Managing Agricultural Terrace Systems for Maintaining the Health and Productivity of Highland Agro-ecosystems

Ek Raj Ojha*

GEMS Institute of Higher Education (GIHE), Kathmandu, Nepal

Corresponding Author

Ek Raj Ojha
e-mail: drekrajojha@gmail.com

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Abstract

Agro-ecosystems are most integrated with the existence of humankind, as they provide the latter with basic necessities such as food, energy, clothing and shelter. In many parts of the world, agricultural terrace systems form a considerable portion of the overall agro-ecosystem and prevail from historical times in areas predominated by a steep terrain, and offer sustenance to a large proportion of the population living in, around and even away from them. They are an efficient adoption of steep lands to render crop production possible, expand cropland, check soil erosion, conserve soil moisture and nutrients, improve groundwater storage, ease farm operations, increase crop yields and beautify the landscape. However, their productivity and sustainability depend on many other components of the overall human-dominated ecosystem. Just as the health of the ecosystem determines the prosperity of its inhabitants the inhabitants possess the capacity to maintain the ecosystem in a proper state only when they are reasonably prosperous. Functioning of a regeneration cycle in the ecosystem is thus highly essential. This paper attempts to address these issues in the universal context, but with a focus on the case of Nepal, in general, and an especially studied location in its far-western region, in particular.

Keywords: Aquaculture, innovations, microfinance, poverty reduction, bio-diversity

1. Introduction

Man is dependent on land and soil not only for his basic necessities such as food, clothing, shelter and medicine but also for recreation and relaxation. As the world population has already reached 6 billion and is persistently growing, the demand for all necessities will naturally grow accordingly (Ojha, 1999). However, land is finite in quantity and its agriculturally suitable proportion is quite small and almost all of which has already been brought to use. In the last 150 years alone cropland area grew by as much as 180%. Owing to the growth in population the per capita availability of arable land reduced to 0.26 ha in 1993 from 0.31 ha in 1983 (IIED and WRI, 1987; WRI, UNEP, UNDP, and WB, 1996, 1998; Ojha, 1999).

In the similar vein, about 56% of the world's poorest people live in such tropical areas nearly half of which are steep and out of that about 16% is excessively steep (Lal, 1988; Sachs, 1999). It is also particularly in these areas that agricultural productivity is declining and thus food scarcity is growing, resulting primarily from soil erosion caused by the nature as well as man (Hurni, 1983; Afroz, 1993; Ojha, 1997a; Ojha, 1999).

2. Materials and Methods

Although numerous reference materials contributed greatly to the completion of this study, most evidences have come from the author's own field investigation made of the sampled areas in far-western Nepal hills in 1994 (Ojha, 1995). The areas surveyed fall within the altitude range of approximately 500 m to 2,500 m above the mean sea level and experience temperatures varying from 14 °C to 23 °C. In regard to climate, high hills are temperate, middle hills sub-temperate, and low hills subtropical.

The investigation comprised the following procedures. To gather data, 195 household heads sampled from the total of 5,000 in the area were interviewed using standardised questionnaires and the data were processed and analysed using the SPSSX/PC programme. Opinions, ideas, and knowledge of local farmers, craftsmen, technical workers, leaders and planners obtained though guided interviews and informal discussions had given valuable insights. Photographs, diary notes, topical observation schedules were supplemental sources of data and information on various facets of the terrace-dominated ecosystem.

3. Agricultural Terracing

An agricultural terrace is an embankment of earth or stone built across the slope (Kohnke and Bertrand, 1959). Agricultural terracing expands cropland and effectively checks soil erosion (Gregor, 1963; FAO, 1977a; Whitley, 1980; Kelley, 1983; Carson, 1992; Ojha, 1997b; Mishra and Bista, 1998). The Food and Agriculture Organization of the United Nations (FAO) has shown, through both field and experimental data, that terracing controls runoff and soil erosion, improves soil moisture conservation and groundwater storage, and increases crop yields (FAO, 1977b). Naturally, terraces have special significance in mountainous regions and countries as they comprise a technique of most efficiently utilizing the sloping areas for cultivation purposes and also because in such areas they have moulded many facets of the dwellers' lifestyle (Ojha, 1997b; Ojha, 2014).

3.1. Quantitative evidences of benefits from agricultural terracing

In general, better prospects for farming and greater scope to control land degradation are factors leading to the continuation of agricultural terracing even today (Manshard, 1968; Kelley, 1983; Hurni, 1988, Thomas, 1988; Williams and Walter, 1988; Ojha, 1997b; Ojha, 2014). Results of field experiments conducted in Ethiopia, India, Indonesia, Jamaica, and Venezuela have shown that terracing can increase crop yields substantially. By conserving the top soil and its nutrients and moisture, and by gradually building up soil fertility, terracing has often doubled the farm production unit^{-1} area of land (Gregor, 1963; Mosher, 1966; Geertz, 1968; Sheng, 1977; Kelley, 1983; Cochrane and Huszar, 1988; Wenner, 1988; Williams and Walter, 1988; Ojha, 1995).

An experiment on the dry-land terrace system in the Citanduy watershed of West Java, Indonesia, indicated the practice of bench terracing, along with a suitable crop combination, causing annual soil erosion only to the extent of 1.5 t ha^{-1} as against 12.6 t ha^{-1} under farmers' conventional techniques. Similarly, the annual runoff under the experimental condition was 21,646 cubic m ha^{-1} while it was as much as 42,634 cubic m ha^{-1} under the conventional situation (Fagi and Mackie, 1988). In a Nepalese highland area, while the extent of annual soil loss from a degraded range-land ranged from 10 to 100 t ha^{-1}, it was only 5−10 t ha^{-1} from well-maintained terraces under maize crop and 5−15 t ha^{-1} from those under rice crop (Mishra and Bista, 1998).

3.2. Additional benefits of agricultural terracing

Agricultural terracing offers the following additional benefits (Spencer and Hale, 1961; Manshard, 1968; Sheng, 1977; FAO, 1988;Ojha, 2014;):

- Reducing pollution and sedimentation of dams, rivers and lakes, and the level of damage by flood and forest fire.

- Creating job opportunities and absorbing farmers' household labour during slack seasons.

- Contributing to revenue collection by attracting visitors.

- Relieving people from food shortage, also through such programs as 'food for work'.

- Increasing farmers' awareness, knowledge and skill about soil conservation, land management, and improved farming techniques.

-Helping to create clean and beautiful surroundings.

The nature and magnitude of benefits from terracing can be clearly comprehended also from the quantitative measure of responses obtained from farmers in far-western Nepal (Table 1). In essence, agricultural terraces form an ecosystem that possesses extraordinary stability and remains continually productive with a virtually undiminished yield (Geertz, 1968).

4. Problems in Managing Agricultural Terrace Systems

Although agricultural terrace systems bear great importance in many ways, they are in many cases trapped in vicious cycles of backwardness and degradation due to various reasons (Kelley, 1983; Messerli, 1983: Khadka, 1985; Blaikie and Brookfield, 1987; IIED and WRI, 1987; Gurung, 1989; Carson, 1992). Therefore, agricultural terraces, which have been ubiquitous and extensive in distribution and use from historical times, urgently deserve special attention and care so that their degradation is prevented, productivity and sustainability restored, and overall quality and beauty enriched (Lal, 1988; Ojha, 1997a; Ojha, 2014).

Particularly in upper hill areas there has mostly been a trend of declining productivity for both dry and wet terraces (Table 2). In many cases, irrigation is inadequate and drainage condition poor (Table 3). Forest depletion has been the nexus of many problems concerning agricultural terrace system management (Carson, 1992; Davidson, 1995; Ojha, 1999). The continual exploitation of such natural resources for use by people and livestock has exceeded the regenerative capacity. Although the level of farmers' awareness of and intent to adopt ecosystem-friendly practices is often quite high, people's actions to replenish the resources have so far been either lacking or inadequate (Davidson, 1995; Ojha, 1997b).

The reckless cutting and grazing of vegetation and faulty methods in the preparation and application of farmyard manure (FYM) are common examples (Table 3). The various reasons behind such several unscientific, weak and wasteful local resource management practices include negligence, low sense of responsibility, poor capacity to unify and integrate individual creative ideas and visions, and the failure to develop and maintain mutual understanding and co-operation within and among communities.

While the resultant depletion in ground water storage and

Table 1: Role of Agricultural Terracing in Maintaining Highland Ecosystems, (Values in indexes)

Role	High hills (f=31)	Middle hills (f=30)	Low hills (f=65)	A N O V A		
				F	d.f	sig.
facilitates drainage	1	0.97	1			
Economic	1	0.97	1	1.3675	2	0.2573
Terracing						
expands crop land	1	0.96	0.98			
improves cultivation surface	0.97	0.93	0.96			
renders farm operations easier	1	0.98	1			
stimulates improved farming	1	0.98	1			
utilizes household labour						
during slack seasons	1	0.92	1			
increases crop yield	1	1	1			
Environmental	0.97	0.93	0.99	4.3505	2	0.0143
Terracing						
prevents forest fire	0.9	0.87	0.97			
beautified landscape	1	1	1			
creates better environment	1	0.91	1			
Overall [3] (14)	0.98	0.96	0.99	5.7863	2	0.0037

f : No. of respondents in the sub-sample; ANOVA–Analysis of variance; F: F value; d.f. : Degree of freedom; sig.: level of significance; Weights used to obtain the index; Agree:1, disagree: 0.0.; Source: Ojha, E.R., 1999, Dynamics and Development of Highland Ecosystems, p.202 (Table 74)

Table 2: Level and Trend of Terrace Productivity, (Level and trend values in score)

Terrace location	Terrace condition	fof (N=195)	Productivity level	Productivity trend
High hills	Dry	63	0.26	0.1
	Wet	24	0.33	-0.25
Middle hills	Dry	70	0.33	- 0.28
	Wet	25	0.37	0.04
Low hills	Dry	81	0.46	0.53
	Wet	85	0.58	0.72

NB: N - Sample size; f: Frequency of responses in the sample; Weights used to obtain the scores for: Productivity level: High: 1.0; Moderate: 0.55; Low: 0.10; Productivity trend: Improving = 3.0, deteriorating = -1.0, and no change = 1.0; Source: Ojha, E.R., 1999, Dynamics and Development of Highland Ecosystems, p.193 (Table 69)

circulation cause cracking and sliding of the land its declining productivity results in the draining away of the effective labour force. Lack of enough employment opportunities and minimum infrastructure and amenities are other important factors causing the drift of potentially productive manpower. Shortage of workforce in turn leads to poor management, damage and disintegration of the agricultural terrace systems. Restoring such systems is usually beyond the capacity of the direct users. And in most cases such adverse situations perpetuate.

The productivity and sustainability of agricultural terrace systems depend on many components of the ecosystem concerned (Table 4). The state of the ecosystem determines its inhabitants' prosperity and wellbeing. Correspondingly, the inhabitants can maintain the ecosystem well only when they are sufficiently prosperous. In essence, a regeneration cycle in the agro-ecosystem is essential for its enrichment and sustenance. Sadly, agricultural terrace systems are now facing various constraints and problems impeding the emergence and growth of a progressive chain of desirable changes (Davidson, 1995; Ojha, 1997b; Table 4). As in the far-western Nepal hills, a gradual process of terrace deterioration and abandonment is manifest in many sites (Davidson, 1995; Ojha, 1997b; Ojha, 2014).

5. Conclusions cum Recommendations

Requirements for enriching agricultural terrace systems are varied and can be broadly categorized as technical, socioeconomic, financial and legislative. Those presented below relate to simple elements of those categories.

Table 3: Causes of Terrace Productivity Deterioration, (Values in per cent)						
Cause	Dry terraces			Wet terraces		
	Hh (f=32)	Mh (f=49)	Lh (f=25)	Hh (f=15)	Mh (f=14)	Lh (f=22)
Shortage of irrigation	34.30	28.60	24.00	6.70	14.30	18.20
Low availability of labour and attention & care	21.90	24.50	32.00	20.00	7.10	18.20
Land slide+erosion+weeds	25.00	30.60	16.00	40.00	21.40	18.20
Improper manuring, fertilizing and cultivation practices+low irrigation	12.50	14.30	24.00	20.00	42.90	31.80
Wild animal attack+shortage of seeds	6.30	2.00	4.00	13.30	14.30	13.60

NB: f-No. of terrace-owner respondents in the sub-sample; Hh-High hills; Mh-Middle hills; Lh-Low hills; Source: Ojha, E.R., 1999, Dynamics and Development of Highland Ecosystems, p.194 (Table 70)

6. Launching Large-Scale Afforestation and Reforestation Programs

Large-scale afforestation in denuded lands (hill tops, slopes, waste- and degraded areas) and reforestation in areas with depleting vegetative cover seem most essential. For this, setting up of specialized plant propagation unit or plant nursery and technical unit to carry out planting activities would be necessary. Restoration and revival of the depleting forests and emphasis to the growing of local plant species could not only be economical but also easy to achieve, stabilize and sustain.

7. Providing Technical Support

Particularly in areas where new agricultural terraces are being built or old terraces are getting degraded or being abandoned, farmers might be in need of technical support with regard to construction, operation and maintenance of terraces. The aspects to be dealt with in this regard would generally include (a) grade, slope, riser, length and breadth of the terraces and (b) auxiliary structures such as trails and waterways. Besides, the supplementary operations such as agro-forestry, contour cultivation, cover cropping, catch cropping, crop rotation, fencing, green-manuring, mulching, strip cultivation, livestock rearing, compost and farmyard manure preparation and use; wattling, and weeding are very important.

8. Offering training

Support to rehabilitate and regulate any malfunctioning irrigation facilities or to create new ones, if required, can serve as a boon. The best way to help in these matters would be to train the farmers and let them involve in tasks as judged by them.

9. Stimulating joint work

Rehabilitation of abandoned, deteriorating or disintegrating terraces should be given priority rather than installation of new ones. In some cases, however, new construction could be highly justifiable. Motivating farmers to form their self-help groups (SHGs) can make large-scale constructions easier, cheaper, faster and better. Even when a terrace program is launched based completely on external support, local people's consent must be sought and participation ensured.

10. Supplying inputs

Terrace farmers should also be supplied with materials and equipment required for adopting the recommended practices. The materials may also include seeds and seedlings of high-yielding and high-value crops suitable for the location. Since increased production and improved conservation are a common concern to many, subsidies could also be offered. Provision of institutional loans can be another incentive. Publicising the best terrace tracts and rewarding their operators can yield a fruitful demonstration effect.

11. Developing infrastructure

Development of infrastructure comprising link-roads, marketing network and regulation, and storage, transport and savings deposit facilities can have an immensely positive impact on terrace system enrichment in several ways. Setting up of locally feasible enterprises can absorb the local workforce, thus reducing the drain of human capital and making it available for the proper management of the labour-intensive agricultural terrace systems.

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