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Soil and Water Conservation Measures for Andaman and Nicobar Islands

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Abstract

Soil erosion due to runoff water is a major land degradation problem in the sloppy and undulated terrains of Andaman and Nicobar Islands (ANI). Soil erosion resulted in fertility degradation and loss of top soil besides landslides due to high intensity storms and steep topography. However, the island suffers from soil moisture deficit during dry season due to high evapotranspiration. Therefore, planning suitable soil erosion control and water conservation measures in ANI is of utmost importance towards solving drinking water crises and optimizing agricultural production. Present study illustrates the different suitable soil and water conservation measures/interventions in ANI that are intended to reduce the erosive energy of water, soil erodibility by altering surface soil characteristics, and to reduce nutrient losses from agricultural fields. This paper also summarised different studies conducted in ANI with an aim to improve agricultural productivity and reduce land degradation.

Key words: *Soil erosion, model, land degradation, nutrient loss, water harvesting*

Introduction

Andaman and Nicobar Islands (ANI) are the tropical, humid and rain fed areas located between latitude 6°40 °N and 14°45 °N and longitude 92°8 °E and 94°1 °E with the total geographical area of 8249 km^2. The average annual rainfall of ANI is ≈3280 mm, which shows 26.40 billion m^3 of potential to store fresh rainwater with 69,185 m^3/capita/year water availability. The devastating Tsunami/earthquake took place on 26-12-2004 has changed the climate of these Islands drastically. It is evident that post Tsunami rainfall patterns are highly variable both in terms of total amount and distribution, which lead to drinking water problems and moisture stress during critical stages of crop production. Even though, about 90% rainfall from May to November is spread over about 117 rainy days, the existing water resources in ANI are not sufficient to meet the ever growing demands of native (380581 as per 2011 Census) and tourist population (515223 during 2018-19 as per Directorate of Economics and Statistics). This is due to the fact that nearly 70% of received rain water is lost as runoff immediately after rainfall due to its steep terrain and proximity to the Sea (Srivastava and Ambast, 2009). This high speed free runoff is associated with soil erosion, which has a scour potential to reduce the soil productivity by removing the most fertile topsoil and obstruct the agricultural operations.

The natural resources in ANI are profoundly afflicting from soil erosion as a result of intensive deforestation, overgrazing and subsistence agriculture due to population pressure, large-scale road construction and mining etc. along with anthropogenic activities. Soil being a non-renewable resource and the basis for 97% of all food production, strategies/measures to prevent soil depletion, land degradation, and erosion are critical for sustainable development. Quantifying the acceptable soil loss without affecting crop productivity is a major challenge for researchers, planners, conservationists, agriculturalists, environmentalists, etc.

Studies on soil erosion from different agricultural land uses in ANI are poorly documented due to various limitations of isolation from mainland, limited resources, undulated topography, huge capital requirement, administrative restrictions, ungauged locations, natural disasters, etc. Table 1 presents the summary of conducted various soil erosion and nutrient loss studies in Andaman and Nicobar Islands.

Table 1 Summary of soil erosion and nutrient loss studies in ANI

Sl. No.	Objective	Study Location/Land uses	Approach	Conclusion	Recommendations	Reference
1.	Soil, nitrogen and phosphorus loss	CIARI, Garacharma Farm	Three treatments: T1: Gliricidia + Maize + Tillage; T2: Gliricidia; T3: Maize	T3 treatment resulted less soil loss (t/ha/yr), less nitrogen & phosphorus losses (kg/ha) than T1 & T2.	Gliricidia hedgerows is good vegetative method for soil erosion control.	Pandey and Venkatesh (2002)
2.	Soil erosion based on selected incident rainfall events	Dhanikhari watershed of the South Andaman	Revised Morgan Morgan Finney (MMF) model, Remote Sensing (RS) and geographical Information System (GIS)	Average annual soil loss was 25.29 t/ha & total soil loss was 27142 tonnes.	Multiple rainfall events in whole year should be considered.	Velmurugan et al. (2008)
3.	Soil and nutrient loss	Five land uses: L1: vegetable fields; L2: contour plantation; L3: arecanut plantation; L4: home garden; L5: evergreen forest.	Runoff plots	Soil loss from the L1 under no till conditions, L2, L3, L4 and L5 was 3.8, 12.4, 10.6, 8.4 and 2.3 t/ha, respectively.	Gliricidia hedgerows for vegetable cultivation and cover crop for coconut plantation are good vegetative methods for soil erosion control.	Pandey and Chaudhary (2010)
4.	Soil loss	Andaman & Nicobar Islands	Runoff plots, Universal Soil Loss (USLE) model, RS & and GIS	In ANI, ≈ 609 km^2 area (7.4%) was under the very slight to slight erosion class and ≈ 90% of area exceeded the tolerance limit of 11.2 t/ha/yr	Planning suitable soil and water conservation measures at critiacal areas.	Sahoo et al. (2013)
5.	Drainage morphometry	Kalpong river, North Andaman	RS & GIS	Study area was susceptible to soil erosion and severe runoff.	Higher order stream or upward extension of tributaries for Kalpong watershed.	Shankar and Dharanirajan (2018)
6.	Soil loss	Agricultural lands of South Andaman	USLE	Annual soil loss of 184098.12 tons was recorded at the rate of 105.38 t/ha/yr.	Converting more mono crop area into double cropped land will reduce the average soil loss annually by 18.4%.	Nanda et al. (2019)

Soil Erosion Control and Water Conservation Measures

It is well known fact that one cannot control the climate and nullify the extreme events in any region. But its impacts can be mitigated by planning suitable conservation measures on long term. These measures include soil conservation, moisture retention, afforestation, improving groundwater recharge and building water harvesting structures. Soil erosion control and water conservation measures are divided into two main categories: 1) *in-situ* and 2) *ex-situ* measures. In-situ measures (Fig. 1) are made within agricultural fields like integrated farming, nutrient and pest management, crop diversification and intensification, contour trenches, bunding, terracing, broad bed and furrow, vegetative barriers, grass waterways, etc., whereas *ex-situ* measures (Fig. 2) include rain water harvesting structures, farm ponds, percolation tanks, earthen dams, check dams, gabions, and agroforestry.

In-situ Conservation Practices

Integrated Farming System (IFS)

In IFS, both the agriculture and non-agriculture activities like livestock production and dairy and fish farming are practiced for generating consistent source of income and to avoid crop failure risk to the farming community. In ANI, various small holder IFS systems have been evolved with the components of plantation crops, paddy cultivation, back yard poultry, fisheries, vermicompost, mushroom, apiary etc. Studies on rice based IFS (animal, poultry, and fish) have indicated 53% increase in employment at farm gate as compared to improved rice based cropping system and also net income by 23% at Port Blair (Ravishankar et al., 2006). Similarly, coconut based IFS integrated with vegetables at Nicobar Island resulted additional employment generation and balanced nutrition of tribals (Swarnam et al., 2014). Integrated Nutrient Management (INM) involves the integral use of organic manure, crop straw, and other plant and tree biomass material along with little application of chemical fertilizer (both macro and micro-nutrients). Similarly, Integrated Pest Management (IPM) involves use of different crop pest control practices like cultural, biological and chemical methods in a combined and compatible way to suppress pest infestations.

Crop Diversification & Intensification

Crop diversification refers to bringing about a desirable change in the existing cropping patterns towards a more balanced cropping system to reduce the risk of crop failure. Crop intensification is the increasing cropping intensity and production to meet the ever increasing demand for food in a given landscape by using advanced technologies, good variety of seeds, balanced fertilizer application and supplemental irrigation.

Contour Trenches, Bunding & Terraces

Contour trenches are made in non-agricultural areas for providing adequate moisture conditions in order to raise tree and grass species. Bunds are small earthen barriers provided in agricultural lands with slope ranging from 2-10%. They control the effective length of slope and thereby reduce the velocity of flowing water to avoid rill and gully formations. Bunds constructed along field boundaries are referred as peripheral bunds. Contour bunds are constructed along the contour in relatively low rainfall areas having annual rainfall less than 600 mm for controlling runoff and storage of water. Graded bunds are constructed in medium to high rainfall areas having annual rainfall of 700 mm and above for safe disposal of excess water. Terraces are usually constructed for cultivating sloppy areas by converting the land into series of platforms one above another. These measures are popular in hilly areas.

Broad Bed and Furrow System (BBF)

Function of BBF is to control erosion and to conserve soil moisture in the soil during rainy days. It acts as a drainage channel during heavy rainy days. It is suitable when the slope of the land is < 3%. In ANI, low lands of islands face the water logging problem during rainy season, which limits the crop choices to rice only and sometimes even this crop too fails. Most comman practice of BBF in ANI is that rice and fish are cultured in furrows and vegetable are grown on beds resulting higher and diversified production. In BBF, beds have also shown reduced salt built up problems (Ambast et al. 2010).

Vegetative Barriers & Grass Waterways

Vegetative barriers are closely spaced grass plantations usually a few rows of grasses or shrubs – grown along contours or with little grade for erosion control in agricultural lands.

Grass waterways are drainage channels either developed by shaping the existing drainage ways or constructed separately for effecting drainage of agricultural lands. They are aligned along the major slope to handle runoff discharge from contour/graded bunds, bench terraces, and contour trenches.

a) IFS

b) Contour trenches

c) Contour bund

d) Terrace

e) Grossed waterway

f) BBF

Fig. 1 In-situ soil and water conservation measures

Ex-situ Conservation Practices

Rainwater Harvesting (RWH)

A specific purpose of RWH is to catch and store monsoonal runoff, where it falls. RWH system can augment the transfer of 'blue' water (rivers and aquifers) to 'green' water (soil water and plant water use). The basic elements of RWH system are catchment area, conveyance, or conduit system, first flush, filter system, storage area, and recharge area. The RWH structures in islands should be planned at the local (individual structure) and watershed scale (community) with an aim to augment the irrigation and drinking needs. In ANI, where groundwater is saline and unusable for irrigation or drinking water, RWH can provide local increases in fresh water as the density of fresh water is less than for saline water. As a result, fresh water lenses that 'float' on top of the saline groundwater and can be harvested via wells. In urban areas, rainwater can be collected from the roof, paved and unpaved areas of a house, a block of flats, a colony, a park, a playground, parking areas, schools, and office complexes through roof top harvesting structures. Thumb rule: 10 mm of rainfall over 100 m^2 of roof area will fetch 1000 litres (volume = rainfall x area).

Farm Ponds & Percolation Tanks

Supplemental irrigation at times becomes essential for survival of horticultural and agricultural crops during dry season with undependable and erratic rainfall. In order to accomplish this, excess rain water has to be conserved in soil profiles through farm ponds. Farm ponds are bodies of water, made either by constructing embankment across a water course or by excavating a pit or the combination of both. Percolation tanks are structures constructed across Nallahs for checking velocity of runoff, increasing water percolation, improving soil moisture regime, and augmenting groundwater recharge.

Earthen Embankments and Check Dams

Earthen dam is a raised confining structure made from compacted soil of clay, sand and gravel. They are constructed across the streams/Nallahs for creating water reservoirs for providing one or two irrigations to the crops at critical periods. They are relatively smaller in height and broader at the base and are used for increasing infiltration, detention and retention facilities. A check dam is a small, temporary or permanent dam constructed across a channel to reduce the effective slope of the channel, thereby reducing the velocity of flowing water, allowing sediment to settle and reducing erosion. Temporary check dams can be made of brushwood, stone, woven wire and log, whereas permanent ones are of concrete and masonry.

Gabions

Gabions are partitioned, wire fabric or mesh containers filled with stone at the site of use to form flexible, permeable, monolithic structures for earth retention. They work as anti sea erosion bunds, revetments, sea walls and riprap.

Agro-forestry and Mangroves

Agro-forest measures increase rainfall and runoff, regulate flows, reduce erosion and floods, 'sterilize' water supplies and improve water quality. However, some negative effects are known from teak (*Tectona grandis*) trees and eucalyptus species, which may 'pump' excessive groundwater, since they cannot adjust their water intake to the temperature by opening or closing their stomata. Positive effects arise from planting nitrogen-fixing trees (legumes), often used in agro-forestry systems in order to regenerate depleted soils and to improve plant productivity.

Mangroves are an excellent control measures for coastal erosion. They reduce the height and energy of wind and swell waves passing through them, reducing their ability to erode sediments and to cause damage to structures such as dikes and sea walls. During rising tides, as the sea comes in, waves enter the mangrove forests. They lose energy as they pass through the tangled above-ground roots and branches and their height is rapidly diminished, by between 13 and 66% over 100 m of mangroves. As this happens, waves lose their ability to scour the sea bed and carry away sediments. Mangroves also reduce winds across the surface of the water and this prevents the propagation or re-formation of waves.

a) RWH

b) Farm Pond,

c) Earthen embankment

d) Check dam

e) Gabion

f) Agroforestry

g) Mangroves

Fig. 2 Ex-situ soil and water conservation measures

Conclusion

Agricultural activities in ANI exposes surface soils to the rainfall, which carry away a huge amount of top fine soil particles along with runoff to the Andaman Sea through low lying streams/nallahs. It is a matter of serious concern that due to huge loss of surface soil on account of soil erosion, associated soil macro, major and micro nutrients are lost recurrently to the mouth of Sea each year leading to nutrient depletion and poor soil fertility. The land mass of the Islands is precious not only from the soil fertility point of view, but also for the existence of the Islands as well. Therefore, suitable soil and water conservation measures are the needy of hour for solving water crises problem for both the drinking and agricultural uses in Andaman and Nicobar Islands. This paper reviewed the soil erosion control and water conservation measures suitable for Andaman and Nicobar Islands.

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