Options for Sustainable Land Management in the Mid-hills of Nepal: Experiences of Testing and Demonstration of Contour Hedgerow Intercropping Technology

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Introduction

Nepal is divided into five major agro-ecological regions, commonly known as the Terai, Siwaliks, Middle Mountains, High Mountains, and High Himalaya. The middle mountain region (mid-hills) is the largest, occupying about 30% of the total land area, and has the highest population density per unit of cultivated land. Much of the country's land base is environmentally fragile and susceptible to erosion and degradation. Cultivation on sloping and terraced land is a common feature of Nepalese hill agriculture.

Degradation of land and mountain ecosystems has become increasingly widespread in recent decades. The traditional farming system and cultivation on steep slopes have further accelerated soil erosion and degradation. Agricultural productivity, especially in the hills and mountains, is declining due to continuing erosion of topsoil. Realising an urgent need to develop and adopt soil-conserving farming technologies for sustainable land management and agricultural productivity in the country, the Soil Science Division (SSD) of Nepal Agricultural Research Council (NARC) carried out adaptive on-farm research in the mid-hills of central Nepal for six years (1995-2001) in collaboration with the International Centre for Integrated Mountain Development (ICIMOD).

The main objective was to test the applicability of sloping agricultural land technology (SALT) as an alternative farming system option to achieve sustainable production by reducing soil erosion on the hill slopes. The specific objectives were to:

- develop prototype cost-effective SALT models to enhance the productivity of agricultural land by conserving soil and its fertility,
- evaluate the acceptability of the technology by local farmers and disseminate the acceptable management technologies among them,
- validate the effectiveness of the technology in controlling soil erosion on sloping lands, and
- identify hedgerow plant species suitable to local conditions.

This paper presents the results of this collaborative project.

Materials and Methods

Biophysical characteristics of the site

The experimental site was located at Paireni village of Chandi Bhanjyang Village Development Committee Ward No. 9 of Chitwan district in central Nepal. The site is situated on north and north-east facing steep (60-80%) hill slopes.

This research study site, at an elevation of about 350m, has a subtropical climate. The annual mean temperature is 22.3 °C, with a maximum temperature of 35.0 °C in May and a minimum temperature of 9.4 °C in January. The annual total rainfall is around 2357 mm, of which about 89% falls during May-September. This study site represents typical cultivated sloping land that is considered as marginal land for crop production.

The soils are, in general, gravelly, shallow, and well to excessively drained. The soil textures are mostly sandy loam to loamy sand, and the bulk density ranges from 1.1 to 1.4 g/cm^3 in surface soil and 1.15 to 1.22 g/cm^3 in the subsurface soil. These soils are slightly to moderately acidic (pH 5.3-6.2) and organic carbon content varies from low (1.1%) to high (3.3%). Total nitrogen percentage is very low (0.04%) to medium (0.16%). The available phosphorous content is high (72 kg ha^{-1}) to very high (215 kg ha^{-1}), and the available potassium content is low (96 kg ha^{-1}) to medium (192 kg ha^{-1}). These soils are tentatively classified as eutric cambisols and eutric leptosols.

The general cropping pattern in the area is maize as a summer crop followed either by millet, buckwheat, winter maize, or mustard as a winter crop. In the experimental site, maize and millet were the main cereal crops during the project period. Moreover, most of the cultivated land in the area is degraded forest and shrub, marginal land recently brought into cultivation after the construction of a highway. Shifting cultivation is a common practice.

Treatments

An adaptive on-farm research experiment was carried out in randomised complete block design (RCBD) with five treatments and three replications. The individual plot size was 20m x 5m, and the cropping pattern was maize followed by buckwheat. The maize variety grown was Rampur Composite, and the buckwheat was local. The treatments were as follows.

Treatment 1. Farmer's practice (traditional)
Treatment 2. Farmer's practice + hedgerows (*Dalbergia sissoo*)
Treatment 3. Farmers' practice + hedgerows (*Dalbergia sissoo*) and without fertiliser
Treatment 4. Farmer's practice + hedgerows (*Desmodium rensonii*)
Treatment 5. Farmer's practice + hedgerows *(Dalbergia sissoo*) + fruit trees (mango)

Runoff and sediment collection

To monitor runoff water, soil loss, and crop yields, each plot was separated by GI sheets and each plot was provided with two runoff water and sediment collection tanks of 1 m^3 each. The first tank that received runoff water and sediment from the plot was provided with 10 outlets, one of which was connected with the second tank, which received the runoff water and mostly suspended sediments from the first tank after it was filled up. Both tanks of each plot were calibrated before the monsoon every year both for volume at different depths and for the outlets of a first tank after overflow. The runoff water volume at a particular depth was determined for each tank according to the volume calibration, and for the second tank the runoff water volume was determined by multiplying the observed water volume with the calibration factor of the outlets of the first tank. There were no covers on the runoff water and sediment collection tanks or the trough to the runoff water. Thus the actual volume of runoff was calculated by subtracting the calculated volume of direct rainfall water from the volumes collected in the tanks.

Testing of hedgerow plant species

Eight plant species were used to establish and develop hedgerows in the farmers' fields; hedgerows 20 to 25 metres long were selected and fixed for monitoring growth and biomass yields for each species. Fresh biomass yields were recorded for each harvest for each species and the total fresh biomass yield (kg m^{-1} $year^{-1}$) calculated.

Results and Discussion

Runoff and soil loss

The amounts of runoff water and soil loss were low in all the treatments (Figures 1, 2). This was partly due to the nature and type of soils at the experimental sites which were very shallow, stony, and coarse textured. There were heavy rains and storms for a few hours during the early monsoon in 1996 that went unrecorded, but caused erosion of most of the surface soil at the research site. This unprecedented event of heavy rain left behind mostly gravel and stones on the land surface. Thus there was not much soil left in the plots for further erosion during the monsoon in the following years so that soil loss for all the treatment conditions was very low. The mean runoff water volume for 5 years (1996–2000) was highest (218 m^3 ha^{-1}) for treatment 5 and lowest (146 m^3 ha^{-1}) for treatment 3. Similarly, the average amount of soil loss over 5 years (1996-2000) was most (669 kg ha^{-1}) for treatment 1 (farmer's practice/traditional) and least (203 kg ha^{-1}) for treatment 2. Soil loss was reduced by almost 70% under treatment 2 as compared to treatment 1, and by approximately 50% under treatments 5, 4, and 3. Thus all hedgerow treatments were promising options to reduce soil loss, with treatment 2 the best.

Crop yields

Maize

The yields of maize in all treatments were much less in 1997 and 1998 than in 1996, 1999, and 2000. This was probably due to the washing away of surface soil in 1996 after which the subsurface soil had to be cultivated. It took some time for fertility to be built up. The 5-year average yield of maize was highest (3.1 t ha^{-1}) in treatment 5 and lowest (2.1 t ha^{-1}) in treatment 4, which had a similar yield to treatment 1 (farmer's traditional practice) (Figure 3). The crop yields obtained showed some effect of treatment.

Buckwheat

The buckwheat yield was higher in 1996 than 1997 to 2000, probably due to prolonged dry winter weather in the later years. The erosion of surface soil in mid-1996 might also have made less soil available for cultivation of the winter crop. The highest 5-year average buckwheat yield (0.6 t ha^{-1}) was obtained in treatment 3 followed by treatment 2 (0.5 t ha^{-1}), and the lowest (0.4 t ha^{-1}) in treatment 1. The data obtained indicate some effect of treatment.

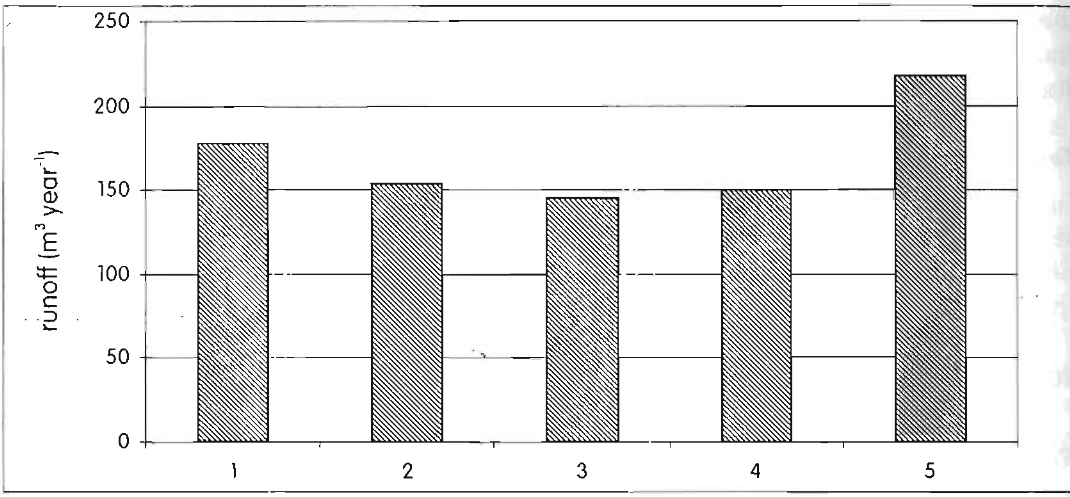

Figure 1: Volume of runoff (five-year average)

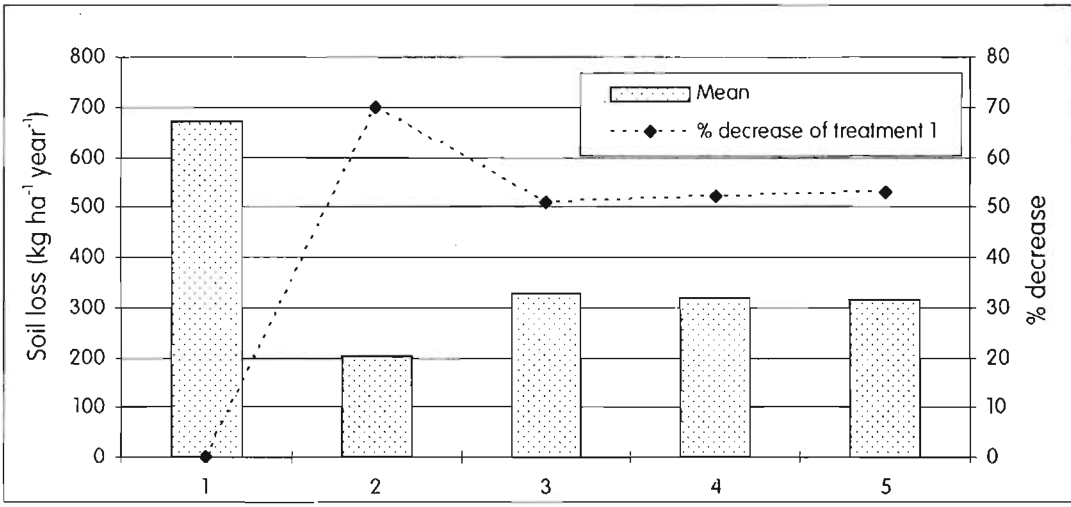

Figure 2: Soil loss (five-year average)

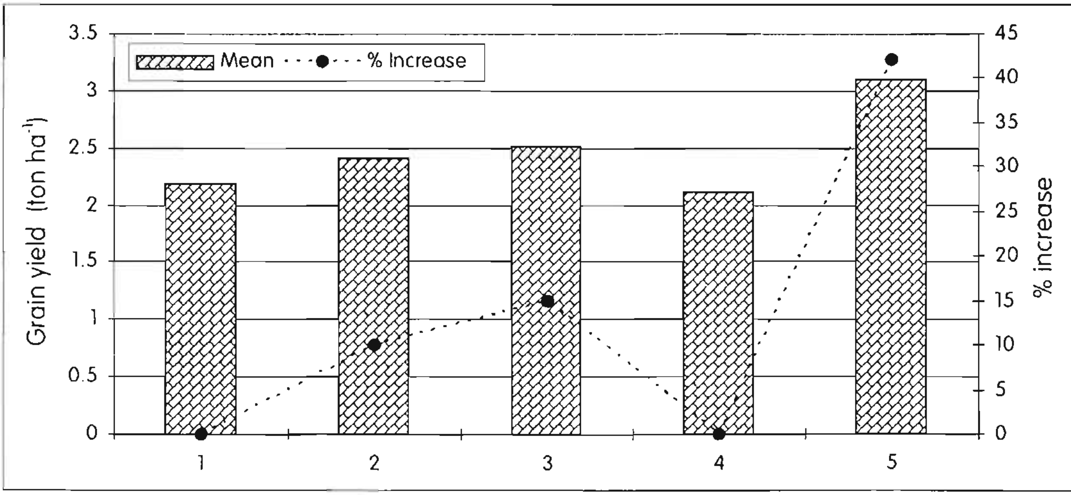

Figure 3: Corn grain yield (five-year average)

Selection of hedgerow plant species

Eight leguminous and non-leguminous perennial hedgerow plant species were tested (Table 1). The maximum fresh biomass yield (4.98 kg m^{-1}) was obtained from *Desmodium rensonii* and the lowest (0.5 kg m^{-1}) from *Albizzia lebbek*. *Flemingia macrophylla* gave the second highest biomass yield (1.0 kg m^{-1}). The vegetative growth was good in the case of *Desmodium rensonii*, *Leucaena leucocephala*, *Tephrosia candida*, and *Dalbergia sissoo*, and moderate in the other species. However, *Desmodium rensonii* and *Tephrosia candida* died after four years and had to be replaced by other suitable species. Similarly, *Flemingia macrophylla* was heavily attacked by insects from the beginning and it was difficult to save it and have a good plant stand. Considering all these results, the following plant species may be recommended for hedgerow development under the conditions at the test site: (1) *Leucaena leucocephala*, (2) *Dalbergia sissoo*, (3) *Indiofera sp*, (4) *Bauhinia purpurea*, (5) *Albizzia lebbek*, and (6) *Flemingia macrophylla*.

Table 1: Hedgerow biomass yields (kg m^{-1} $year^{-1}$)

Species	Year					
	1997	1998	1999	2000	Mean	Remarks
Dalbergia sissoo	0.32	0.41	0.69	1.52	0.73	Good growth
Bauhinia purpurea	0.33	0.41	0.31	0.92	0.49	Mod. Growth
Albizzia lebbek	0.28	0.23	0.31	1.07	0.47	Mod. Growth
Tephrosia candida	1.20	0.68	0.47	-	0.78	Good growth
Leucaena leucocephala	0.87	0.25	0.85	1.95	0.98	Good growth
Indigofera sp. (local)	0.49	0.28	0.47	0.72	0.49	Mod. Growth
Flemingia macrophylla	-	0.73	0.52	2.28	1.04	Mod. Growth
Desmodium rensonii	7.78	6.68	0.49	-	4.98	Good growth

Future Implications

The research activities have increased the awareness of the problem of soil erosion and land degradation and of the SALT farming system among farming communities and extension workers. The research site has become an important demonstration site for their visits, and is an important visual aid to help people understand the phenomena of soil erosion and land degradation and see an example of how to overcome or lessen the problems.

Many visitors have come to the project site to see and understand the various activities and SALT models under testing. They have included farmers, university students, extension workers, and research scientists from different districts under different programmes of government, NGOs, INGOs, and research organisations including NARC.

Many farmers have now started adopting SALT farming, not only in and around the research site but also in other areas and districts. Local farmers, extension workers, NGOs, and INGOs are requesting regular training programmes on the technologies in order to disseminate the knowledge more effectively and to encourage people to adopt the SALT farming system. These are certainly positive impacts of the research project. There are, however, some practical issues in initiating adoption of the technologies that must be considered while formulating any programme for developing and adopting the technologies for the future. These issues are as follow.

- Open grazing is generally practised during the winter season, and it is difficult to protect hedgerows from cattle since most of the farmlands are left fallow for 4-5 months.
- The winter season is generally almost without rain, and it is very difficult to keep the hedgerows alive during such a prolonged dry period, especially during the initial years of hedgerow establishment, since most of the farmlands in the area are under rain-fed cultivation.
- Large amounts of planting materials are required and should be made available in sufficient quantity to the farmers well in time.
- Farmers and even extension workers may need training on the technologies to ensure their wide and extensive adoption.
- Government departments and NGOs concerned with the dissemination and extension of the technologies should include this in their annual programmes and provide incentives to the farmers in adopting the new technologies.

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