and shrubs can be found on the farmlands (terraces). Most of them were not planted, but deliberately preserved/retained when the terraces were built. The species found most commonly on farmlands are listed in Table 1, of which the first ten species constitute roughly two-thirds of all such woody perennials. Evidently these are the species that are preferred by the farmers for their multiple outputs (fodder, fuel , fruits, timber, fence posts, etc.).

In addition to these trees and shrubs, public (communal/governmental) forests and grassland in the vicinity provide 30% of the fodder requirements and 70% of the firewood needs of the villagers.

Table 1. Perennial plants in contour strips on farmlands in Western Nepal in the order of their occurrence

Local name	Botanical name	Type	Main use
Kutmero	*Litsea polyantha*	tree	fodder, fuel (timber)
Dabdabe	*Garuga pinnata*	tree	fodder, fuel (timber)
Keraa (banana)	*Musa* spp.	tree	fruit, mulch
Berulo	*Ficus clavata*	shrub	fodder
Chilaune	*Schima wallichii*	tree	fodder, fuel, timber
Kanyu	*Ficus semicordata*	tree	fodder, fuel
Assuro	*Adhatoda vasica*	shrub	livefence, erosion control
Sal	*Shorea robusta*	tree	timber, fodder, fuel
Gidari	*Premna* spp.	small tree	fodder
Badahar	*Artocarpus lakoocha*	tree	fodder, fruit, fuel
Bans	*Dendrocalamus strictus*	tree	fodder, fuel, timber
	Arundinaria spp.	tree	fodder, fuel, timber
	Bambusa spp.	tree	fodder, fuel, timber
Fosro	*Grewia* spp.	tree	fodder, fuel
Thotne	*Ficus hispida*	tree	fodder, fuel
Bilaune	*Maesa chisia*	tree	fodder, fuel
Khirro	*Wrightia antidysenterica*	small tree	live fence
Mayel	*Pyrus pashia*	small tree	fuel, timber, live fence
Koiralo	*Bauhinia variegata*	tree	fodder, fuel, fruit
Aap (mango)	*Mangifera indica*	tree	fuitt, fuel
Boklimho	*Rhus javanica*	tree	fodder, fuel
Belaunti (amba)	*Psidium guajava*	tree	fruit, fuel
Arhu	*Prunus persica*	tree	fodder, fuel
Rohini	*Mallotus phillippinensis*	tree	fodder, fuel
Simal	*Salmalia malabarica*	tree	fuel, timber, spice
Kaulo	*Machilus gamblei*	tree	fodder, fuel
Dhalai	*Castanopsis indica*	tree	fodder, fuel, timber
Gaelo	*Callicarpa arborea*	tree	fodder, fuel
Kiloa	*Tinospora malabarica*	small tree	fuel
Dalchini	*Cinnamon* spp.	tree	spice, fuel
Anghero	*Pavetta indica*	small tree	fuel
Paingyo	*Prunus cerastoides*	tree	fodder, fuel, timber
Amilo	*Berchemia floribunda*	tree	fruit, fuel
Khamari	*Gmelina arborea*	small tree	fodder, fuel
Kimbu	*Morus alba*	tree	fodder, fruit, fuel
Bakaino	*Melia azedarach*	tree	fuel, fodder
Kabro	*Ficus lacor*	tree	fodder, fuel
Darim	*Punica granatum*	tree	fodder, fuel
Gajyo	*Bridelia retusa*	tree	fodder, fuel
Amaro	*Antidesma diandrum*	shrub	fuel
Jamun	*Syzigium* spp.	tree	fodder, fuel
Lankuri	*Fraxinus floribunda*	tree	fuel, timber
Ankhatarvwa	*Trichilia connaroides*	tree	fodder, fuel
Chuletro	*Brassaiopsis hainla*	tree	fodder, fuel
Naspati	*Pyrus serotina*	tree	fruit, fodder, fuel
Barahmas	*Nerium odorum*	small tree	fuel, sacrificial value
Bharlo	*Bauhinia vahlii*	tree	fodder, fuel
Khari	*Celtis australis*	tree	fodder, fuel, timber
Aaru bakhadaa	*Prunus domestica*	tree	fruit, fuel
Balayo	*Rhus succedanea*	tree	fodder, fuel
Phaledo	*Erythrina variegata*	tree	fodder, fuel
Chiuri	*Bassia butyracea*	tree	fodder, fruit
Nemaro	*Ficus roxburghii*	tree	fodder, fuel
Bohori	*Ziziphus jujuba*	tree	fodder, fruit
Kafal	*Morus indica*	small tree	fruit, fuel

3.3 *Animals*

Table 2 below indicates the average number of livestock per household:

Table 2.

	No	Uses*
Cows	1.4	manure, milk religious needs
Oxen	1.3	draught, manure
She-buffaloes	1.3	milk manure
He-buffaloes	0.1	draught, manure, meat
Goats	2.6	meat, manure
Pigs	1.6	meat
Poultry	5.8	eggs, meat

*In addition to these uses, the animals are also sold in times of cash needs

3.4 *Arrangement of components*

The cropping systems are different in the non-irrigated (*bari*) and irrigated (*khet*) lands. The cultivation on the sloping *bari* land is very labour-intensive. Maize is the most common summer crop, and it is grown as a sole crop or in mixed/relay cropping sequences. On the irrigated (*khet*) lands, one crop of rice is cultivated as a sole crop. After the harvest of rice, khet is fallow for the rest of the year. Figure 3 presents the cropping pattern and cropping intensity of the *bari* lands of the Tinau Watershed Project area.

Trees and shrubs are grown usually in strips of 1.5 to 6 m width along the boundaries of the fields, and the strips are spaced about 25–30 m apart. Thus there are about 400 running metres of tree strips of varying width per hectare, covering roughly 10% of the land area (Figure 4).

3.5 *Interactions between components*

The intimate association between the components of the system results in interactions, both positive and negative, in both space and time. The direct interactions involve those between tree strips and field crops (soil conservation, shading by trees on adjacent rows of crops), fodder trees and animals, cattle (manure) and crops, etc. One of the main competitive interactions is the use of grass for thatching vs for cattle feed. Then there are cyclic interactions involving the use of crop residues for soil protection and fertility build-up. But the most significant interaction effect between trees and crops in the system is that the whole system of farming on these hills with slopes up to 40% works only due to the existence of contour strips of trees and shrubs. These not only protect the soil from erosion, but also provide the much-needed fodder, firewood, and fence posts and other types of farm timber. The farmers are very aware and appreciative of these positive interaction effects of the woody perennial strips so that they reconcile to the negative interaction effects (shading and consequently lower yields of crops near the trees, damage to young crops by dripping of large drops of rain from the overstorey trees, etc.).

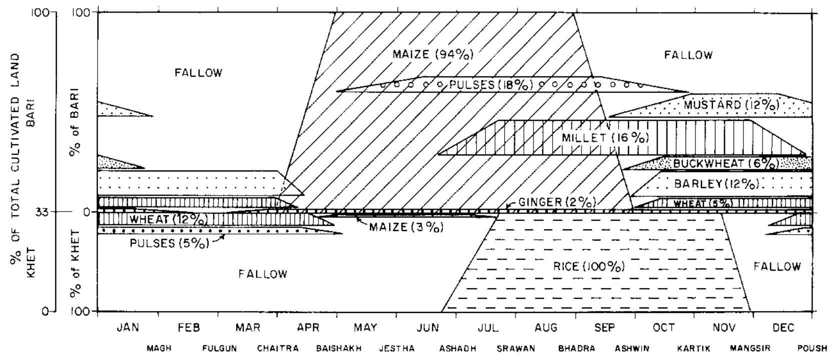

Figure 3. Cropping pattern and cropping intensity on *bari* (non-irrigated) and *khet* (irrigated) lands in Western Nepal.

Figure 4. Photograph showing the arrangement of multipurpose tree slips.

4. System functioning and dynamics

4.1 *Socio-economic aspects*

Some of the basic farm management data are given below:

- average number of members per farm household: 6.4 (2–10), of which 2.8 are below 15 years of age
- land available per household:
  private agricultural land: crops: crops 0.60 ha, grass 0.15 ha } 0.75 ha

private tree strips . . . . 0.09 ha
common grazing land . . . . 0.15 ha
forests (communal, governmental) . . . . 0.55 ha

- yearly labour input per household: 900 man days (m.d.)
  for agriculture 450 m.d.
  for animals 150 m.d.
  for water and firewood collection, food preparation etc. unknown but steadily increasing; estimated 300 m.d.
- manure produced by stall-fed animals, equivalent to 35 kg N ha^{-1} yr^{-1}, is distributed on the fields;
- no chemical fertilizers;
- no other external inputs.

Usually all farm production is for home consumption only. The market facilities are poor; the quality of the produces is also poor compared to that of the products from the terai flatlands. Therefore, there is only little sale produce in towns nearby.

Usually all able-bodied persons work on the household farm especially at times of peak labour requirement such as sowing season. Moreover, it is also a common practice for the neighbouring families to help mutually in farm operations. All work requiring hard physical labour is done by men. During winter when there are practically no agricultural operations on the farm, there is a considerable extent of unemployment, when some men look for out-of-the-farm jobs.

About 10% of the households earn money by non-farming occupations such as carpentry, tailoring, handicrafts, etc.

4.2 *Production*

4.2.1 *Agricultural crops.* The average yields of agricultural crops on the sloping bari land are:

Maize	899 kg/ha
wheat	637 kg/ha
millet	206 kg/ha
rapeseed	186 kg/ha

At an average of 6.4 members per family, these figures amount to an annual average of 90.9 kg of cereal grain production per capita. The average consumption of cereals per capita is 130 kg/year; thus there is a deficit of about 40 kg cereal grain per capita annually. This deficit is covered mainly by rice produced in the plains and foothills, which is purchased by cash obtained from the sale of animals or accrued by way of wages when the farmer works elsewhere as a paid labourer.

4.2.2 *Fodder.* Table 3 indicates the fodder supply and demand position in the two villages of the study area. The Table indicates that the total production is

Table 3. Annual production and demand of fodder in the two villages of the study area

	Village 1		Village 2	
	tons TDN*	% of total demand	tons TDN*	% of total demand
Production				
Agricultural by-products – wheat – maize – millet – other	28.8	14	13.2	7
Privately owned trees (contour strips)	85.9	41	101.6	58
Private grassland	3.0	1	4.2	2
Forests (government, communal)	49.6	23	43.6	25
Common grazing land	5.7	3	6.3	4
Total	173.0	82	168.9	96
Total Demand	211.4	100	176.7	100
Total Deficit	38.4	18	7.1	4

*TDN = Total Digestible Nutrients

Basis of calculation

BLU – Big Livestock Unit of 300–400 kg live weight
1 cattle – 0.80645 BLU
1 buffalo – 0.86666 BLU
1 goat/sheep – 0.06 BLU

For Nepal, an annual fodder demand of 2t dry matter/BLU equivalent to 1t TDN/BLU is estimated
Source: Pandey (1982).

less than the total demand. The deficit is met mainly by collecting fodder from distant areas. But it is also common that the animals are under-fed during the dry season.

4.2.3 *Firewood.* Each family farm has about 300 running metres of tree strips with 300–400 trees on them. According to the farmers interviewed, these trees provide firewood for the family for about 4 months of the year. This figure sounds reasonable if we assume a mean annual consumption of 0.7 m^3 of firewood per head, and an average extraction rate of 18.9 m^3 ha^{-1} yr^{-1}. For the rest of the year, firewood is collected from the public forests around. However, since the growth rate in the public forests is very low (about 3 m^3 ha^{-1} yr^{-1}), these public forests are subjected to rapid degradation and over-exploitation as can be seen from their depleted appearance all over the country.

4.2.4 *Other farm products.* A few poles and timber needed to build and maintain houses and for other farm uses are easily obtained from the trees on the contour strips. Some 10% of the families keep honey bees in log hives producing small amounts of honey and wax, which are used for household consumption only.

4.3 System dynamics

From the foregoing descriptions, it is evident that this is a purely subsistence system on which practically no improvement has been made over the past several decades. It is likely to break down fast because of pressures of population increase and a myriad of consequent problems – such as fragmentation of holdings, extending farming to marginal areas and forests, causing more soil erosion and greater firewood shortage, overgrazing of pastures, decline in soil fertility and crop production level and so on and so forth. In short, the weight of all these factors is destroying the very basis of the improvement in land use. Even now, many people from the hills are migrating to the terai flatlands where new land suitable for agriculture is still available. However, this possibility will run out soon.

4.4 Overall performance assessment

This low-input, integrated production system has been functioning for quite some time, though at low production levels, primarily because of the existence of the horizontal contour strips of trees. The greatest contribution of these trees is their protective function in reducing the erosion hazards and thereby making crop production possible on those steep slopes where farming would otherwise be impossible without having extremely expensive and therefore unaffordable terraces and other physical measures of soil conservation. However, it has to be emphasized that these tree strips cannot often stop the erosion completely, but would only reduce the magnitude of erosion and/or improve the efficacy of the physical soil conservation devices.

The rainfall distribution pattern is so unsatisfactory that much of the total annual rainfall, which is reasonably high in several places, is received in a short span of time from July to September. This not only aggravates soil erosion, but also diminues crop growth drastically during eight months of a year.

The hill farming system is a thoroughly neglected system. Although it extends over quite a large area and accounts for the sustenance of a large number of Nepal's population, it has not received any scientific research attention worth mentioning. As a result the system has continued without any positive change or technological innovations for the past several decades, and the poor farmers continued to become poorer and poorer as their numbers kept on increasing.

The important element of the system that can be extrapolated to other areas with similar problems is the use of multipurpose trees on such steep areas for erosion control and production of multiple outputs. Areas that are rated as unsuitable for sustainable crop production because of erosion problems will increasingly be brought under the plough to cope with increasing population pressure, and then systems like this could serve as field examples where the concept of integrated agroforestry systems have been translated into practical possibilities.

5. Improvement possibilities

Two sets of possibilities can be visualized for the improvement of this system. First, the improvement through component technologies and secondly innovations in farming systems.

5.1 *Component technologies*

A significant sign of improvement that has become evident in the recent past is that young, literate farmers – majority of the older farmers are illiterate – have begun to be interested in better inputs such as improved crop varieties, improved breed of cattle, better fruit trees and vegetables for marketing, use of fertilizers, etc., and these efforts have shown substantial improvement possibilities. Several arms of the extension machinery of His Majesty's Government of Nepal are now working in the area. These include agricultural development offices, livestock and veterinary offices, forest offices, agricultural development bank that gives credit facilities on favourable terms, and so on.

5.2 *Improved farming systems*

Elements of improved farming systems will include use of more fruit trees and incorporation of a variety of multipurpose trees in the contour tree strips. Agriculture also has a good potential in the area. Intercropping of medicinal plants with the tree species also seems to offer a viable possibility especially in areas that are very unsuitable for food crop production. The special report 'Medicinal Plants of Nepal' commissioned by the Food and Agriculture Organization (FAO) of the United Nations (Malla, 1982) gives a good account of the medicinal plants, their uses, availability and potential role in farming systems and community forestry programmes. Some of these medicinal plants have already been metioned as components of the farming system of the study area (Table 1).

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