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Soil and Water Conservation Problems and Measures in Hilly Area

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Introduction

Soil and water are the most important resources on which agriculture is based. Proper management of these valuable resources are important to sustain long-term agricultural productivity. Unfortunately, soil erosion is usually only identified problem in hilly areas when channels are cut through fields during high rainfall situations that are so deep they restrict cultivation practices. In fact, soil erosion occurs at unsustainable levels when small rills are recognizable in a field. Soil loss is not only a problem for the farmer, with the loss of organic matter and fertility; it is also an environmental problem. Soil and water conservation form an integral part of any strategy for management of natural resources on all the ecosystems, more so in hilly regions. These measures mainly aim at the in situ conservation of rainwater and thereby allowing more of this water to get infiltrated into the soil to replenish the ground water storage. The main goals of soil and water conservation are to obtain the maximum sustained level of production from a given area of land by preventing soil degradation and environmental pollution. Thus, soil conservation practices usually aim at the primary causal factors and areas.

Why Soil and Water Conservation:

Land and water are natural resources that are essential for the existence of life. Land provides food, fodder, fuel, and shelter in addition supporting secondary and other economic life supporting system. However there has been a continuous depletion of land resources and the quality of land is deteriorating due to various factors like soil erosion caused mainly due to shifting cultivation, heavy downpour of rainfall, large scale deforestation, reckless mining activities, overgrazing, general mismanagement, etc. Such soil erosion leads to degradation of soils' physical property and loss of plant nutrients. It takes nature nearly 600-1000 years to build 2.5 cm of topsoil but it get displaced within a year only due to misuse. It has been

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reported that 6000 million tons of productive soil is lost every year from total of 80 million hectare of cultivated land alone in India. It has also been proved that soil lost from unprotected land is about 120 tonnes /ha/year and may even reach up to 300 tonnes /ha/year. Thus, apart from depletion of fertile soil, erosion results in the loss of runoff water, plant nutrients and micro flora, siltation of reservoirs and riverbeds thereby adversely affecting irrigation and power potential, causing floods in plain and valley which damage crops, animals, habitation, communication, etc. But most of them adversely affect agricultural production, forest productivity and availability of water both for irrigation and drinking besides bringing about a disturbance in the soil and water balance.

Problems Related to Soil Erosion:

Shifting cultivation: It is also well-known as jhuming cultivation and considered as the step-in transition from food gathering or hunting to food production. In this system farmers burn the vegetation and cultivate plots of land in the virgin forest until the yields of the crops fall below subsistence level. At this point the farmers abandon the land to natural fallow and move to a new site. When the original area is well-thought-out to have healthier soil or gained fertility, the farmers or growers of crop return to repeat the practice, until the fertility of the land is apparently exhausted. As a result of population explosion, demand for food and fuel increased and land availability for agriculture has reduced. Indiscriminate chop down of trees on the hill slopes brought an undesirable eco-imbalance. Further, the hill tops are the main source of water; deforestation of this hilltop trees led to the removal of water source. This, in fact ended in the loss of topsoil. Together with this, deforestation significantly condensed the retaining capacity of the soil. Erosion of soil in the catchment area resulted in silting of the reservoirs and streams leading to unprecedented floods. Hence, this situation needs to be tackled on top priority to keep the ecological imbalance intact as well as to meet the fodder, food, fuel requirements, etc., in these tracts.

Unscientific land use on hill slopes: The whole resource degradation process in the region is closely associated up with the land use system. Evaluation of some of the land use systems practices indicates that most of them are hazardous to resources and are not conducive to the aims of permanent agricultural systems with sustainable production. Horticultural crops

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cultivated on the hill slopes without proper soil and water conservation resulted in soil erosion. The soil erosion varied with the degree of disturbances caused to the soil surface.

Over exploitation of forest: Exploitation of forest indiscriminately increases the soil erosion on hills and flood in downstream areas. Fuel shortage becomes acute. This again means additional encroachment of forest land causing in more denudation, environmental degradation and loss of biological components of soil and vegetation. Even too much grazing by cattle may also damage forest.

Land degradation: The level of land degradation that follows use of forest areas for agriculture is mainly determined by the level of management. Apart from soil loss that accompanies land clearing and early stages of plantations, there is also severe nutrient loss. The practice of jhuming or shifting cultivation has increased the problem of land degradation. The involvement of such a huge area in shifting has affected large scale deforestation, soil erosion, loss of productivity, ecological imbalance, and land degradation. The growing population pressure has resulted in misuse of land resource and national options for high value plantation crops have severely affected the tropical forests.

SOIL AND WATER CONSERVATION MEASURES

Types of Conservation Measures in Soil and water management practices such as tillage and cropping practices, directly affect the overall soil erosion problem and solutions on a farm. When crop rotations or changing tillage practices cannot effectively control erosion on a field, a combination of measures might be considered necessarily. For example, contour cultivating, strip cropping, or terracing may be considered. The most practiced measures involves: -

1. Agronomic conservation measures function by reducing the impact of raindrops through interception and thus reducing soil erosion and increasing infiltration rates and thereby reducing surface runoff and soil erosion

2. Biological measures for soil and water conservationwork by their protective impact on the vegetation cover. A condensed vegetation cover prevents splash erosion; reduces the velocity of surface runoff; accelerates accumulation of soil particles; increases surface roughness

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which diminishes runoff and upsurges infiltration; the roots and organic matter stabilize the soil aggregates and increase infiltration.

3. Physical measures are structures built for soil and water conservation Some principles should be considered. They should aim to increase the time of concentration of runoff, thereby letting more of it to infiltrate into the soil; divide a long slope into several short ones and in that way reducing amount and velocity of surface runoff; protect against damage due to extreme runoff.

Agronomic measures:

Strip Cropping: In this cropping system, crops are grown in regular or irregular trips. To make it effective, this system should be used only on slopes up to 6%. It breaks, long slope length to shorter ones and this provides protection from erosion. Retardation of flow of runoff provides more opportunity for running water to infiltrate, thereby conserving the water.

Contour Strip Cropping: In this system crops are arranged in strips or bands on the contour at right angle to the natural slope of the land. In this system of layout, tillage and planting of crops are practiced along the contour. The crops follow a definite rotational sequence in contour strip cropping, strips of uniform width are placed across the general slope in this system.

Field Strip Cropping: In this system strips are placed across the general slope. The width of the strip will be too large at some locations and too narrow at some other locations. These strips do not curve along the contours at places where they cross the natural water course and depressions.

Buffer Strip Cropping: In buffer strip cropping the strips of a grass or legume crops, that completely cover the ground, is placed in between contour strips. They are planted in regular intervals. The width of the buffers either may be even or irregular. Buffers may be placed on critical slope areas of the field. The primary objective of the buffers is to give protection from erosion or allow areas of deposition.

Crop Rotation: Crop rotation is a regular succession of different crops grown on the same patch of land to have beneficial effects like soil and water conservation, sustained yield and maintenance of soil fertility. The best set of rotation to be adopted depends on the slope and

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topography, soil conditions and management requirements of the farm. A three-year cycle of cereal, legume and grass-legume may be considered ideal.

Conservation Tillage: The main purpose of the tillage is the preparation of seed bed. However, the role of tillage has become increasingly important as a conservation tool. Its basic aim is to provide an adequate soil and water environment for the plant growth. Excessive tillage is not beneficial.

Stubble Mulching: The practice of maintaining crop residue on the soil surface is an effective measure to minimize soil erosion and to consume moisture. It also adds nutrients to the soil after decomposition. The mulch absorbs the kinetic energy of the raindrop. Therefore, detachment of soil particles in minimized to a greater extent. This practice can also be adopted when land is fallow and to protect small-grain and row cropland during the period of seedbed preparation for a succeeding crop.

Cover Crop: Any crop while serving as a solid cover, whether specially planted for that purpose is a cover crop. But generally, the term is used to those crops that are planted especially for checking soil erosion, adding organic matter to the soil, and improving soil productivity.

Cover crops for soil fertility and erosion control:

Cover crop is any annual, biennial, or perennial plant grown as a mono- or polyculture to improve any number of conditions associated with sustainable agriculture. Cover crops are fundamental sustainable tools used to manage soil quality, water, weeds, pests, diseases, and diversity in an ecosystem. Keeping the soil covered is a fundamental principle of conservation agriculture. Crop residues are left over the soil surface to protect soil surface after harvesting or during kill-down when the cover crops are slashed and left in the field at flowering. Additional cover crops may be needed if the gap is too long between harvesting one crop and establishing the next. Cover crops improves the stability of the safeguarding agriculture system, not only in the improvement of soil properties but also for their ability to promote an increased biodiversity in the agro-ecosystem. Cover crops are advantageous in stabilization of soil moisture and temperature, protect the soil throughout fallow periods, mobilize and recycle nutrients, improve the soil structure and break condensed layers and

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hard pans, permit a rotation in a monoculture, control weeds and pests and produce supplementary soil organics that improve soil structure.

Green manure:

Green manure are plants grown to collect nutrients for the main crop where they pierce the soils with their roots, deliver nutrients and support infiltration of water into the soil. The contribution of organic matter to the soil by green manure crop is comparable to the addition of 23 to 33Mgha^{-1} of farmyard manure. Leguminous plants fix nitrogen (N) from the air into the soil and this N enriches the soil and feeds plants in the area. The portion of green manure-N available to a crop planted later is usually about 40 to 60% of total amount of N contained in the legume.

Contour farming:

Contour farming involves tilling, planting and weeding along the contour or across the slope rather than up and down. Contour lines are lines that run across a hillslope such that the line stays at the same height or altitude and does not run uphill or downhill. As contour lines travel across a hillside, they will be close together on the steeper parts of the hill and further apart on the gentle parts of the slope. Research show that contour farming alone can reduce soil erosion by as much as 50% on moderate slopes. However, for slopes steeper than 10%, other measures have been used in combination with contour farming to enhance its effectiveness.

Trash lines: Trash lines range from simple bunds of cereal and legume stover to more sophisticated pegged brush lines. Apart from obstructing runoff and improving infiltration, trash lines also increase soil organic matter content when incorporated into soil throughout ploughing, enhance soil macro porosity, water holding capacity, soil hydraulic conductivity as well as improve soil fertility upon break down of bunds of cereals and mineralization. Their effectiveness depends on the size of the bunds and their spacing. Large trash lines have been shown to reduce erosion, increase both infiltration and available water to crops leading to increased crop yields.

Biological measures:

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Vegetative barriers: The use of stiff-stemmed vegetation as barrier strips in cropland areas vulnerable to erosion is a new conservation practice that can augment more conventional measures designed to reduce soil losses. These are narrow, parallel strips of stiff, erect, dense vegetation planted on or close to the contour. These blocks cross concentrated flow areas at convenient angles for farming or are used in the same manner as terraces. They reduce the velocity of runoff water, causing deposition of sediments on the upslope side of the barriers.

Mechanical / engineering /physical measures: Mechanical measures are aimed at arresting the movement of eroded soil and runoff by reducing the slope length and or slope steepness, and to conserve rainwater in soil profile.

Bunding: Bunding is an engineering method which measures effective for the mild slope lands. However, on foothills and within a highly undulating terrain wherein land slope is within or around 8 percent bunding is a very effective erosion control measure and especially in dry area. The main objective of bunding is to reduce the slope length. Bunding are two types namely, Contour bunding or narrow based terracing and broad based terracing.

Contour Bunding or Narrow Based Terracing: Contour bunding or narrow based terracing is adapted normally at those places where rainfall is low and surface runoff is to be stored for inducing infiltration. It has a height up to 100cm and area under bunding is not available for cultivation. These are constructed as bund on contour and are of two types. The one which is laid on contour for storage and absorption of runoff is called as contour bunding and the one which is used for safe disposal of excess surface runoff is called graded bunding.

Broad Based Terracing: Broad based terracing has a base of 2.4 to 8m with side slope of 1:4 to 1:8. The maximum height of the bund at the center is between 30 and 60cm. In this bunding area is not lost as the area over broad-based terracing is cultivated. These are called level or absorption type when laid on contour for storage and absorption of excess surface runoff. When these are laid on grade for safe disposal of excess surface runoff, these are called graded of disposal or channel type.

Trenching: Construction of any form of depression or micro pit or trench over the land surface is done to arrest both excess surface runoff and silt carried with it.

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Contour Trenching: When the trenches are made on contour then they are termed as contour trenches. These are called continuous when there is no break in length and can be 10 to 20m long across the slope depending on the width of the field. However, when these are laid scattered with a maximum length of 2 to 4m, these are called staggered contour trench.

Graded Trench: When the trenches are given a grade and are not on contour, these are called graded trench.

Moisture Conservation Pit: Small pits can be constructed across the slope to harvest rainwater. Eroded soil will be deposited in the pits and water collected will be gradually infiltrated into the soil, thus increasing the moisture regime of agricultural land. They are suitable in between plantation crops grown on flat and slightly sloping lands. Pits of size 1.5m x 0.6m x 0.6m may be constructed at suitable intervals according to the site conditions.

Half-moon Terracing: The half-moon terraces are assembled for planting and maintaining saplings of fruit and fodder trees in horticulture and agro-forestry land use system. This type of construction is made of earth cutting in half-moon shape to create a circular level bed having 1 to 1.5m diameter. It provides facilities for retaining soil fertility, moisture and application of added fertilizers and manure for healthy growth of plants.

Stonewall: This is a barrier of stones pitched as a short walls across the slope at a predetermined spacing. When this wall is made on contour, it is called contour stone wall and when it is laid on some grade, it is called a graded stone wall. These are preferred where stones are available in plenty and the soil is shallow.

Zing Terracing: When only a part (normally lower side of the slope) of the field is leveled and runoff from the remaining sloppy land is utilized to take crops from the level portion, keeping the sloppy area under grass or pasture, horticulture or bushy vegetable, it is known as zing terrace. It is very useful in low rainfall areas.

Conservation Bench Terracing: These are similar to that of zing terracing except that instead of taking grass, horticulture, bush, etc. on the sloppy area, the crops which require less moisture, are cultivated on sloppy land and the runoff is brought to the level portion/ land for taking crops which require high moisture.

Cutoff drains, retention and infiltration ditches

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Cutoff drains are commonly dug across a slope to interrupt surface runoff and carry it safely to an outlet such as a canal or stream with least risk to provoking erosion. They are used to protect cultivated land, compounds and roads from uncontrolled runoff and to divert water from gulley heads. Retention ditches are dug along a contour to catch and retain incoming runoff and hold it until it seeps into the ground. They are an alternative to cutoff drains when there is no nearby waterway to discharge the runoff into. They are used as harvest water in semi-arid areas. Infiltration ditches are one way of harvesting water from roads or other sources of runoff and consist of a ditch, 0.7-1.5m deep, dug along a contour, upslope from a crop field. When it rains, runoff water is diverted from the roadside into the ditch, which is blocked at the end to hold the water. Water locked in the ditch seeps into the soil and maybe used for rain harvesting agriculture where moisture is stored in the ground.

Conclusion:

As the soil erosion create serious problems for food security, of which a large proportion includes negative environmental consequences. Land is being the major source of the food (99.7%) supply, it has to be conserved by the location specific management practices for future needs. Particularly in hilly areas where the farming needs more attention for conservation practices to sustainable crop production, efforts to enhance land productivity, conserve soil and water, and increase soil fertility by adopting the soil and water conservation

measures.

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