

Management of steep land

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According to land capability classification steep land is classed as unsuitable for farming, and consequently no intensive research on management of such land was conducted. Steep land suffers from severe water erosion, low moisture availability particularly under arid climate, aggravation of drought effects and soil fertility impoverishment. Sloping Agricultural Land Technology consisted of : (i) Land management, and (ii) Rain-water management. As a matter of fact, land has to be managed appropriately to manage rain-water such that excess of run-off leaves the land without damaging it. For this creation/improvement of vegetative cover, construction of structures like contour bunds/graded bunds, anicuts, terracing and run-off collection tanks/farm ponds are necessary. Steep lands with shallow soil are not suitable for arable farming and must be put to alternate land use as silvi-pastoral system, horti-pastoral, agro-forestry system, etc. Afforestation of steep land (slope > 30%) with deep alluvial soil could neither control water erosion nor reclaim the eroded land.

Key words: Management, Steep land

LAND and water are the most important resources for agriculture, and their management should be an integral part of any agricultural development programme. Agricultural development should aim at greater biomass production without loss of natural resources i.e. without soil/land degradation. Soil erosion is universal phenomena. Soil degradation is one of the major problems confronting agriculture throughout the world-even in advanced countries like USA where three billion tonne of the valuable top-soil is lost every year, despite 75 years since establishment of the Soil Conservation Service and expenditures of tens of billions of dollars since the dust Bowl. The problem is worse in Canada as a result of change in production practices since World War II. In advanced countries, negative effects of soil erosion on crop-yields have been masked by improved crop varieties, heavy dose of fertilizers applied, better measures of plant-protection and improved tillage and planting

practices. In India, the problem of soil erosion was worse, and land degradation was responsible for low yields. About 2/3rd of the cultivated land was suffering from soil erosion of one kind or another (Fig-1). In the initial stages, it may not be noticeable to the farmer, but later on it may be beyond his means to control it. Not only soil, but even productive lands are being lost to ravines at an alarming rate (8,000 ha/annum). A conservative estimate suggests that 5 to 7 million ha of land is lost annually through soil degradation

Available technology

Soil conservation research was



Fig. 1. Barren steep land

established in early 1950s of the last (20th) century. Research on steep lands (slope > 30%) was limited because according to land capability classification such lands is classed as unsuitable for farming. The fool proof technology was not available to manage steep lands (slope > 30%) most profitably. Also, soil conservation research was not integrated into farming/cropping

systems, because an independent Institute namely, Central Research Institute of Dryland Agriculture was established for conducting research on cropping systems. How can one think of developing the dryland agriculture without research on land and rainwater management - the sole mandate of Central Soil and Water Conservation Research and Training Institute, converted into Indian Institute of Soil and Water Conservation, Dehradun.

Limitations of steep land

Various limitations of steep land are:

- **Soil erosion:** According to Universal Soil Loss Equation, the soil loss from steep land is 500 tonne/ha or more (100 tonne/ha will remove top soil in 20 years).
- **Upper part dries up fast:** Moisture availability on steep land is too low. During dry season, vegetation cover is sparse or nil. Hillocks may be sliding down the slope while soil on lower part is protected by vegetation.
- **Soil fertility impoverishment:** Leaching results in loss of nutrient cations and may result in soil acidity. The problem was more severe on permeable soils *i.e.* Entisols, Inceptisols, Oxisols (Red and Lateritic soils)
- **Worst combination:** Steep land and arid climate (a long dry period in a year) is the worst combination leading to fragile system. Even under such circumstances investment now is more productive in alleviating conservation problems on steep lands than in developing new areas through irrigation, because of enormous cost of irrigation projects, their long gestation period and chance of soil degradation by irrigation through development of salinity/alkalinity.
- **Not suitable for arable farming:** Steep land usually has a soil shallow in depth and coarse in texture and consequently not suitable for raising crops particularly under rainfed conditions.
- **Drought effects:** Adverse effects of drought are aggravated on steep land.

Steep land under the plough

Non-availability of information on their appropriate management does not imply that steep lands are not being used or cultivated. Due to high pressure of human and livestock population, some countries have no choice but to bring such land under the plough for food production. In Nepal, hill slopes upto about 45% are cultivated. In Ethiopia, 54% of the total land area has a slope exceeding 8%, and 29% has a slope >30%. In other countries also steep land was being used as it covered a significant part of their total land. In India, a decrease in area of steep land is also due to cultivation of such land by the farmers.

Conclusions based on development projects

A large number of projects on development of steep lands were executed throughout the world by International organizations/agencies like Food and Agriculture Organisation, United States Agency for International Development, World Bank, Canadian International Development Agency, Overseas Development Agency, Japanese International Cooperation Agency, Swedish International Development Agency etc. General conclusions derived from these are:

- Basic principles and approaches were the same whether there is high rainfall or low rainfall regimes, thickly or sparsely populated zones, advanced farmers or subsistence peasants, but the necessary practices for soil conservation tend to be site specific.
- A close and complex relationship usually exists between the different forms of land-use in any area. For example, bird and animal damage compels a farmer to plant the same crop/variety as his neighbour. If there is no crop in the field, freedom to grazers to put their animals makes stubble mulching difficult/impossible.
- Since land resource was shrinking in every country, sound land policy was necessary for wise- and rational land-use. Competition between industry and farming, *e.g.* can lead to unrest, exploitation of marginal

land, reduction in forest area, lack of fuel wood and consequent burning of cow is dung.

- Rain water management is a key to soil conservation and more emphasis on *in situ* water conservation, run off management, etc was necessary.
- Watershed development approach was appropriate for soil conservation, as water erosion was dominant on crop land.
- The work could be done by a multidisciplinary team or by various departments in an integrated manner.
- Farmers/beneficiaries should be a party to decisions on planning and execution of works. Scientists should learn indigenous technology, if available, from farmers.
- A farmer was interested in soil water conservation only if it resulted in increased biomass-production.
- If fool proof technology for a specific situation was not available, the programme should be flexible, so that it can be changed/modified in light of the experience gained while executing the project.
- The project period should be longer- at least five years, 3 years not sufficient.

Maintenance: There should be a provision for maintenance of works executed, preferably the maintenance cost must be given to farmers as incentive.

Sloping agricultural land technologies (SALT)

Appropriate SALT technologies included improvement of ground cover, conservation tillage, cover crops, dry seeding, mixed cropping, inter cropping, strip cropping, grass strips, agro-forestry, alley cropping, and agri-horti-pastoral system, and grass development on bare ground and grass land improvement.

Suitable combinations of different technological components may differ under different land topography, soil type and climatic regimes.

- SALT essentially concerns
- (i) Land management and
 - (ii) Run-off management

Actually for the sake of discussion only, land management and run-off



Fig. 2. Run-off collection on steep land



Fig. 3. Drumstick plantation on steep land

management were treated separately. As a matter of fact, land has to be managed appropriately to manage the run-off (rainwater). Hence, land and water management go together.

(i) Land management

The steep land has to be managed such that run-off passes away from it without or with minimum damage to soil/ land. Various steps are

Improvement of soil properties: Soil properties like high humus content, granular structure, better infiltration and increased water storage capacity all reduce soil erodibility. Manuring, fertilizer application, zero/minimum tillage, mulches, improve soil properties.

Vegetative cover: It includes following

Increasing ground cover: If present ground cover by raising a crop was not adequate, the ground cover must be increased by dry seeding, intercropping, grass strips (alternate with crop rows), alley farming, agro-forestry instead of cropping alone, particularly on land with slope 6 to 15% and shallow soil.

More dense cover: If steep land is being eroded even after natural vegetative cover, it means the cover is not dense enough and therefore more dense cover was needed. Seeding of grass + legume to improve grassland will also provide more dense cover.

Prohibit grazing: Instead of free grazing, cut and carry method or rotational grazing must be adopted.

Negotiating the slope

Slope length: Reduced by structures that either retain or divert run-off

water.

- (a) Contour bunds,
- (b) Graded bunds.

Slope gradient: Reduced by terracing

- (i) Bench terraces level in both direction.
- (ii) Narrow bench terraces for tree plantation.
- (iii) Intermittent terrace or orchard terraces.
- (iv) Large trenches for early stages of afforestation or hill side ditches.
- (v) Absorption terraces (between 2 contour bandhis or anicuts-height 2 m at VI of 2 m) to impound all or most of run-off. Suitable for deep permeable alluvial/red clay loam. Not suitable for black soil.
- (vi) Terracing in stages: Terracing over time using soil moved by erosion.

Control of inevitable run-off: Such that excess water runs out of the field without or with minimum damage to soil.

- (i) Water diversion bund or diversion drain or cut off drain: to protect arable land against run-off from higher land.
- (ii) Graded bunds (a series at intervals).
- (iii) Grassed waterway.

(ii) Run-off collection

Run-off collection was the most important step to be taken for increasing the productivity of rain-water on steep land. Also, one of the most important elements in the design of improved soil and water management technique was the concept of harvesting excess runoff from steep lands in water storage reservoirs for

subsequent use in supplementary irrigation (Fig. 2). Also, every effort should be made to conserve as rainwater as possible, *in situ* i.e. right where it fell, by manipulating the surface soil, using surface mulches, stubble mulches and modify land configurations. In spite of all these efforts, runoff was still a certainty and the emphasis should be given on runoff collection and its reuse.

Alternate land use

Marginal steep lands with shallow soil have certain limitations resulting in poor productivity of normal crops raised on such land. The limitations could be soil depth, steep land slope, light texture, excessively drained with very poor water holding capacity. All these properties make the soil (sandy or sandy loam) unsuitable for crop-production particularly under rainfed conditions. Due to population explosion on one hand and ever shrinking land resource on the other, marginal- and sub-marginal lands are brought under the plough. Cultivation of such land, if not managed well leads to serious imbalance in the ecosystem and complete wastage of land resource as ravines. Thus, for such land, an alternate land use rather than arable cropping would be more efficient.

Biological measures that provide an effective cover on ground or close to the ground surface are likely to be more effective, more ecologically compatible and more durable. Thus, grasses are more suitable to provide vegetative cover against soil erosion and the species providing the best cover are the most suitable ones.



Fig. 4. Control of run-off through anicut in gully

Different alternate land use systems

Depending upon land slope, soil depth and distribution of rainfall, suitable alternate land-use systems are recommended to obtain maximum biomass production without any detriment to natural resources. These systems minimize the risk, generate much needed off-season employment, using the off-season rains which may otherwise go waste. These systems can better tolerate the dry periods between the rains due to their deeper root-systems.

As already stated, planting of grass was the most effective means of soil conservation on marginal lands. Besides, it provided nutritive fodder if sown mixed with legumes (preferably perennial). Silvopastoral system consisted of growing multipurpose trees with pasture grasses and legumes such as *dhaman* (*Cenchrus ciliaris*) and *hamata* (*Stylosanthes hamata*), respectively. The trees should be fast growing drought tolerant and with good coppicing ability and should provide fuel, fodder and timber. Their foliage should be palatable and digestible. The grasses to be grown should be compatible with tree species, possess high palatability and good nutritive value. The both species of stylo, viz. *Stylosanthes hamata* and *Stylosanthes scabra* grew well with *dhaman*

(*Cenchrus ciliaris*), *anjan* (*Cenchrus setigerus*), *gonya grass* (*Eurochloa mosambiensis*) etc. in respect of establishment, persistence, nutritive value and palatability. Other legumes from genera *dolichos* (*Dolichos lablab*) and *clitoria* (*Clitoria ternatea*) got established well on vertisols and in high rainfall regions but their persistence was not good. Macroptilium also performed similarly.

As regard top-feed trees, *subabool* (*Leucaena leucocephala*), *khejri* (*Prosopis cineraria*), *Poplar* (*Populus deltoids*), *bakain* (*Melia compacta*) were found suitable. Silvopastoral systems with wide spacing between trees and appropriate grasses can be tried on steep to very steep land (30 to 50% slope) with shallow soil.

Horti-pastoral system

On steep land with medium depth of soil, fruit trees can replace forest trees. Well established and maintained orchards can result in better returns than field crops on the same piece of steep land. Besides, horti-pastoral system can protect the land from soil erosion. But fruit growing enterprise requires heavy initial investment on planting material, land preparation irrigation, fertilization and plant protection and many years wait before the trees bear fruit.

Custard apple (*Annona squamosa*) ber (*Zizyphus mauritiana*), guava

(*Psidium guajava*), *karonda* (*Carissa carondus*), *lasoda* (*Codia myxa*), *drumstick* (*Moringa oleifera*) and *aonla* (*Emblia officinalis*) can be planted on upper reaches of a slope while pomegranate (*Punica granatam*), mango (*Mangifera indica*), *phalsa* (*Grewia asiatica*), *litchi* (*Litchi chinensis*), *orange* (*Citrus reticulota*), *sweet lime* (*Citrus auratifolia*), *jack fruit* (*Artocarpus heterophyllus*), *jamun* (*Syzygium cumini*) and *bael* (*Aegle marmelos*) on lower part of the slope (Fig. 3).

Combination of silvi-pastoral and horti-pastoral systems

To deal with steep land with hill tops, a three-tier system is recommended by the ICAR centre, Shillong. In this system forest trees are recommended to be grown at the hill-top, horticultural plants such as pomegranate (*Punica granatum*), *phalsa* (*Grewia asiatica*), *litchi* (*Litchi chinensis*), *orange* (*Citrus reticulota*) etc. in the middle portion of the slope and grasses with legumes on the lower portion.

SUMMARY

Steep land is classed as unsuitable for arable farming under the Land Capability Classification, as it usually has shallow soil severely eroded by rainwater, impoverished of plant-nutrients and soil colloids. Still such land is brought under the plough even in advanced countries like U.S.A. and Canada. But no intensive research on management of such land has been conducted and consequently fool proof technology for appropriate management of steep land is not available. Hence, the need for intensive research on steep land management cannot be over emphasized. Various aspects to be covered are: land and water management practices, nature and density of vegetative cover, negotiation of slope, run-off collection and recycling and alternate land-use systems.

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