SR-47

# SOIL AND WATER CONSERVATION WITH SPECIAL REFERENCE TO N.E. REGION

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# PREFACE

*The North Eastern Region is the highest rainfall zone of the country and is richly endowed with water resources of its two mighty river systems the Brahmaputra & the Barak. The region is a huge sprawling land mass made up of extensive countless hills and mountainous terrain that rises in the north to the snow-capped heights of the Himalayas. However, the region presents a case of poverty in the midst of plenty. While the narrow valley portions suffer from excessive floods/drainage congestion the hilly regions consisting of about 70% of land mass is prone to severe soil erosion.*

*Although the national water policy gives highest priority for drinking water, it could not be achieved as desired any where in the North East. The problem is more acute during winter in some hilly areas even like Cherapunji which is in the wettest belt of the world. The region is yet to receive basinwise and even sub-basin wise planning for composite purposes of providing drinking water and other uses with due regard to ecology and environment.*

*To contribute to some improvements to the complex water resources problems of the region, soil & water conservation through watershed treatment is one of the important factors being considered specially for hilly areas. Such measures may also augment dry weather flow on hill slopes to provide for drinking water.*

*It is in this context that Adviser(IFC&WSM),North East Council requested interested bodies to take up a pilot project in the Cherapunji area for soil & water conservation. Therefore, the Regional Coordination Committee of NERC, in its 5th mh meeting held at Shillong on 13th Sept,1995 advised NERC to initially prepare a status report on the subject for other field works to follow. The report should be an useful reference on the subject.*

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ABSTRACT

North Eastern Region is one of the richest areas in the world in soil & water resources. Its water resource is undoubtedly sufficient enough to satisfy its ever increasing demands of its own as well as the other parts of eastern India. But due to management problems the region is yet to put these vast resources into some beneficial uses worth the name and rather chronically suffers from devastating floods or drainage congestion in the valleys and acute shortage of even drinking water or large scale erosion in the hills.

Management of excess water or controlling the frequent calamities it causes to the horrors of the people is, however, beyond the scope of the topic. But looking at the other side of the problem i.e. scarcity of water amongst plenty specially in the hill region during non-monsoon, there is urgent need of all round soil and water conservation for which every forum technical or administrative has been expressing its serious concern since long.

There have been many successful scientific efforts towards this elsewhere in the country. There have been small scale practices and experiments in the North Eastern Region as well, but in reality most of the people of the region are yet to have know hows of the same or motivated enough to translate the ideas into reality. Then barring few experimental, research and indigenous practices, no comprehensive watershed management plan for resource conservation has yet been made in even the serious problem areas like Cherrapunji etc.

In view of the growing concern of all the sectors to the soil & water conservation in *North East Hill Region*, this report is an attempt to review the problems and methodologies in details, analyze it for applicability and suggest suitable remedial measures.

## 1.0 INTRODUCTION :

There is increasing environmental crisis throughout the globe. Influence and demand of burgeoning population on soil & water, the two primary constituents of the ecosystem had already caused great damage to our nature and environment. Therefore, like other parts of the world India is also making its best efforts to conserve natural resources emphasizing on resource planning for every hydrological unit. National water policy envisages that water which is already a scarce resource will become even scarcer in future. Although Green Revolution has helped us to achieve a measure of self-sufficiency in foodgrains, we are still seriously short even at our present low levels of nutrients and consumption of oilseeds, pulses, animal proteins, natural fibers, timber, fuel wood and a host of other commodities which owe their origin to the soil. The loss of soil fertility and potential production through erosion and soil degradation are our national problems, the solution of which concerns not only the farmers who produce the food, but also the urban dwellers who consume it, and the government which has control over land use, agrarian, land tenure and taxation policies. This underscores the conservation of our land and water resources.

North Eastern part of the country comprising seven states has large diversity in topography, climate and soil conditions. Barring Assam and Imphal valley, flat lands in these states are rarely available. In the narrow valleys and hilly terrains there is green lush throughout the year. But the agriculture scenario is not very encouraging. It is also a paradox here that while the highest rainfall in the world is recorded around Cherapunji area, many areas are prone to ravages of floods of the two mighty river systems- the Brahmaputra and the Barak, large parts of the hilly region including Cherapunji experience severe scarcity of water during non monsoon months.

Rampant deforestation and shifting cultivation is posing threat to eco-system of NEH Region. Large areas are under serious threat of wind and water erosion. Not that thousands of acres of land are declining in productivity, it is also causing serious hazards to storage and control structures for water resources development. Besides loss of soil and water, the loss of nutrients particularly nitrates, phosphates and potassium from the soil is enormous. It is because of these reasons that Planning Commission has commented that soil and water conservation is the only foundation upon which India's prosperity in general and NEH Region in particular can be planned.

So far as the NEH Region is concerned there are some efforts of states departments for soil & water conservation like land improvement, gully control works, afforestation works, grass land development, soil conservation engineering works etc. But it is a long way for these works to cover even fifty percent of the area. For any significant relief to the vexed problems people's participation in the guided direction is the only way.

The North East Council, the apex body to look after specially the inter-state developmental activities of the region has been concerned with the water-shed management problems of the hilly areas also. It also invited attention of water resources sectors like NIH to educate and motivate people in soil & water conservation programs specially in hilly region. The report is an effort towards this direction to analyze the problems, review the available technology and suggest suitable remedial measures with special reference to N-E Hilly Region.

## 2.0 REVIEW :

Soil and water conservation practice is considered to be the only way for improving our environment. Large-scale soil and water conservation activity in India began in 1951. Till the end of sixth five year plan, nearly Rs 22,000 million have been spent on improvement of about 29.3 million hectares of land with various soil and water conservation measures(Gupta R K et al.). In the early phases, the soil and water conservation programs were mainly confined to the improvement of agricultural lands, contour bunding being the principal activity. However, in the last two decades, the concept of integrated land-use planning on watershed basis was introduced. This was mainly owing to the establishment of a chain of Soil Conservation Research Demonstration and Training Centers during the First and Second Five Year Plans. In the last 25 years, these centers have identified the soil and water conservation problems of the country and produced some practical technologies for field application. Fig.2.1 and Fig.2.2 broadly show soil conservation regions of the country and its erosion prone areas respectively.

### 2.1 Physical Concepts (Agriculture and Non-agriculture) :

#### 2.1.1 Agriculture Land :

Soil and water conservation practices for our agricultural lands include contour farming, mechanical measures such as contour bunding, graded bunding, bench terracing on steep slopes, runoff harvesting, storage and recycling.

Contour Farming experiments at Dehradun have shown that contour cultivation alone can reduce runoff and soil loss from agricultural .pn6watersheds even in the high rainfall regions. At Dehradun, the seasonal runoff value of 54% from the untreated catchments was reduced to less than 40% of the rainfall where contour farming was practiced. The corresponding reduction in soil loss was from about 30 tones to less than 20 tones/ha during the rainy season. The methods

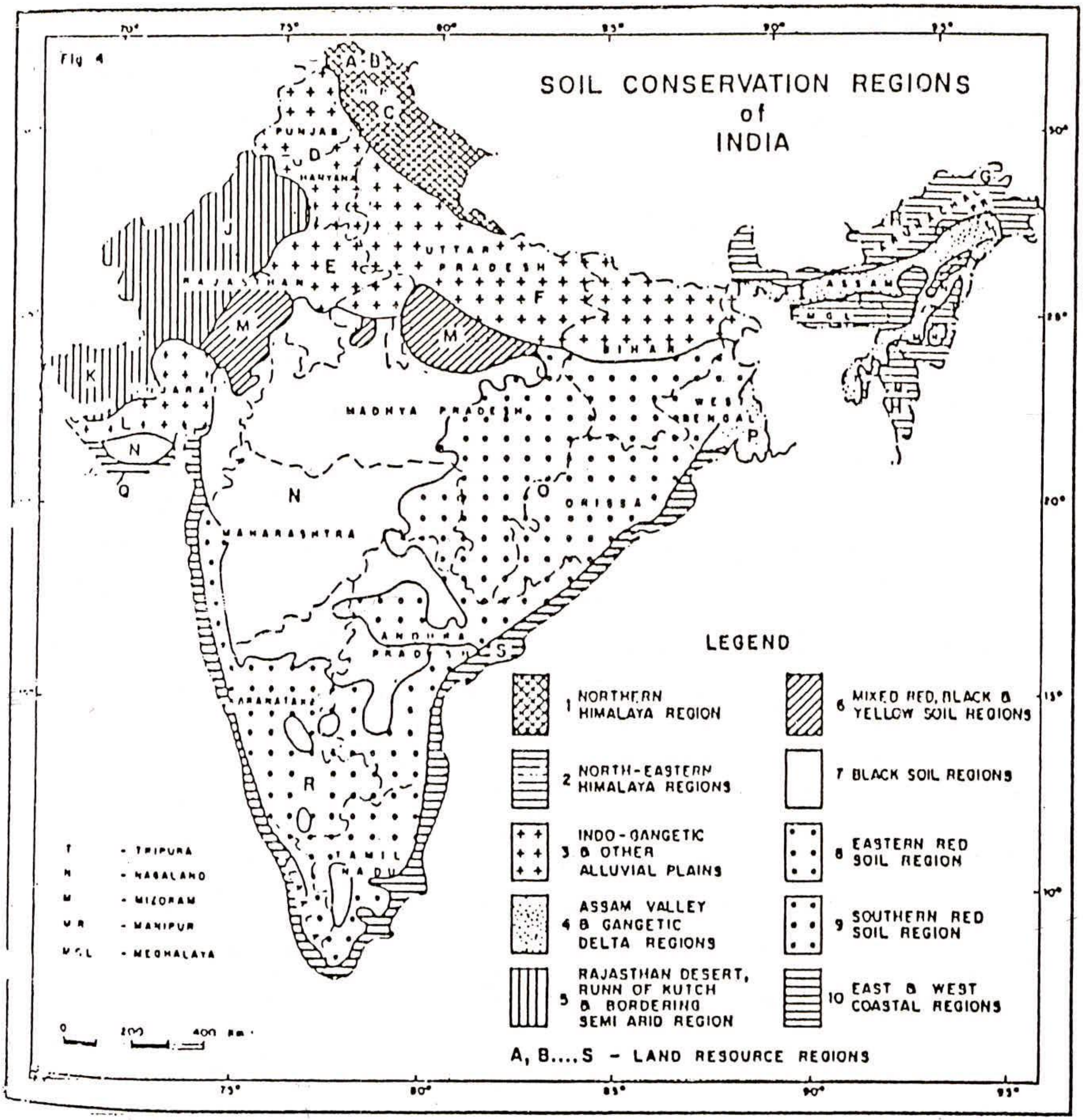



*Fig. 2.1 : Soil Conservation Regions of India.*

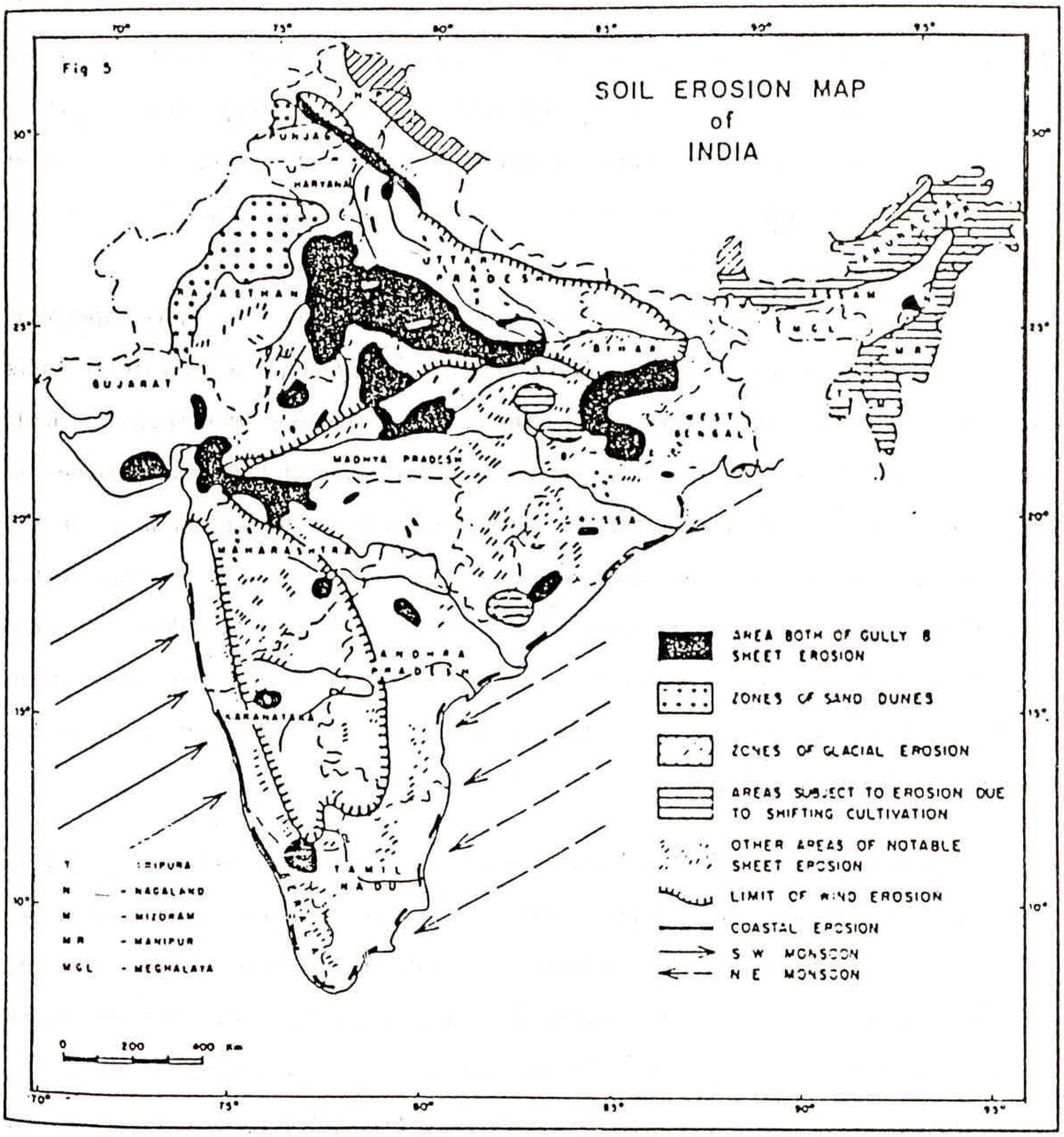



*Fig. 2.2 : Soil Erosion Map of India.*

have been demonstrated in **Fig.2.3** & **Fig.2.4**. In the Ootacamund region, the soil loss from areas having slopes as high as 25% was reduced from 30 tones/ha to 15 tones/ha when farming was done on contours. Potato crop was raised in these catchments. These practices, besides conserving water and soil in the catchment also preserves the soil fertility. Similarly, contour cultivation in the black soil region of Bellary improved the jowar yields by 17 to 34 per cent.

Terracing is a very effective means of conserving soil, but it is expensive. To be economical, it must permit yields to be maintained on a long-term basis under more intensive use than would otherwise be feasible. Nonetheless, yields may be reduced for a few years on the areas where top soil has been removed to build the terraces. The yield reduction can be minimized by stockpiling the top soil and replacing it after the terraces are built, but this adds to the cost. Often it is more practical to use fertilizers manure, green manure and tillage practices to improve exposed subsoil than to replace topsoil. Reduced soil loss should result eventually in higher yields than would have been obtained without the terraces as shown in **Fig. 2.5**.

Forage crops and trees conserve soil effectively, but they take time to grow. Range management may require several years of little or no grazing to let desirable grasses become well established. Increased production in later years will make up for the earlier decreased use. A grazing program that maintains productivity should then be established. Trees take even longer to grow and become marketable. The value is there, however, the land value increases as the trees grow toward marketable size.

**2.1.2. Non-Agricultural Lands :**

These lands have many limitations of slope, erosion, stoniness, rockiness, shallow soils, wetness, flooding, etc. Such areas are therefore, generally unsuitable for cultivation of agricultural crops. The deep gully parts of the ravines are in this group. The work done at Dehradun research centers have shown that these lands can be put to productive use as pastures and forest lands.

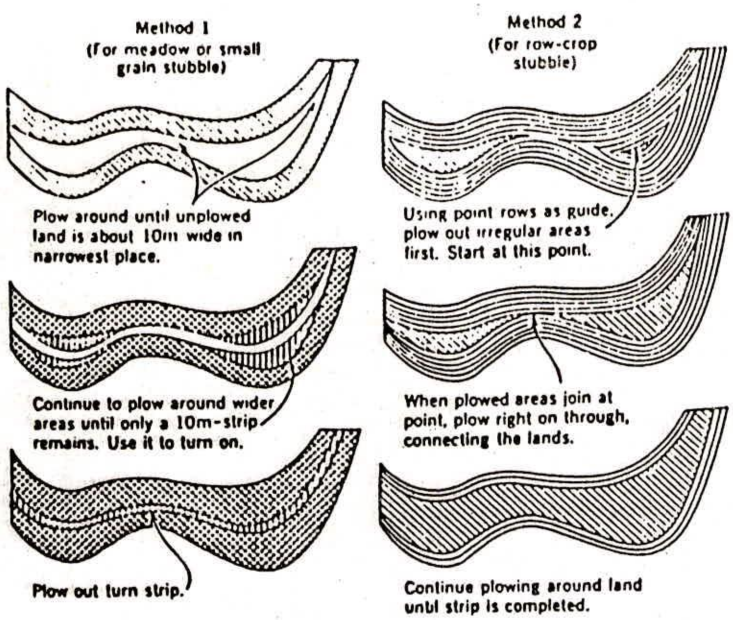



*Fig. 2.3 : Methods of plowing out point-row areas.*

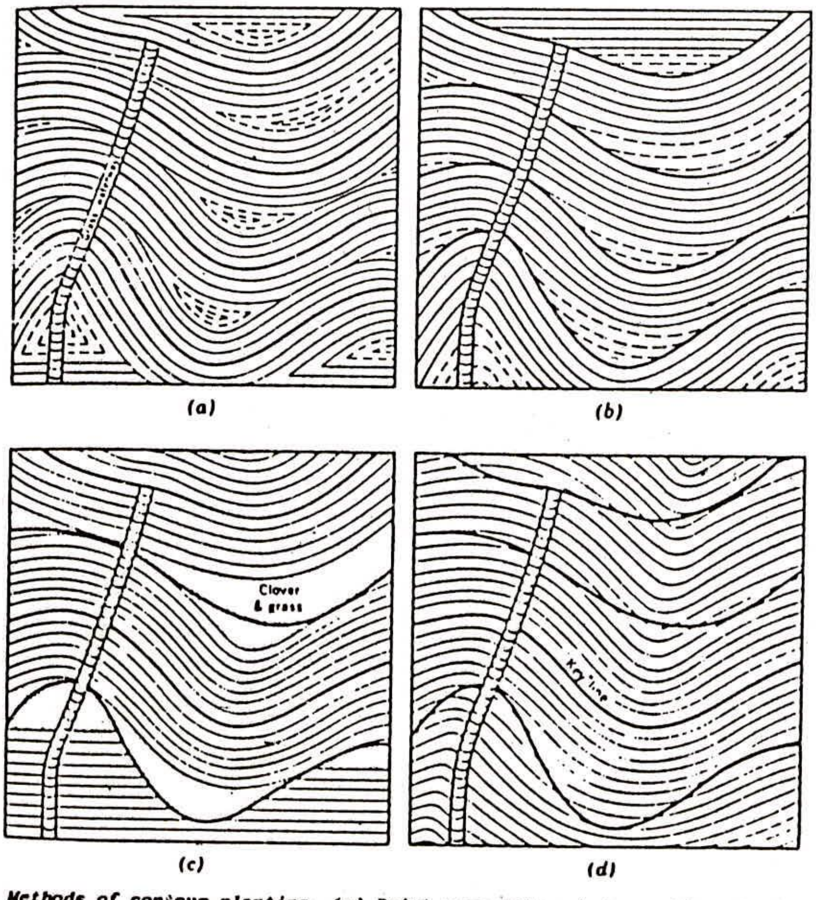



***Fig. 2.4 :** Methods of contour planting. (a) Point rows midway between lines.Entire field is in a cultivated crop. (b) Point rows end at nextcontour lines below. Entire field is in a cultivated crop. (c) Point rows not farmed, but area is in small grain or hay crop. (d) "Key" line system, point rows only at corners. Field is in one crop.*

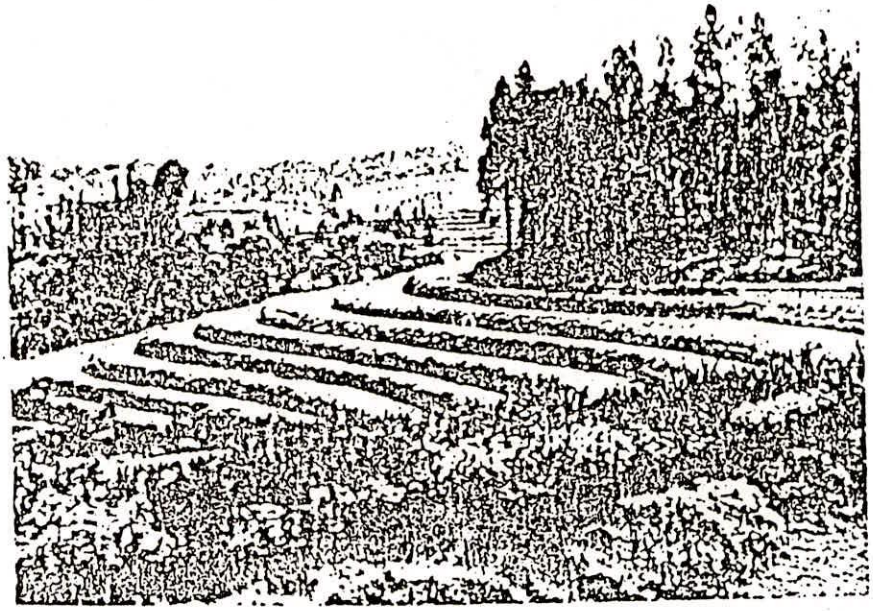


*Fig. 2.5 : Terraces on the hill slopes for erosion free cultivation.*

Establishment of vegetative cover is one of the effective ways of soil and water conservation. It has been demonstrated that natural fallow, with grasses and shrubs or grasses alone give the least and negligible runoff and soil loss when compared with the practice of cultivated fallow, which gives maximum rate of runoff and soil loss.

### 2.2 General Aspects of Conservation Programs :

#### 2.2.1 Physical & Natural Aspects :

The food, fodder, fuel, fruit, fiber, timber and other material needs of the people and bovine population can only be met by the watershed resources, the nature's gift to the mankind. The population pressure in our country is very high and agriculture has already extended to marginal lands distributing the interaction between land and water cycle. Out of the 329 m ha geographical area, there is no more possibility for enlarging the area under agriculture beyond the existing 143 m ha. On the other hand, about 175 m ha (more than 50 %) of the degraded and arable lands are subjected to land degradation (wasteland) due to soil erosion, waterlogging, salinity and alkalinity, floods, changing water courses and shifting cultivation. Such lands are getting further degraded to one or more degradation forces.

In North East Hilly Region too while increasing the food production to meet the needs of the increasing population, adequate attention was not paid to maintain the productivity of the soil resources. As a result, vast stretches of soils are now at various stages of degradation.

Apart from the climatic and soil related factors, socio-economic and area specific factors are also very important from the point of view of land degradatiion. Some such factors are as under :

--Due to small holdings proper care in soil and water conservation measures is not given by the farmers.

--Farmer's being resource poor, unable to take up corrective measures.

--Fragmented holdings and undulating topography accelerates the degradation process due to lack of management and risk in investment.

--Small farmers are compelled to grow crops for their immediate requirement and thus ignoring the suitable crop rotation.

--Open grazing of cattle in absence of stall feeding.

Degradation of land in terms of physical, chemical and biological properties leads to lowering down the productivity and sustainability. It has many implications, the important of which are the lowering down of the Gross National Product (GNP) and standard of living of villagers, besides improvement of soil in term of fertility. Degradation of land leads to loss of precious rain water and along with it the valuable nutrients. India is loosing about 8.2 million tonnes of nutrient annually as a result of soil erosion only, out of which about 3.5 million tonnes gets lost from the N.E Region alone. Another associated problem is the siltation of tanks and reservoirs, clogging of drip and sprinkler irrigation systems and also lowering down of water table in wells. It cause an all-round scarcity of drinking and irrigation water resources, giving rise to droughts and drop in productivity.

It is estimated that India is losing her forest and land resources at the rate of 1.5 million hectare annually. Small and fragmented holdings of farmers coupled with a resource-poor base of dry land and hilly region farmers has not left much scope for management of land and water. The land-tenure system in vogue stands in the way of efficient management of natural resources on watershed basis.

An important constraint to the application of soil conservation is the social and economic conditions of the farming community. Each farm family is engaged in the attempt to earn a living from the land which it cultivates. The total income produced by the farm will be used to satisfy the basic needs of the family, to pay the landlord and for agricultural inputs and to maintain the farm capital including the land. If the total income from the farm is sufficient, a due share will be spent on inputs and soil conservation. If the income is low and the farm has a low production capacity, the portion of income spent on the maintenance of the soil will be insufficient to maintain the land. In other words, the first requirement for effective soil conservation is that the income from the farm should be large enough to provide a sufficient portion for the maintenance of soil capital. Hence, poor soil, insecurity of tenure, low prices of agricultural commodities, high rents are the natural impediments to soil conservation programs. It is therefore illusory to plan expanding agriculture on marginal lands on the assumption that soil conservation and land improvement will compensate for a low production potential.

With increasing population and rising per capita demand for land resources, the seriousness of soil and water erosion can only be tackled by collective approach. North East Hilly Region have inherent biophysical and socio-economical constraints such as :

- Isolation
- Inaccessibility
- Widely scattered settlements
- poor infrastructural facilities
- Maintenance and social customs

These constraints and in absence of any additional source of income and employment opportunities compel the growing population to continue working on agriculture sector or to migrate to plains for employment. The agriculture sector itself has the constraints of limited arable and highly fragmented holdings, poor irrigation facilities and less productive marginal and steep sloping lands.

While the management of private land lies exclusively on the individual, the management of common lands, which often are highly eroded and degraded, present considerable problems, even though these lands have been developed under soil conservation programme. The Government and common lands (including panchayat lands) do not seem to have any caretaker and well wishers. These lands are free for all and it is no wonder that they are in very bad shape in the whole north east region.

### 2.2.2 Social Aspect

Another consideration in planning soil conservation programs is that in most instances, community or cooperative action is indispensable. Small farms which are characteristics in our country, do not allow for an individual farmer to have an impact on land improvement. Soil conservation programs will, therefore, have to be tackled on a watershed basis. Some erosion or flood control measures may be within reach of a group of farmers but for larger undertaking, the support of Government is called for. It is clearly the Governments role to maintain the country's basic resources of soil and water. Technical assistance programs often denying priority to soil conservation programs because of lack of immediate economic return, should be the deciding factor for investments in soil conservation work. At all times, farmers should be closely involved in the planning and execution of field programs. New management techniques should not become a continuous burden to the farmer. On the contrary, they should be within his capacity and he should understand the beneficial effects.

Many developing countries have a historical legacy of land reserved for the use of some agency or power. In sovereign states of feudal systems, land was automatically the ruler's except where some form of title had been granted in return for services rendered. Whatever the historical background, many developing countries have a sizable proportion of land which was previously reserved and is now up for grabs. As authoritarian management has declined, population pressure and land hunger have increased as also has the chance of getting away with unauthorized or illegal encroachment on reserved land. In some cases, encroachment have been ignored, the previously reserved forests were thrown open to settlements. After Independence, the Government of India had no choice but to accept and regularize some of these encroachments.

There are also some examples where the land was deliberately withheld from settlement because it was ecologically unsuitable. This is particularly true of steep mountainous land in the humid tropics. However, even in such areas, terrifying destruction of the land is occurring as a result of the spread of agriculture in the form of small farms into a land which cannot possibly support this use in the long term, e.g., the steady climb of cultivation up the mountain slopes in the Himalayas of India and Nepal.

In India, the declared policy is 'land for landless' and Government legislation is that 50% of all state or public land must be made available for allocation to people who do not own any land. The practical limitation to this policy in a country like India is that there is no reserve of spare land suitable for cultivation. The common land is usually worn out or eroded or so steep that it is only suitable for forestry.

Right of ownership to land is one of the factors which lead to an over stressing of land resources. Partly it is historical; in the past there was enough land for everyone to have some and increase in population just meant bringing more land into use. Alongside the assumed rights of land ownership there are other historical rights which do not fit into today's land-use pattern. Throughout India, there are rights of villagers to graze certain areas, to cut fuel wood, to take timber for making agricultural implements. The story of the rights is so ancient and so complex that Muslim, Moghul and British rulers have in turn accepted the situation as too difficult to changes as in the present days. The problem is that these rights make it often difficult to manage efficiently even the so-called reserved forest.

A corollary of the acceptance of the universal right to own land is the allocation or encroachment of poor land. The other consequence is that it leads to the progressive sub-division of land holdings. Examples of such fragmentation are seen in many Indian villages. In some states, this has lead to the consolidation programme which in effect puts all land into a common pool and then redistribute it in more manageable parcels. But this procedure has yet to make major strides.

### 2.2.3 Economic Aspects :

The economic constraint of the subsistence farmer is his inability to take risks. The essence of farming is, therefore, to minimize risks or to improve the odds in the gamble against weather, pests and diseases. Apart from the on-site benefits of erosion control, there may be other reasons why erosion control is required. The down-stream damage caused by sedimentation, increased flooding, reduced hydro-electric power, interference with irrigation, may be more important than the loss of soil. The farmer of the Himalayas cannot be reasonably expected to care very much about the silting of an irrigation reservoir 1,000 km away in Gangetic plains. It is easy to calculate the costs of soil conservation and more difficult to determine the benefits; even more difficult to quantify the benefits in cash terms.

### 2.2.4 Awareness :

At present, there is a wide gap between awareness of the soil erosion problem and comprehensive action to combat it. Prospects for establishing comprehensive soil conservation programs are some times not good because the proposals may not appeal enough to politicians, decision makers and planners. Also from an economic and short-term point of view, they may not be attractive to many farmers, particularly to those who are in economically weak position. Important reasons for the indifference are (i) lack of knowledge of the soil erosion problem; and (ii) lack of knowledge of how to solve the problem. It appears conclusive, therefore, that the interests of future soil conservation programs, particularly in developing countries can best be served by creating a better awareness of the problems and its solutions and to obtain effective results.

## 2.3. Shaping Soil Conservation Programs :

It is necessary to consider soil conservation not as an end in itself but as a means of maintaining and increasing the productivity of the soil on a long-terms basis. This calls for the introduction of soil conservation activities with improvement measures such as soil management, recycling of organic materials, changing attitude to shifting cultivation, tillage practices adjusted to environmental conditions and adjusting cropping and farming systems. In other words, it is necessary to consider soil conservation as part of an overall soil management concept.

It is also necessary to relate research work and scientific guidance to the more immediate needs of applying practical soil conservation programs. Some of the thrust areas in this regard are:

(i) Adjustments, improvements and studies on applicability of soil conservation and soil management practices.

(ii) Comprehensive land-use planning.

(iii) Selected research problems of immediate importance.

In most of the developing countries, there is extreme dirth of well-trained soil conservation staff, both for research and extension. Intensive training programs at various levels are urgently required.

A sound scientific and technical basis for conservation programs starts with an assessment of a country's land resources, than its production potential and degradation hazards. The achievement of short-term results should, however, ensure that comprehensive soil conservation programs are not unduly delayed. In most cases, in the planning and execution of soil conservation programs, a co-operative watershed approach involving the whole community is indispensable. The small sizes of farms in most developing countries does not allow for the individual farmer to have much impact on soil conservation processes and the only alternative is to tackle it by a concerted action on a watershed basis, where all efforts reinforce and complement each other. It is important to create a socio-economic environment which encourages the farmers to develop efforts and resources to the conservation of the country's soil resource. Government plays a role in providing financial helps consisting of loans, subsidies and other incentives. Foreign assistance is also forthcoming in respect of soil conservation programs.

2.3.1 Cost-Benefit Considerations :

The costs of soil conservation are usually obvious and therefore seldom overlooked. The returns are less identifiable, especially where conservation merely preserves productive potential that would otherwise be lost. Lowered potential may be masked by weather variations, more fertilizer, new crop varieties, and improved crop management.

Soil-conservation practices often provide long-term benefits in exchange for immediate costs. It is unfortunate but not surprising that immediate needs of the present often win over the future prospects. Conservation practices that include short-term benefits are therefore easier to promote than those that are strictly long term. However, some practices such as terracing are used in spite of the long time required to recover its costs. Changes in tillage, including contour tillage, reduced tillage, and no-till systems, are usually profitable, but their adoption has been slowed by appearance and convenience factors and pest problems.

Many people may benefit from a landowner's conservation practices. For example, soil that is held on a field neither muddies the water of a stream nor becomes sediment on other land. People living downstream therefore benefit from soil conservation practices upstream. In a broader sense, everyone has a stake in the productive potential of the land. Such interest is represented to some degree by governmental participation in soil conservation through research, education, cost sharing, tax benefits, and legal actions. Such participation is justified by the importance of productivity potential as a national asset. Reduced productive potential is the most serious long-term effect of erosion.

2.3.2 Benefits From Soil Conservation :

Soil conservation yields many kinds of benefits. Those to be considered in this section include increases in net returns from land, retention of productive potential, reductions in erosion losses and sediment damage, and environmental benefits.

<u>Increases in Net Returns</u>: Some conservation practices produce an immediate profit, some lead to a delayed profit, and some produce no monetary profit but are used for aesthetic or other non monetary reasons. Some practices are usually considered under the heading of good management rather than conservation because they increase profits. Fertilization according to soil tests is such a practice. Fertilization is actually an important soil conservation practice.

Various forms of <u>conservation tillage</u> often increase net returns. Most of them reduce the energy input use for tillage and thereby reduce costs.

Several studies have shown that average corn yields are insensitive to tillage practices as long as comparable stands and adequate weed control are obtained. Minimum tillage usually shows an advantage on sloping land, where it helps conserve soil and water. Conventional tillage usually yields more than no-tillage where continuous corn is grown on land wet enough to be conducive to root disease. Results with wheat and some other crops have generally been less favorable to no-tillage than corn yields have been.

Fuel and machinery savings from reduced tillage make it possible for producers to make larger profits from equal yields even if they use more pesticides. Rising energy costs and new types of herbicides, insecticides, and fungicides have led to a marked expansion of minimum tillage in recent years.

<u>Water Conservation</u>: The importance of water conservation depends on the amount of water already in the soil for plant use. Water conserved before a dry period can make the difference between success and crop failure. Excess water retained during a wet period by holding water on drier sloping land rather than letting it run on to level areas below can damage the crop and reduce yields.

<u>Pest-Control Profits</u> Weeds, insects, and plant diseases can cause increased erosion by reducing the stand of the crop. Controlling these pests can reduce erosion and increase profits at the same time.

### 2.3.3 Deferred Profits:

Fertilizer, tillage water management, and pest-control practices should increase profits the same year they are applied. Several years may be required to repay the investment costs of drainage, irrigation and new machinery but increased returns usually begin with the next harvest. The returns may be delayed longer when practice such as terracing, revegetating grazing land, replanting forests, or soil reclamation are used. These practices must therefore be considered for long-term investments.

Reclamation of sodic soils is another example of delayed profits. Sodic spots are often so unproductive that any plant growth is an improvement. Improving them to grow profitable crop it takes time often years. Deferred profits often create a conflict between long-term and short-term values. Degraded vegetative cover and serious soil loss can occur under short-term exploitation of lands.

## 2.4 Soil And Water Conservation Methods :

Adequate control of water erosion requires an integrated use of the best physical and engineering practices that will protect the soil, reduce runoff and conserve soil & water. The results of studies conducted in India and other parts of the world have been reviewed in the publications (17), (25).

### 2.4.1 Mechanical/Engineering Measures :

Mechanical measures form the second line of defence in agricultural areas which are subjected to relatively severe erosion hazards. These include contour farming, strip cropping, conservation tillage, terracing and microwatershed treatments.

The engineering aspects of erosion control are primarily concerned with changing slope characteristics so that velocity of runoff is reduced. For example, the length of slope may be controlled by the spacing of terraces across the slope. The effect of degree of slope on the concentration of runoff may also be controlled by terracing. The cutting action of concentrated water in terrace channels, gullies, or drainage ways may be controlled by a combination of suitable engineering structures and vegetative protection. In addition, contour farming and strip cropping changes slope characteristics. Contour farming seeks to make each row of a particular crop to serve as a minimum terrace to decrease the rate of water movement from a cultivated field. Strip cropping functions as a means to reduce the length of slope for tilled crops.

Some of the measures widely used for soil and water conservation with their objectives are described/reviewed below:

## *TERRACING*

Terraces are a number of platforms or wide steps across the slope of the hills made by cutting earth at regular intervals. These are mechanical barriers that break the slope length and reduce the degree of slope.

The major effect of terraces on the control of erosion is to cut down the length of the watershed and to conduct the water off the field at a low velocity. Reducing the velocity of the water in the terrace channel causes a deposition of a large portion of the silt load in the channel. Consequently, only a small part of the soil that is eroded between terraces leaves the field in the water that causes the erosion. It has been experienced that when terracing is combined with good agronomic practices, erosion can be decreased to a minimum.

The spacing of terraces to control erosion is determined primarily by the slope of the land. Terrace spacing should vary with the ability of the soil to absorb water and transmit it through the profile. If the infiltration capacity of a soil is twice that of another soil of comparable slope conditions, a wider spacing of terraces on the former than on the latter should not cause increased runoff losses.

The key to the successful functioning of a system of terraces is the terrace outlet as detailed in Fig.2.6. Since terracing concentrates water in the channels, the outlets must handle this concentrated flow as it is discharged down the slope. This means that outlets must be completely stabilized to prevent gully erosion. The ease and economy of stabilization depend considerably upon the properties of the soil over which concentrated water must flow. The major difficulties in obtaining suitable outlets are found in connection with the terracing of moderately sloping soils that have a high silt content and soils that possess heavy clay subsoils.

Many silty soils do not contain sufficient clay to cause much cohesion between particles. Such soils erode easily under the current action of concentrated water. They present a difficult problem in the construction and maintenance of good terrace outlets. Since the soil has little cohesion, binding power can be provided through the roots of suitable grasses.

The type of terraces detailed in **Fig.2.7** commonly suited to the North Eastern Region, because of its high rainfall. It is 'Bench Terracing' with inward as well as length-wise (when feasible) slope. The other type of terracing which can be utilized for raising tree crops on hill slopes is the Half Moon Terracing.

Farmers in the hilly areas have to undertake farming in hill slopes and the common practice in the N.E. Region is to cultivate along the slopes. This leads to erosion of top soil which is most essential for crop growth, removes the soil nutrition with erosion and lead ultimately to low production. In such cultivation there is no scope for improved cultivation practices and use of irrigation water. It also finally disturbs the soil and water balance in the area.

**Terraces in hilly region** normally should be made in gentle slopes (upto 33%). However, terraces on higher slopes may be made with reduced batter of risers. Typical sections for making terraces are shown in **Fig.2.8** and **Fig.2.9**. The following have been suggested in making terraces:

*(a) The first step is to decide the vertical interval. The interval should normally be around 1 to 1.25 meters.*

*(b) To mark the contours in the interval and start with the ridge.*

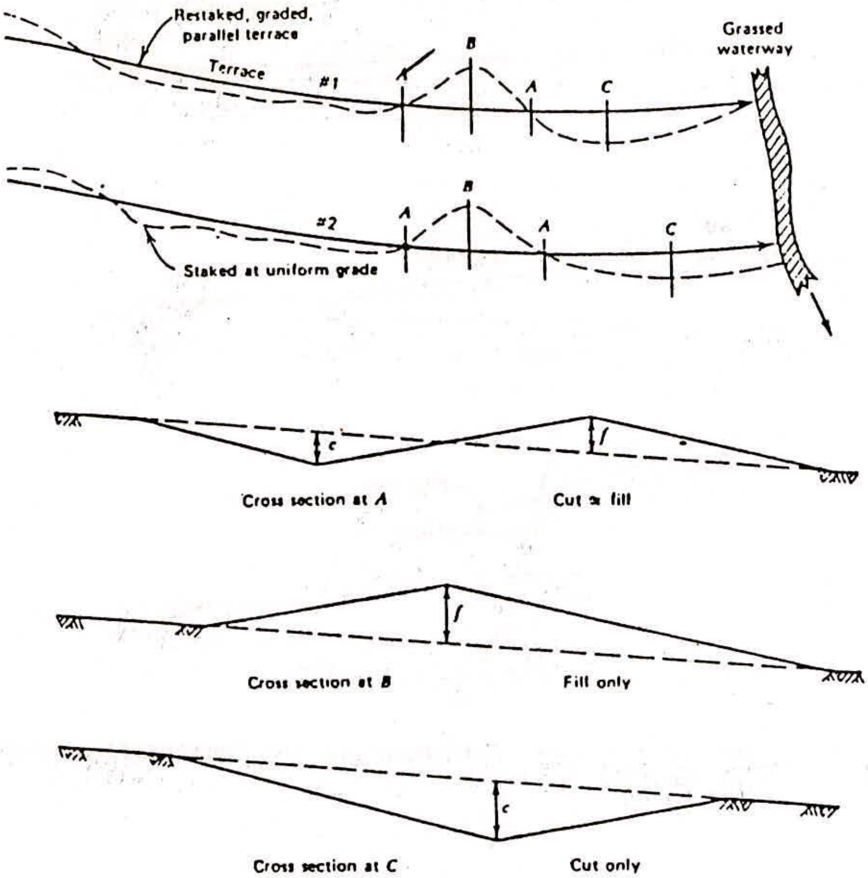



*Fig. 2.6 : Layout of parallel terraces with varying cuts and fills.*

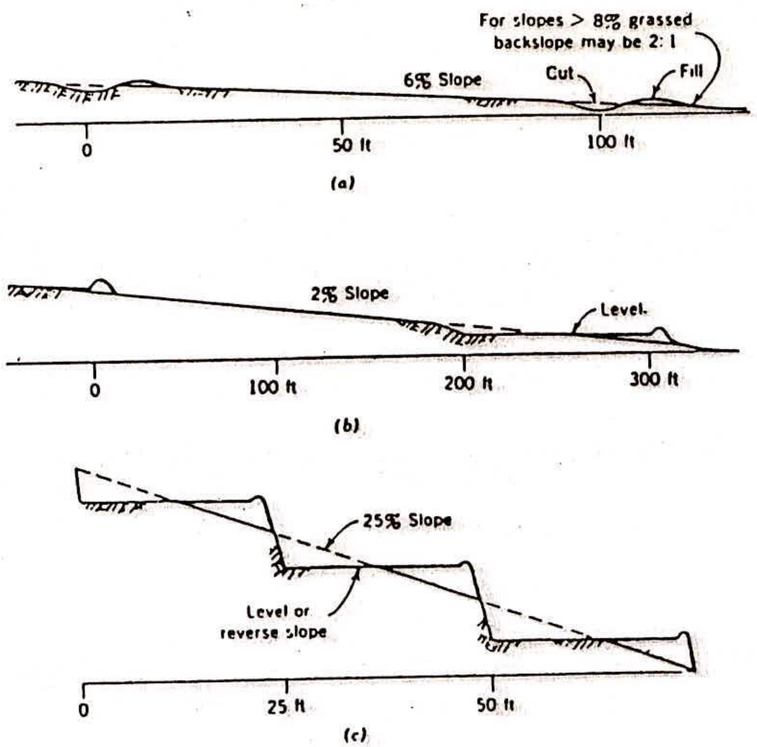



*Fig. 2.7 : Types of terraces. (a) Broadbase (b) Conservation bench (c) Bench*

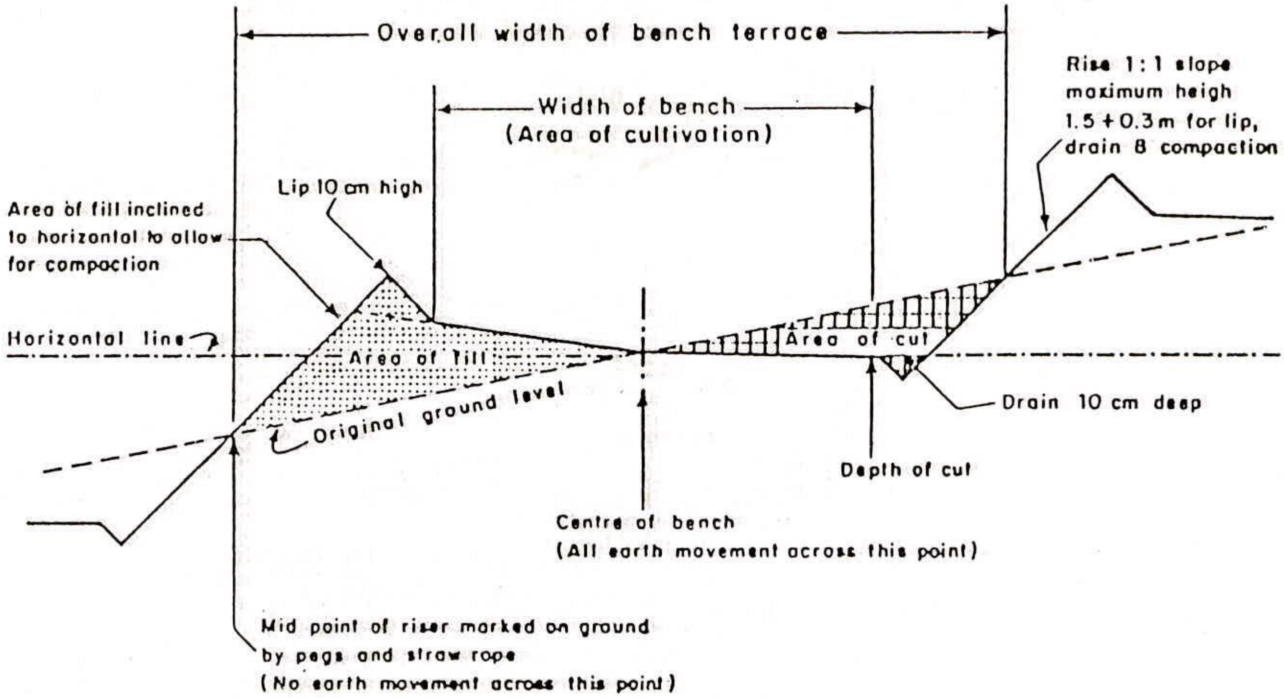



*Fig. 2.8 : Typical cross section for back-sloping bench terrace.*

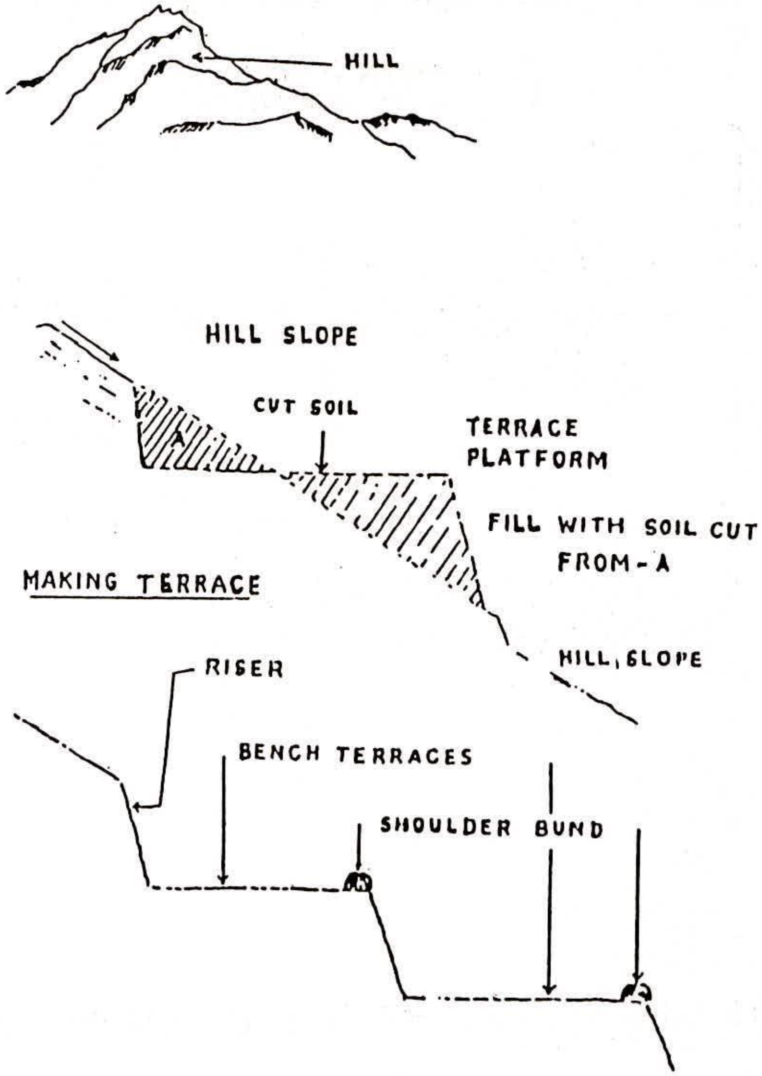



*Fig. 2.9 : Making bench terrace.*

*(c) To cut the lower most terrace first. This procedure has an advantage that the top soil of the upper terrace can be spread on the lower one so that all terraces except the top-most one will not lose the productive top soil.*

*(d)To continue cutting and making terraces upwards.*

*(e)The terraces should be sloping inward with 2-1% grades. Lower grades are preferable. Longitudinal grades, if given, should range between 0.5 to 0.8%.*

*(f)The terraces should be normally be about 2 meters wide. Table 2.1 gives the vertical interval and width of terraces for hills with different slopes.*

**Table 2.1**
**Approximate Terrace Width on Hill Slopes**

| Slope (percent) | Common Vertical Intervals | |
|---|---|---|
| | 1 meter | 1.25 meters |
| 10 | 9.5 | 11.5 |
| 15 | 6.0 | 7.5 |
| 20 | 4.4 | 5.5 |
| 25 | 3.5 | 4.2 |
| 30 | 2.9 | 3.5 |
| 35 | 2.2 | 2.9 |

*(g)Risers may be given 1:1 batter slope which will be gradually reduced to 1/2:1. The risers normally should be slanting upwards. They may be straight if they are properly protected from soil loss by stones etc.*

*(h)The risers can sustain grass cover as a source of fodder.*

*(i)It is preferable to have a shoulder bund at the edge of the terrace to ensure stability of the terraces. The bund may be around 15-25 cm., in height.*

*(j)Terraces are usually made from the top. Although it is little less expensive, yet it will not ensure prevention of the top soil. If terraces are made from below (specially when the area is small) the top soil of the upper terrace can be spread in the lower one while cutting.*

*(k)For making half-moon terraces earth from the slope is cut to make a flat bottom with a half moon or semi circular curve in the riser. Such half moon terraces are made at distances in which the trees are to be planted. While weeding, application of fertilizer and irrigation etc. can be done easily avoiding soil erosion, the unnecessary cost of making bench terraces are saved when only trees are to be planted on the hill slopes.*

Proper maintenance of the terraces is essential and special care needs to be taken in the first two years. The following steps should be taken for the purpose:

*(a)Tillage operations should be done starting from the outer edge and continuing parallel to it inwards.*

*(b)Pot-holes, breaches and cleavages need to be repaired immediately.*

### *CONTOUR FARMING*

Contour farming is the practice of performing field operations, such as ploughing, planting, cultivation and harvesting approximately on the contour. The small ridges and plant stems in the contoured row hold water and thus prevent run-off. The ridges are most effective in row crops, but the water holding of the ridges supplemented by plant stems, makes contouring valuable for small grains also.

### *STRIP CROPPING*

It is the practice of growing alternate strips of close-growing and inter-tilled crops in the same field. In fact, it is not a single practice but a combination of several good farming practices, particularly crop rotations, contour farming and cover cropping, and may also include conservation tillage operations, and stubble mulching. When strip cropping is combined with contour tillage or terracing, it effectively divides the length of the slope, checks the velocity of run-off, filters out soil from the run-off water and facilitates absorption of rain. It is especially effective when inter tilled crops are interspersed with sod type crops. Strip cropping is also more effective in controlling erosion in areas of moderate to low rainfall intensities. The three general types of strip cropping shown in Fig.2.10 are:

i. Contour Strip Cropping in which crops are arranged in strips or bands on the contours at right angles to the natural slopes of the land. Generally the strips are cropped in a definite rotational sequence. Where the slopes of a field are more or less uniform, contour stripping is generally practiced.

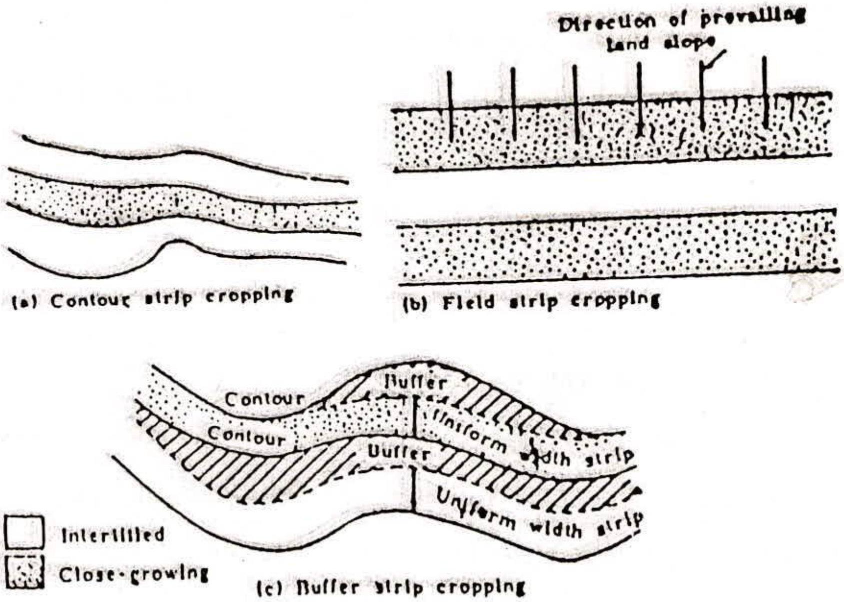



*Fig. 2.10 : Typical layout for different types of strip cropping.*

ii. Field Strip Cropping which consists of strips of uniform width running generally across the general slope and the practice is recommended only in areas where the topography is too irregular or undulating.

iii. Buffer Strip Cropping which consists of strips of some grass or legume crop laid out between contour strips of crops in the regular rotation. They may be even or irregular in width and can be placed on critical slope areas of the field.

*CONSERVATION TILLAGE*

Stubble-mulch farming is a protective covering for the soil which would control runoff and erosion. In other words, since the falling raindrop is the precursor of water erosion, then a mulch on the surface of the soil should provide the necessary protection. The major problem consisted of being able to obtain a mulch while preparing the land for the planting of crops. This problem can be solved by using a duckfoot type of cultivator that stirs the soil under the trash blanket without turning under the organic matter serving as the mulch. This practice has been termed "subsurface tillage." It has received great emphasis throughout the country as a soil and moisture conversation measure.

Tillage is the mechanical manipulation of the soil to provide soil conditions suited to the growth of crops, the control of weeds, and for the maintenance of infiltration capacity and areation. Traditionally tillage has consisted of cutting loose, granulating, and inverting the plouth furrow slice, thus turning under the residues. While the essential basis for tillage is the preparation of a seedbed, the role of tillage has become more important as a water conservation measure. The conservation tillage operation can be classified into following classes:

(i) Mulch tillage : Mulch tillage or stubble mulching is a crop and soil management practice that utilizes the residual mulches of the preceding crop by leaving a large percentage of this vegetation residue on or near the surface of the ground. Tillage that leaves the surface of the soil cloddy and mulched with crop residues is an effective accompanying measure with strip-cropping to minimize soil erosion and to conserve moisture. It is one of the most effective measures to conserve soil and moisture on land that is in fallow and to protect small grain and row crop land during periods of seed bed preparation for a succeeding crop. In extremely heavy mulches, particularly when they are perennial, or when soil moisture is relatively high, it is sometimes necessary to particularly invert or cut up the crop residue.

__(ii) Listing and Ridge Planting__ : Listing or ridging are terms used to describe the formation of alternate furrows and ridges on the land. When it is done on contours it helps in conserving soil and water. When small dams are created at intervals in furrows it is known as **basin listing** or **tied ridging.** In low rainfall areas in which a large percent of the annual rainfall comes in short intense storms, and in regions where gently sloping fields permit the use of contouring alone as soil and water conservation practice, tillage is frequently carried out with listers.

### *MECHANICAL PROTECTION WORKS*

Mechanical protection works are to supplement good agronomic or cultural practices and should not be viewed as a substitute for them. They are usually permanent structures of earth or masonry, or a combination of both, which have to be constructed either by hand labour or machinery to protect the soil from erosion by water and also to conserve water. These include interception, diversion or storm channels or drains and terraces of various kinds, waterways for drainage and water disposal, gully control structures, and dams. Design and construction of these practices to acceptable standards are essential if they are to be effective and require minimum maintenance.

The main purpose of the diversion type channel is to protect lower lying land from erosion by intercepting run-off flowing down into a main drainage channel or waterway Level terraces intercept and arrest run-off and thus encourage the water to soak into the soil safely to a protected drainage way. In addition, most terrace water are designed to reduce the effective length of the slope of the land, thus reducing the hazard of erosion by run-off.

Surplus water from diversion channels or terraces is usually disposed of by surface drainage to main drainage channels or waterways planted with sod forming grasses. Gully control structures usually take the form of small dams constructed of rock, masonry, brush or wood which reduce the velocity of the water conserving and flow control structures which are used to store water for irrigation, for watering livestock or domestic consumption.

With most land which is cultivated on slopes, no matter what soil conservation measures may be applied, all effort in this direction can be ruined by run-off water flowing down the hill or catchment above, entering the cultivated area and scouring out rills or gullies, washing away crops, or breaking down terraces. An interception or diversion channel outside and above the cultivated area is the best remedy in this situation and is in fact absolutely essential. In many cases this may be the only mechanical structure necessary in addition to good agronomic and tillage practices. It is surprising how often this simple, cheap and effective practice is overlooked.

Other water harvesting by engineering practices are:

1. Silt traps,
2. Check dams, and
3. Bunds and terraces.

<u>Silt Traps</u>: These are built of stones across the beds of intermitted streams. The size of silt trap structure varies enormously. In order to assess the adequacy of silt traps one must consider two aspects. : first, its cost and second, its effectiveness in harvesting runoff. Few silt trap-structures are shown in Fig.2.11.

<u>Check Dams:</u> Check dams of varying design are constructed for the purpose of stabilizing the grade and harvesting runoff water from large catchments, even

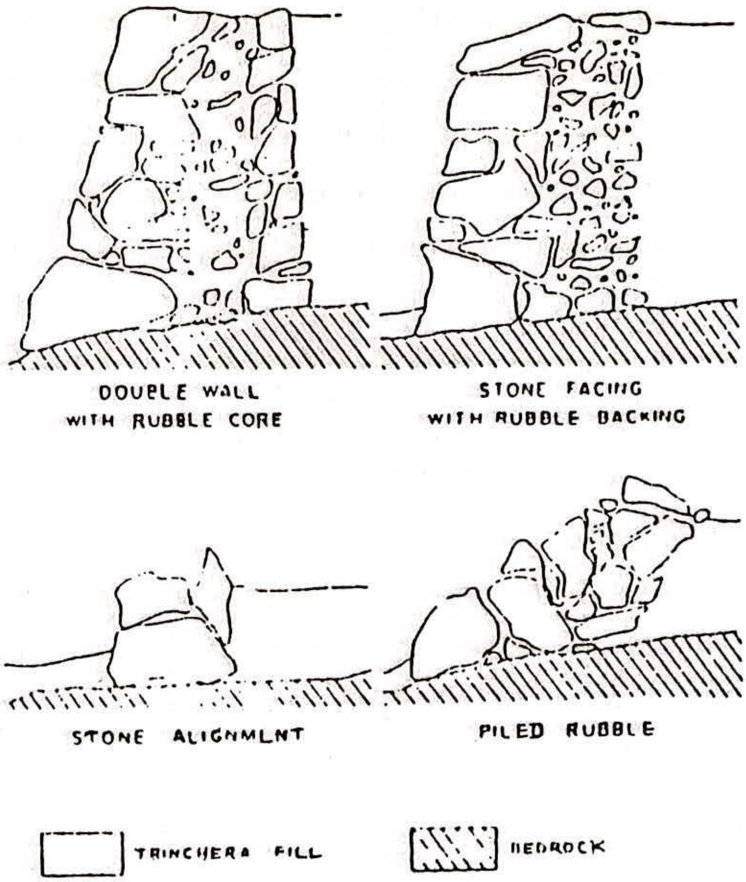



*Fig. 2.11 : Silt trap structures used for water harvesting.*

under arid conditions. Check dams are made of locally available materials like brush, poles, woven wire, loose rock and plants or slabs. Temporary check dams constructed across the bed of a gully have two uses : (1) to collect enough vegetation and (2) to check channel erosion until sufficient stabilizing vegetation can be established. Few temporary check dams are shown in **Fig.2.12, Fig.2.13** and **Fig.2.14.**

The life of temporary check dams depends on the quality of the materials and efficiency of construction; but under ordinary conditions, they should last from 3 to 8 years. The check dams normally used in small catchments are Woven-Wire Dams, Bush Dams, Loose Rock Dams and Plank or Slab Dams.

**Bunding** is by far the most effective and widely practised field measure for water harvesting. It is the placing of small earthen dams across local streams to collect the rain water. The reservoirs so formed are called tanks. Tanks are usually shallow and the stored water covers a large area which means a relatively large evaporation.

### 2.4.2 Runoff Harvesting, Storage and Recycling :

Harvesting of runoff at a micro level for storage and recycling is necessary and possible for better utilization of rainfall, control of erosion and providing some essential and life-saving irrigations to the crop during the dry spells in the monsoon season and also for growing a second crop in rabi season in many regions of the country (ranging from the humid areas of Dehradun to the arid and semi-arid regions).

Small ponds and tanks are essentially micro reservoirs for storing the excess runoff water during the intense storm periods. They are subjected to some seepage and evaporation losses. But these should be controlled to some extent. In the ponds constructed in alluvial soils (Agra and Vasad region), heavy seepage losses have been observed. On the other hand, seepage losses from dugout ponds in black clay soils at Bellary, in general are negligible. Seepage

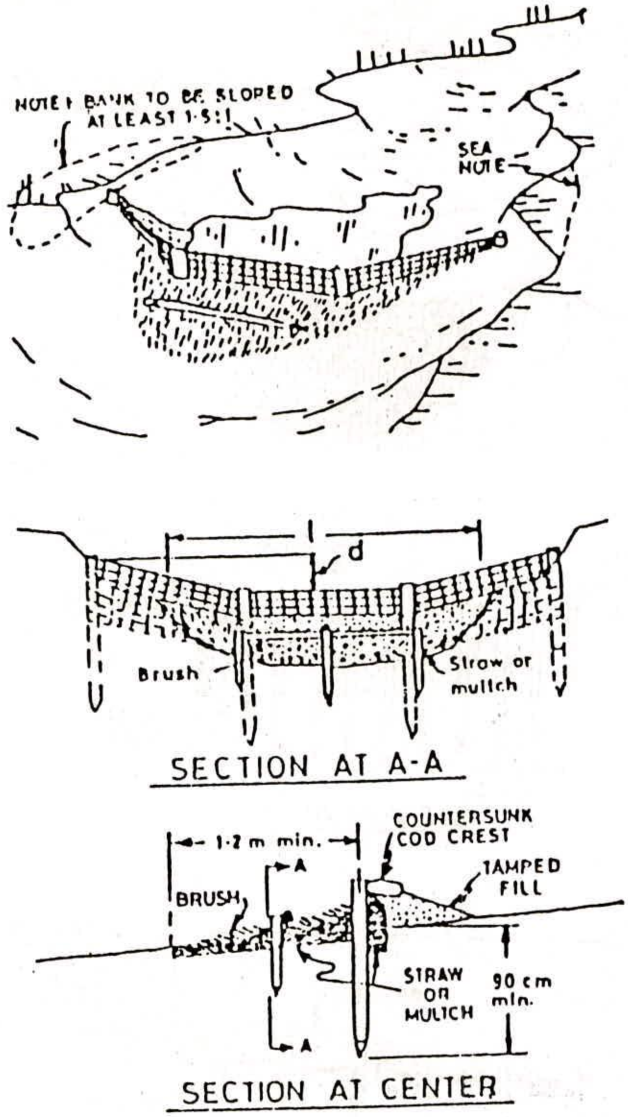



*Fig. 2.12 : A woven wire dam for water harvesting.*

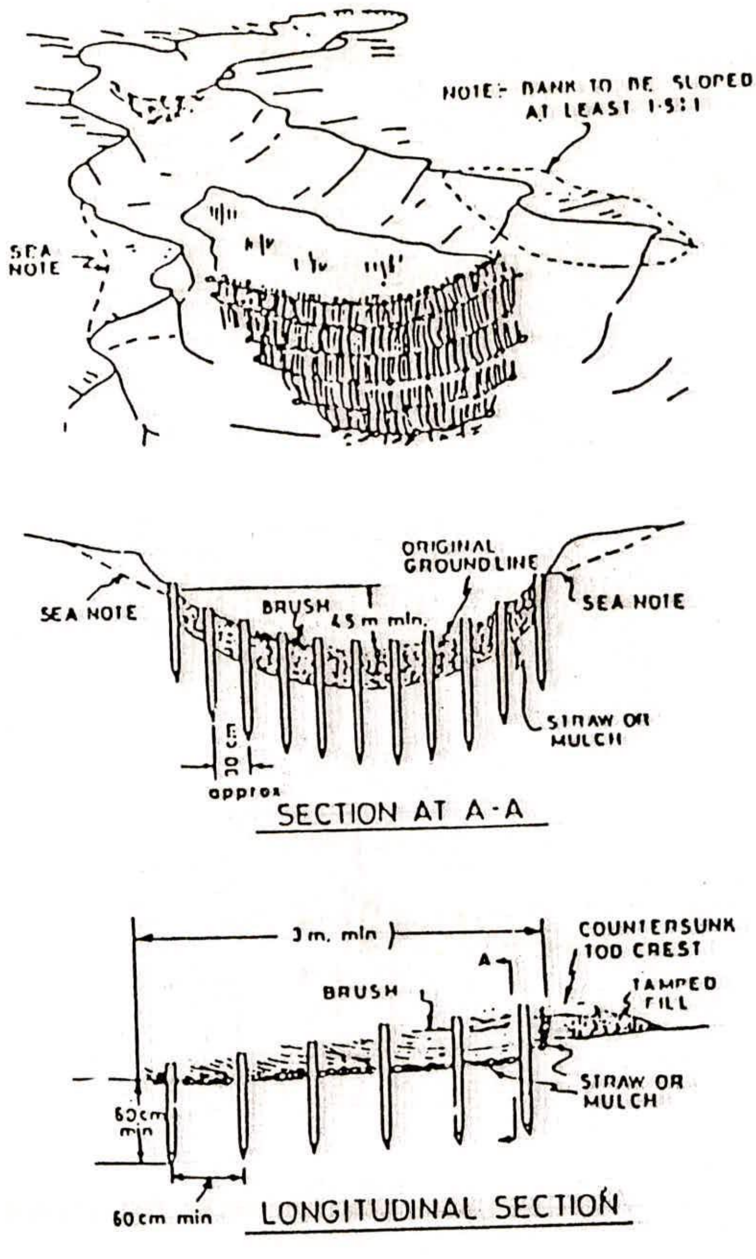
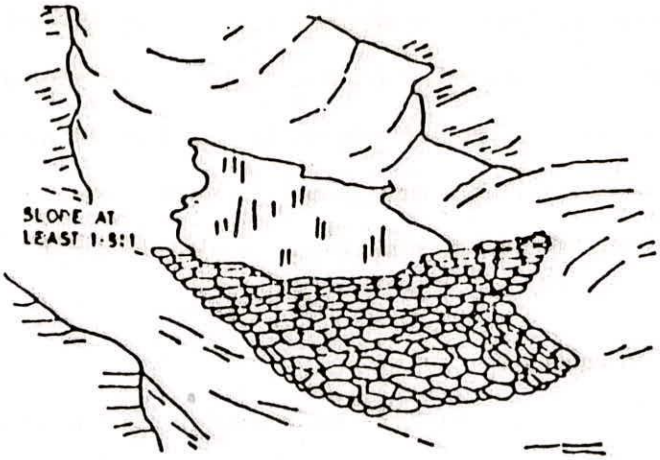
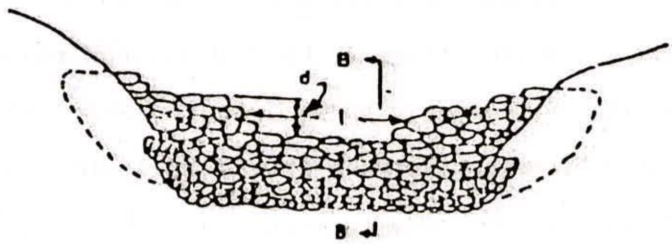
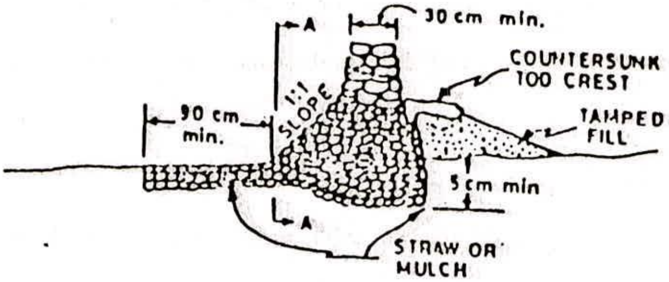



*Fig. 2.13 : A brash dam for water harvesting.*




SECTION AT A-A




SECTION AT B-B

*Fig. 2.14 : A loose rock dam for water harvesting.*

control techniques for farm ponds are still in experimental stages. However, at present, in comparison with the cost of water resources development by large reservoirs or by minor irrigation works, the cost of lining the small farm ponds with bricks and cement and cement concrete appears to be justified, particularly in areas where there is no other source of irrigation water.

### 2.4.3 Agronomic Practices :

Agronomic practices involve the planning and management of crops and crop sequences to provide maximum plant cover, tillage practices that will give optimum absorption of rainfall, and the use of residues to assure the best possible protection from raindrop impact. Vegetation management can alter water budget of watershed by modifying the hydrologic processes involved therein. The very concept that different vegetation covers have different evapotranspiration requirement, is used for vegetation management approach.

Vegetation management practices have significant potential to increase or decrease water yield from watersheds. However, the results reported so far have been mainly of studies conducted in small watersheds which may not be applicable for big catchments.

### 2.4.4 Minimum Tillage :

It is known that the intensive tillage of tropical soil leads to rapid break down of soil structure , more rapid decomposition of organic matters and loss of moisture. Therefore, the less the soil is tilled consistent with satisfactory crop husbandry the better. In this sense minimum tillage means the least tillage necessary to produce the crop. Minimum tillage prepares a seedbed-rootbed that has a minimum of compaction and a maximum infiltration rate. Minimum tillage leaves the soil more receptive for rainfall absorption and more resistant to detachment and transportation of soil particles.

Indigenous peoples of Africa and Asia have practised minimum tillage for a very long time primarily to save labour within the range of facilities and tools available to them. For example in Africa, in the Sevannah zones it is common practice to dig holes with a hoe one pace apart and plant maize seed in each hole, without any other form of seed bed preparation. If there is grass in between the holes it is left untouched, or may be lightly slashed.

### 2.4.5 Artificial Recharge of Ground Water :

In ares of declining trends of ground water, the artificial recharge of ground water is of great use in water harvesting. Ground water recharge involves augmenting the natural movement of surface water into underground formations by some method of construction by spreading of water, or by artificially changing natural conditions as shown in **Fig.2.15** and **Fig.2.16.** Varieties of methods are adopted for it viz. water spreading, recharge through pit & wells, induced recharge from surface water bodies etc.

Construction by percolation tanks is a technique useful for arid and semi arid regions in hard rock area. Low rainfall belt in Western India, which receives monsoon rains only during the four months in a year, forms a typical area in which percolation tanks are constructed for water conservation. Rainfall in most of this region is between 300-700 mm. Geology, soils and site selection are much more critical for spreading infiltration recharge system needs following aspects to consider:

-Surface soil must be sufficiently permeable to maintain high infiltration rate.

-Vadose zone must be permeable and free from clay layers or other fine materials that would restrict downward flow of water.

-Aquifer must be unconfined, permeable and thick

### 2.4.6 Rain Water Harvesting for Drinking Water :

Roof water harvesting is common in areas having high rainfall intensity well distributed in the year i.e. Himalayan areas, North Eastern States, Andaman Nicobar, Lakshadweep, Rajasthan and Southern parts of Kerala and Tamil Nadu.

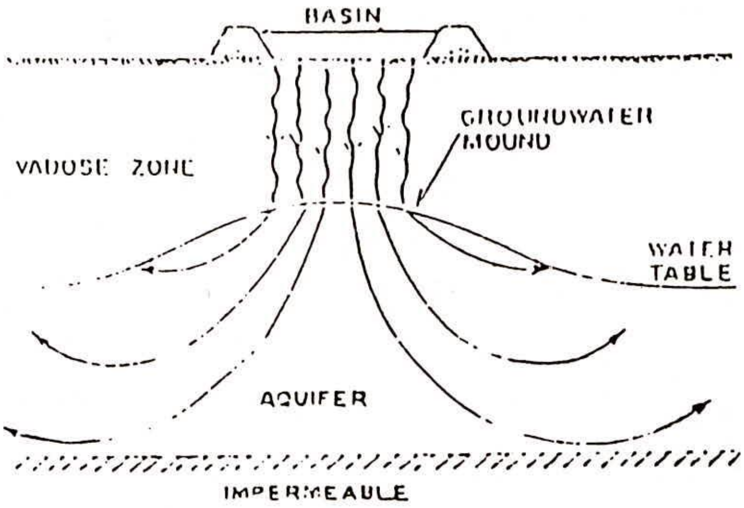



*Fig. 2.15 : Water harvesting by percolation tanks.*

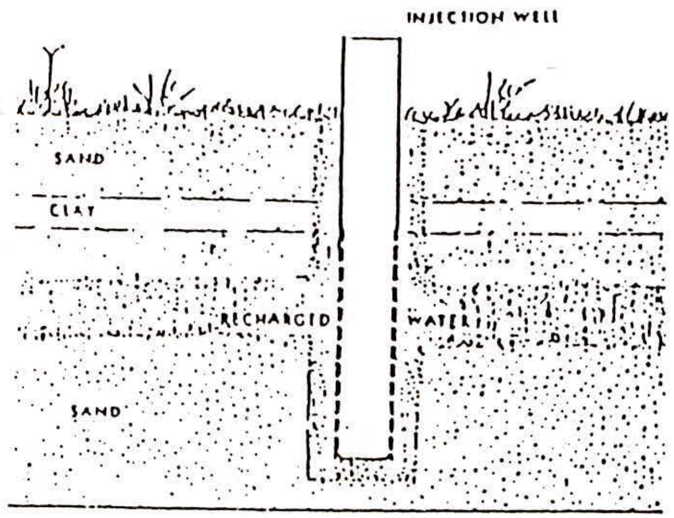



*Fig. 2.16 : Water harvesting by injection wells.*

Rainwater harvesting is being increasingly followed for meeting the drinking water needs of rural areas particularly during the periods of drought. These are many methods available for harvesting of rainwater. The method is site specific. Following steps are commonly followed in rainwater harvesting from roofs (Fig.2.17):

1. Collection of rainwater,
2. Separation of first rain flush,
3. Filtration of rainwater,
4. Storage of rainwater, and
5. Distribution of water.

Before supplying for human consumption the raw water from the pond should be filtered through a sand filter and kept in a PVC tank connected to a hand pump for withdrawal. In spite of certain limitations rainwater harvesting will be beneficial for providing drinking water to human beings as well as to cattles in areas lacking alternative sources.

### 2.4.7 Ravines :

Ravine areas which occupy nearly 4 million hectors require intensive soil conservation measures. The ravines (gullies) are classified as shallow, medium and deep ones on the basis of gully depth, bed width and the area. The ravine reclamation research work has shown that small gullies (<3m deep) can be reclaimed by clearing, minor levelling and construction of a series of contour bunds at a vertical interval of about 0.9 m. Pipe outlets or grasses ramps are to be provided for draining the excess runoff water, if any, from the treated area. At the end of the small gully system, a composite check dam is provided as a protective measures against any loss of soil. The expenditure is recoverable in 7-8 years by taking up profitable crops like tobacco or horticultural plantations and simultaneously providing irrigation water. Incidentally, the ravine lands are in alluvial regions where good quality ground water is also available.

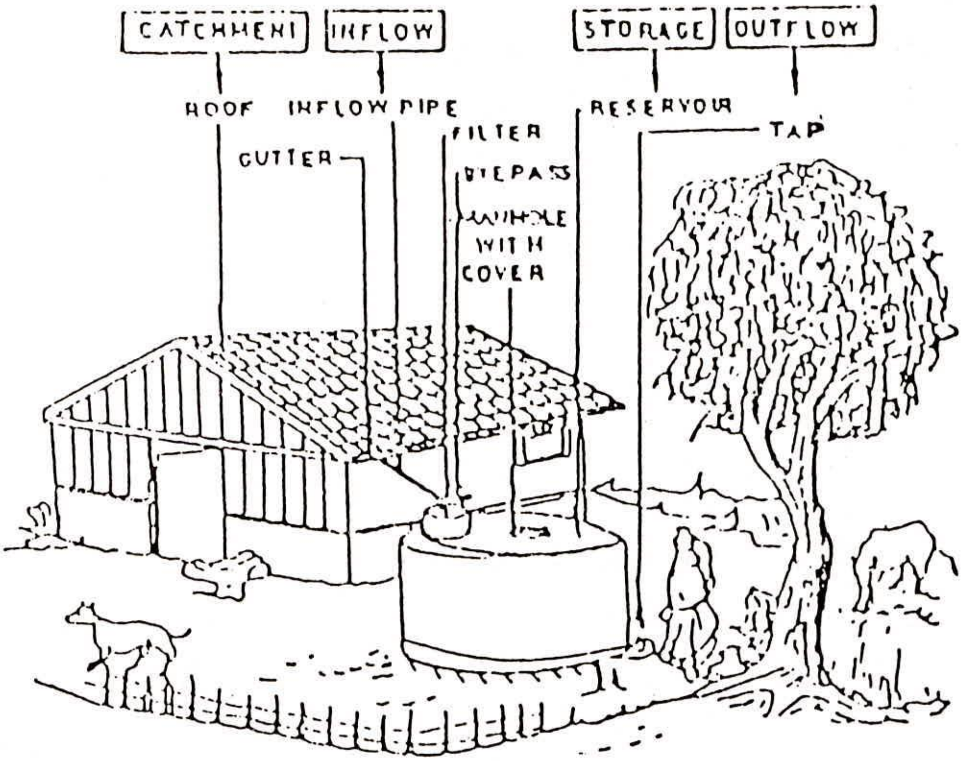



*Fig. 2.17 : Rain water collection through roofs.*

The deep gullies, which occur in the lower reaches having wide beds are easily accessible for reclamation as agriculture lands. These are, therefore, utilized as woodlands by adopting appropriate afforestation techniques with suitable tree species and constructing gully plugs in the bed of the main and branch gullies. Gully heads and sides are stabilized by planning grass species like Dichanthium annulatum. Gully plugging (with the hedges, brushwood earthen and composite ones) is done in the gully beds for conserving the soil moisture, controlling the soil loss and providing better growing conditions for the natural as well as planted grasses and forest species.

**2.4.8 Watershed Management Approach**

By definition, watershed management approach is an intensive one and may sometimes appears to the traditionalists to be initially expensive (in relative sense) over the other methods. Economic evaluation of the watershed approach was conducted at Central Soil and Water Conservation Research and Training Institute, Dehardun, and its utility was proved beyond doubt.

The following components must receive attention in any watershed management project :

(1) Soil conservation measures-moisture retention, safe disposal of runoff, various mechanical measures.

(2) Storage and recycling of runoff-ponds and storage reservations and conveyance.

(3) Improvement of fuel-fodder production including horticulture and changes in land-use, if necessary.

(4) Optimal land-use and cropping systems including mid-season corrections and appropriate cultivation methods.

(5) Groundwater recharge and development.

(6) Water management including drainage (if necessary), lining of water courses, proper field layouts, land leveling and crop saving irrigation methods.

(7) Development of livestock, poultry and other associated activities.

The deterioration of natural resources in an area can be contained and the total resources properly developed only by adopting the watershed approach. The basic unit of development is a watershed, which is a manageable hydrological unit. In this approach, development is not confined just to agricultural lands alone, but covers the area, starting from the highest point of the area (ridge line) to the outlet of the natural stream. This will involve implementation of ameliorative measures on barren hill slopes, marginal lands, privately owned agricultural lands and badly cut nallas and river courses.

Microwatersheds Systems operate on the same basic principle as other forms of land alteration where runoff from a collector area is concentrated, retained and infiltrated within a small ridged plot. In the case of microwatersheds, the collector area and infiltration plot serve only one individual tree or a very limited number of plants. The collector area of microwatersheds is devised to maximize runoff while infiltration is encouraged in the basin immediately surrounding the plant. Mulch is frequently used to decrease evaporation.

Development components : of watershed development approach are very crucial. These include :

1.Organization: Land-use questions can only be tackled in close collaboration with the owners and naturally, local people will have to be organized in the development. To promote such an interaction, the size of the watershed should not be too large or too small. It could be between 300-500 ha and a cluster of several (say 10) such watershed could be managed by a single organizational unit.

The organization, which is to implement these projects, should be capable of integrating extension, inputs and marketing. The ideal solution will be to create a watershed development agency at the unit level, which has all the powers to plan, organize and implement the entire project. Alternatively, the watershed authority, could be the powerful organization to plan a project, allocate funds to the line agency, who in turn, will execute the projects subject to the scrutiny by the watershed authority. Since no project can be successful without peoples' participation, the watershed development agency could incorporate selected representatives of the local people. Simultaneously, watershed development agencies should be created at district, state and central levels also. Regular and systematic training of the workers involved in these agencies must also be taken care of, so that the trained personnel are able to discharge their duties effectively.

The National Watershed Development Project for Rainfed Areas, (NWDPRA) is a major thrust program which was lunched by the Department of Agriculture and Cooperation (DOAC) of the Ministry of Agriculture and Cooperation (MOAC) of the Government of India during the period of the eight plan (1992-1997). The program operates in 2,500 small (500-1000 ha) pilot watersheds around the country for over 3.9 million ha of the nation's 148 million ha of rainfed lands. Watersheds having less than 30 percent of their area under irrigation are defined as rainfed watersheds.

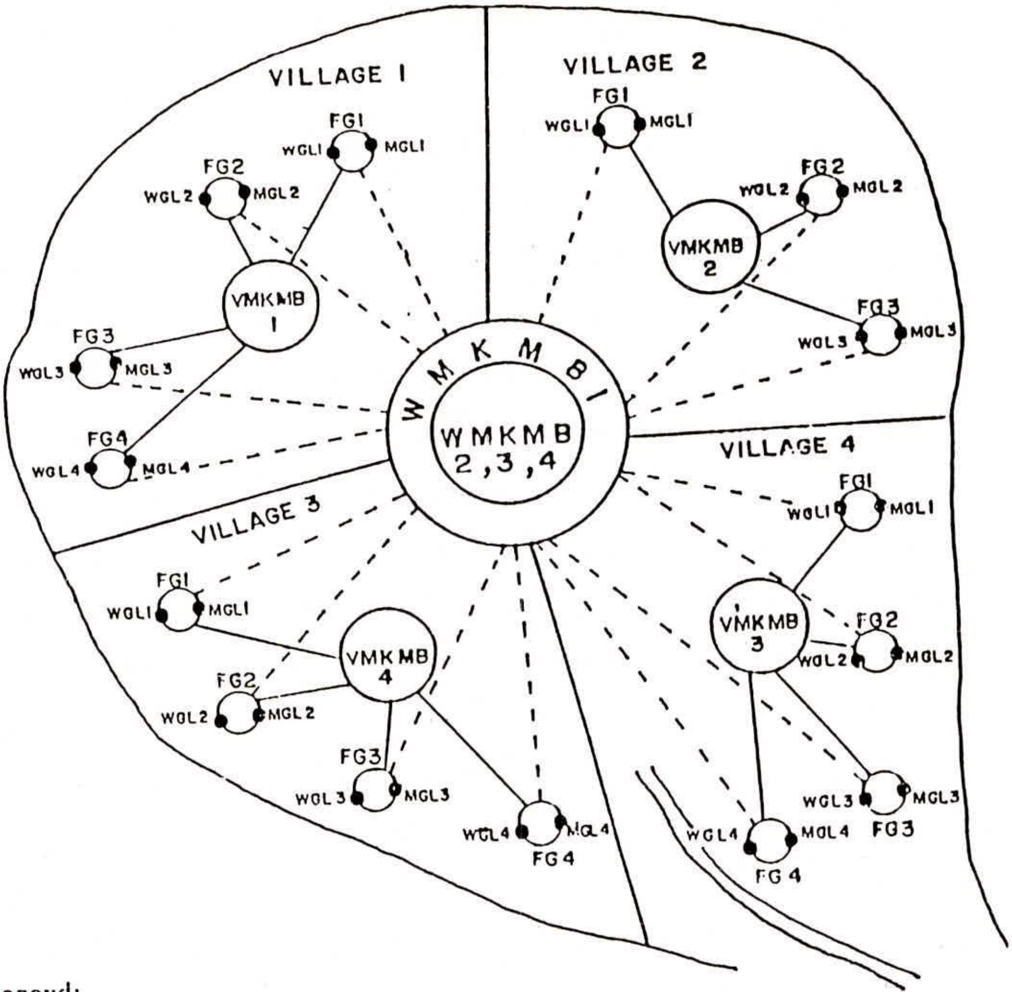
The ultimate objective of the NWDPRA is to develop the natural resource base, sustain its productivity, improve the standard of living of millions of poor farmers and landless labourers and work towards the restoration of the ecological balance. The strategy of the program is primarily based on the twin concepts of integrated watershed management through peoples' participation and sustainable farming systems development. The program began operations in 1991-92 with a total budget of Rs. 1338.64 crores(MOAC, 1992)(36).

In the following paragraphs a possible modified farmers' organization network model, based on previous experience of FAO rural development programs (FAO, 1993a, 1994) and the MKM(Mitra Krishak Mandal comprising of about 5 elected or selected friendly farmers from each of the different villages in a small watershed) experience of the NWDPRA is presented(36).

One of the first efforts on entry into the watershed after the farmers are motivated, should be on the formation of farmers' groups. These groups should be as homogeneous as possible. A small group size not exceeding 15 families, will create more vibrancy and dynamism. The farmers' groups could be built around fast cash income generating multiple activities. The selection of these activities could include a cafeteria of choices as has already been done by the NWDPRA program. Each farmers' group could have two elected group leaders: a women and a man. All these elected women and men group leaders (WGL and MGL) could form the memberships of the friendly farmers' committees in a village or village MKM (VMKM) within a given small watershed. Five elected farmers from these farmers' group leaders could form a village MKM Board(VMKMB) of a particular village in the small watershed. It could include three women and two men group leaders from small/marginal and landless farmers only including the Gopals. No innovative or so called enlightened farmer should be included in the village MKM. The women/men group leaders from each of the villages in the small watershed would also form the membership of the MKM of the small watershed itself which would then elect the small Watershed MKM Board (WMKMB). The WMKMB would be the farmers' organization responsible for the NWDPRA program in a watershed. The model is shown in Fig.2.18.

2.Costing and Finance: Each watershed of about 300-400 ha could be completed at an overall cost of 8-10 lakhs (at the present cost) in a period of about 3-4 years. Without financial inputs, in the form of subsidies or outright grants, the programme cannot make headway because of the relatively low economic levels of the people for whom this development is envisaged. Apart from this, watershed development involves community activities like constructing soil and water conservation structures, storage ponds, conveyance systems and afforestation of village common lands. Individual inputs in such activities are normally ruled out, and hence the need for institutional financing.

3.Constraints to Soil Conservation Programs: The question arises as to why soil conservation is not more widely applied ? Why so much land is being wasted in spite of millions of people suffering from hunger ? Why conservation programs appear to be so difficult to implement ? The answer is that conservation needs




Legend:

FG = Farmers' Group
WGL = Woman Group Leader
MGL = Man Group Leader
VMKM = Village Friendly Farmers' Committee
VMKMB = Village Friendly Farmers' Board
WMKMB = Watershed Friendly Farmers' Board

*Fig. 2.18 : Proposed farmers' organization network model for NWDPRA.*

and require a general policy by which soil conservation becomes an integral part of wider land-use and receives support within a social and economic environment which is conducive to the maintenance and improvement of the soil resources.

4.Correct Appraisal of Soil Conservation Benefits : It should first of all be realized that any change imposed on the use of land will produce effects on its productive capacity either in a positive or a negative sense. These possible effects must be forecast and if some are likely to cause degradation, systems of management have to be designed to overcome deterioration. If such measures are too costly or too complex to be sustained at the farmers' level, it will be necessary to select an alternative, better adjusted form of land-use. Increasing agricultural production should aim not only at sustaining higher levels of useful biological productivity but also at ensuring that the system is stable. This principle should be applied particularly when forest lands are cleared for cultivation, when grassland areas are turned into aerable land, when monocultures are to replace multiple cropping, when paramount agriculture is planned to replace multiple cropping, when permanent agriculture is planned to replace shifting cultivation and when irrigation or mechanization are being introduced. Conservation requirements should, therefore, lie at the basis of land-use planning decisions. One of the reasons, that much of the land is still waste, is because this general principle is ignored and that short-terms solutions are often given priority over long-term imperatives.

5.Planning for Soil Conservation at the Farm Level: A soil conservation plan is a blueprint for measures needed to control erosion. It should be prepared in consultation with, and with the co-operation of the individual or groups of individuals involved in the decision making process, because it is they who will have to implement the plan.

In the developing countries particularly in the large areas of land under shifting cultivation, the majority of the farms are small, scattered or fragmented and under various forms of ownership, tenancy or usufructory rights. Therefore under these conditions it is not practical to prepare conservation plans for each individual farm. Each area which may consist of several farms, or group of such areas under cultivation must be considered as one land management unit for planning purpose. Political and administrative boundaries should not necessarily coincide with catchment boundaries, but they have to be considered in selection of areas for planning in accordance with soil, climate, topography and land use.

Planning process should therefore start after decision has been made as to which catchment or catchments are in need of treatment in order to raise agricultural production. The first step is to systematically collect as much available information as possible about the area - soils, topography, rainfall - amount, distribution and intensity - drainage systems, stream flow, present land use, ecological and social conditions, and so on. The gathering of all this information will need time, money and personnel and this means selecting priorities on information needed within resources available. It should not take too long to find out why soil erosion is taking place, and to try to introduce some of the most obvious remedial measures immediately while more detailed information is being collected. For example - is run-off water from slopes above rushing through cultivated lands ? If so can the run-off be diverted and disposed of safely outside the cultivated area ? Are the farmers carrying out obvious malpractice such as burning crop residues or cultivating and planting crops in rows up and down the slope ? If so steps should be taken for immediate correction. If wind erosion is the problem what are the possibilities of planting wind breaks ? Are some of the farmers already successfully using indigenous soil conserving systems of cultivation which could be extended on a wider scale, such as pit systems, mound systems, trash bunds, mixed cropping, grass or bush fallows, ladder terracing or bench terracing ? These and many other questions and possible answers should come to mind after the initial field reconnaissance survey by the planner. The success of any plan will depend on the confidence of the soil conservationist and/or extension workers. This confidence can only be built up by promoting continuous dialogue and discussion among themselves and with the extension works, and by practical demonstration. The most convincing demonstrations are those which are carried out on the farmers' lands using the resources which they have. Demonstrations on experimental farms and research stations are seldom so convincing because the farmers may imagine, sometimes correctly, that the methods and systems demonstrated are beyond their understanding and availalble resources around them.

After sufficient data has been gathered the plan should be finalized in consultation with the individual or individuals responsible for implemlementing the plan. WheWhen agreement is reached on the soil conservation practices to be applied, these should be shown on the plan map. Quantities, cost estimates and appropriate designs should be included as part of the plan. A time-table for implementation should also be included. During implementation of the plan, careful supervision must be given to installation of structures. In addition it is essential to keep all parties involved fully informed as to the purposes and results to be expected. While the plan is being applied to the land the results must be monitored to see if the plan is meeting its objectives.

Important watershed characteristics & data required for planning scientific land use is furnished in **Appendix-I**. Broad guidelines for preparation of watershed management project with special reference to NEH Region are furnished in **Appendix-II**.

## 3.0 STUDY AREA - N.E. HILLY REGION(NEHR) :

### 3.1 Geographical Situation :

N.E.H. Region lies between $21^{0}51'-29^{0}30'$ N latitude and $88^{0}2'-97^{0}25'$ E longitude. It is almost bottled up between Bhutan and Tibet in the north, Burma in the east and Bangladesh in the south and west. The region comprises States of Assam, Manipur, Meghalaya, Nagaland, Sikkim, Tripura and Union territories of Arunachal Pradesh and Mizoram. Land utilization pattern of the NEH Region(31) has been detailed in **Appendix-III** and the most profitable Cropping System in NEH Region(31) has been detailed in **Appendix-IV.**

Over period of time cropland, pasture and forests have decreased as land is being diverted to non agricultural and other uses. Urban land, roads etc. have increased. Over time, land in agriculture may change from one use to another, that is, cropland may change to pasture and other pasture may change to cropland. For urban land and developed land to change back to agriculture is not likely. One of the leading causes of farmland loss is poorly planned suburban development. Efforts to reduce this type of use have not been successful. **Fig.3.1** shows the various agro-climatic zones of NEH Region.

### 3.2 Physiography:

The region can be divided into three physiographic divisions:

1.Meghalaya plateau covering 65% land area.

2.North-Eastern Hills & Basin covering 22% of land area.

3.Brahmaputra valley covering 13% of land area

The topography of the region is mountainous except Assam valley. The altitude varies from about 50 to over 7300 meters from mean sea level. The change in the topography and altitude is very rapid in Sikkim and Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura (Jampui hills), some parts of Lohit

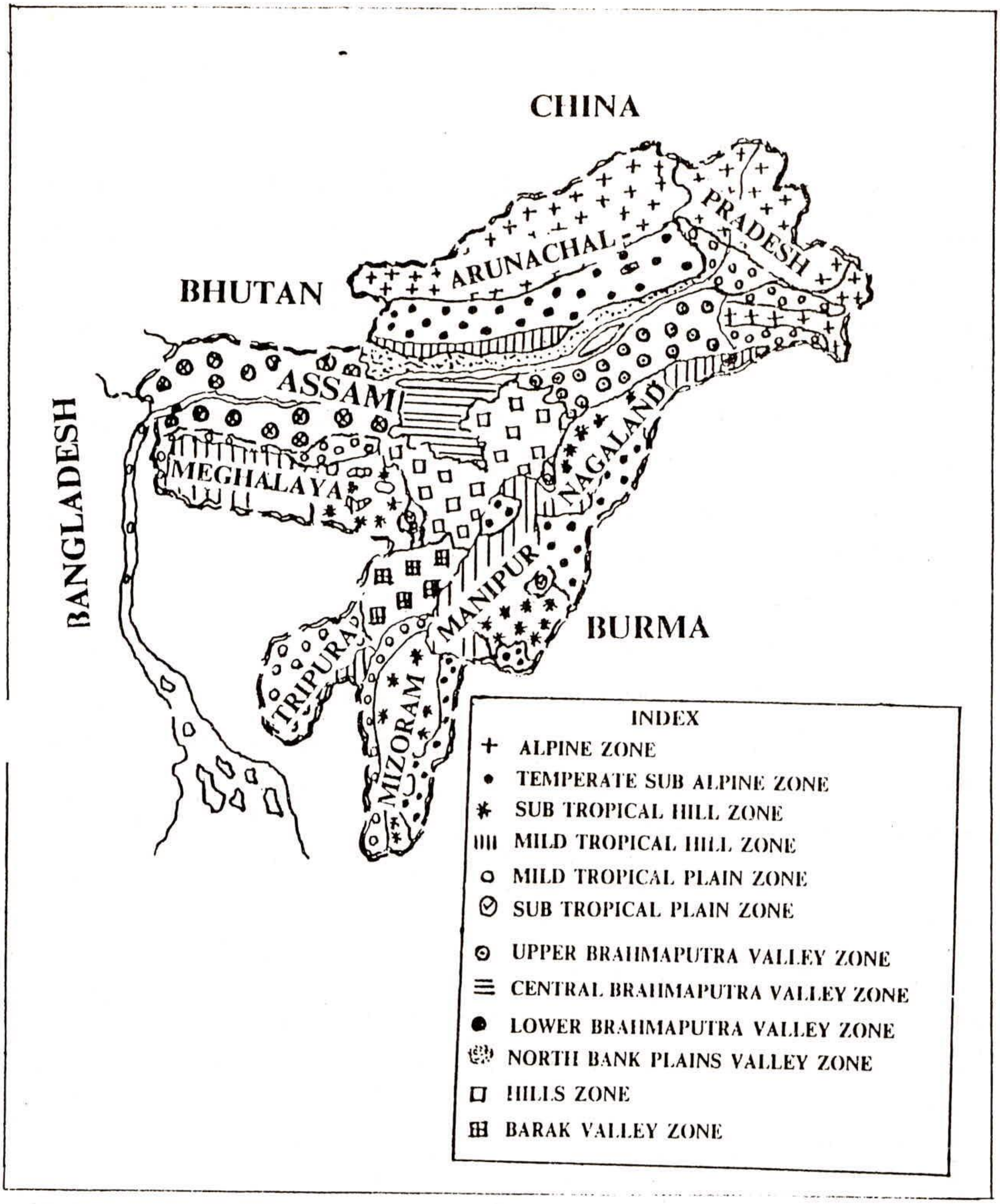



*Fig.3.1 Map Showing the Agro-climatic Zones of N E Region.*

and Tirap, Cachar and Haflong. Its change is less rapid in Garo, Khasi, Jaintia and Mikir hills. Major part of Tripura valley is interspersed with small isolated hillocks called tilla. The Assam valley, through which the Brahmaputra and its tributaries flow has only a gentle slope from north-east to west.

### 3.3 Climate :

The climate of the region varies from sub-tropical to temperate. Monsoon is the principal rainy season of the region and accounts for almost 65 per cent of the total rainfall. The amount of seasonal rainfall varies from 1000 mm to 2000 mm. The maximum of over 4000 mm occurs at Cherrapunji plateau (with Mawsynram 16 km from Cherrapunji itself recording over 11,406 mm) and in some places of Arunachal Pradesh. The Imphal-Lumbding region receives the minimum rainfall (<800 mm). The variability of rainfall during the monsoon season is less than 20 and 15 per cent in Assam and the extreme north-east part of the region, respectively. During the winter season, the average rainfall exceeds 50 mm and it varies from 300 to 800 mm in the summer season. Temperature ranges from $0^0$C in the Himalayan range to $35^0$C in some parts of Tripura.

General rainfall pattern in NEH Region is shown in Fig.3.2.

### 3.4 Vegetation :

The dominant tree species are *Artocarpus chaplasha, Michelia champaca, Ficus elastic, Mesua ferrea, Alstonea scholaris*, etc. There is a thick bamboo growth, the common species being *Dendrocalamus* and *Hamiltonii.* The thick undergrowth is composed of canes, climbers and evergreen bushes. The pine forest is mainly composed of *Pinus khasya* and is mostly encountered at altitudes of 800-2000 meters.

Forests of North Eastern Region can be broadly classified(13) based on altitude ranges as:

(i)Tropical & Sub-Tropical: comprising mainly evergreen & semi-evergreen,

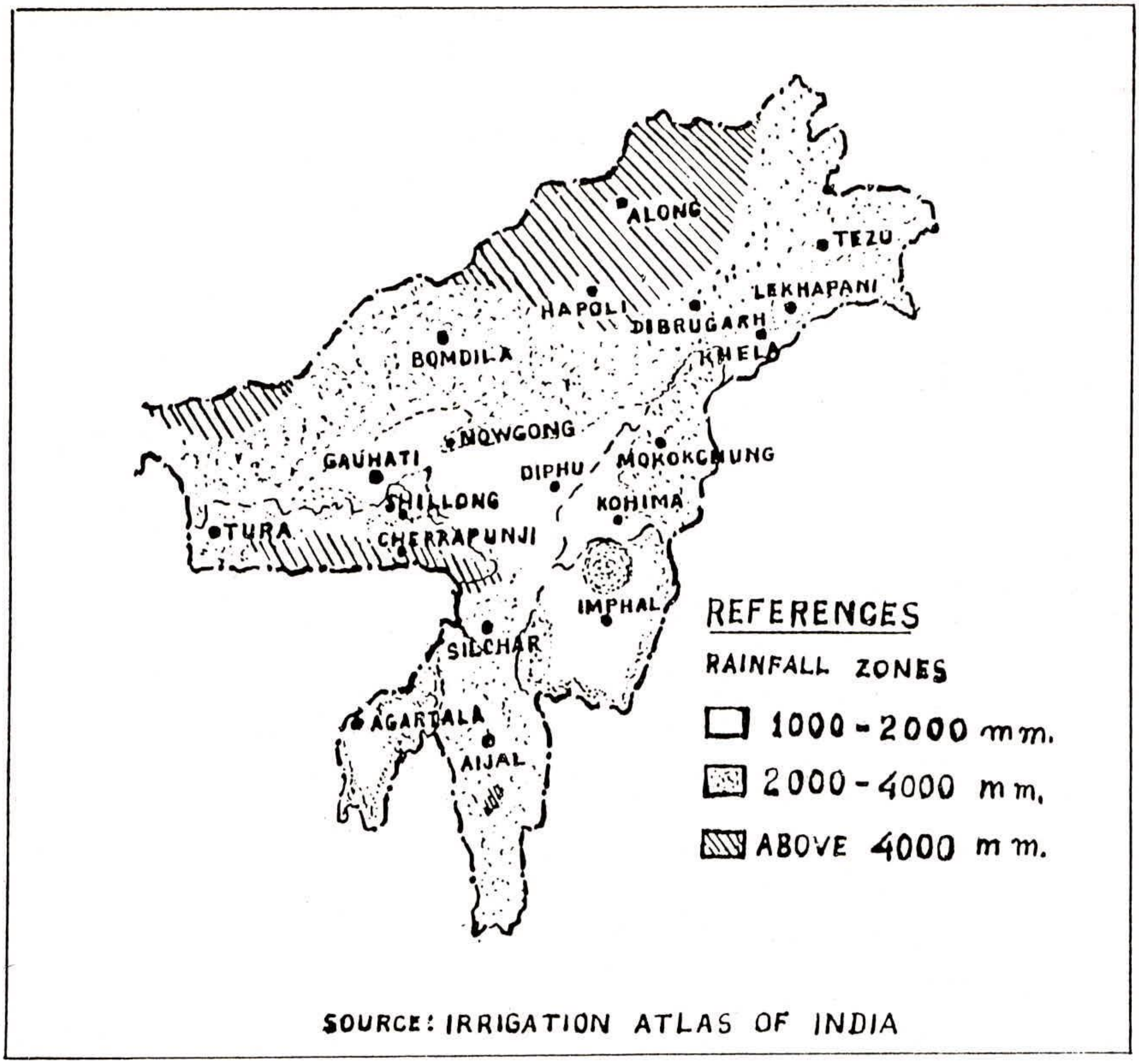



*Fig.3.2 Rainfall pattern in N E Hilly Region*

moist & dry deciduous, grass land, pine and mixed forests met within altitude range from plains to around 1800 m.

(ii)Temperate: forests occupy an altitude range from around 1100 m-2500 m at Shillong plateau, Naga hills, Mizoram, Arunachal Pradesh, parts of NC hills. Major tree species are *Acer, Rhododendron, Betula, Michelia* and *Magnolia.* The trees in the temperate forests have number of saprophytic plants such as orchids, ferns and mosses while the harbaceous species are found underneath.

(iii)Alpine Type: Such vegetations are confined to very high altitude beyond 3000 m at Arunachal and parts of Manipur. Trees such as *Abies species, Juniper sp.* and *Berberis* are common. As the altitude increases beyond 4500 m the trees are replaced by hardy, perennial herbiceous plants belonging to the species of *Primula, Rheum, Arenaria, Saxifraga* and *Sedum* etc.

Based on 1982 figures area under forest in North Eastern Region has been reported(13) as under:

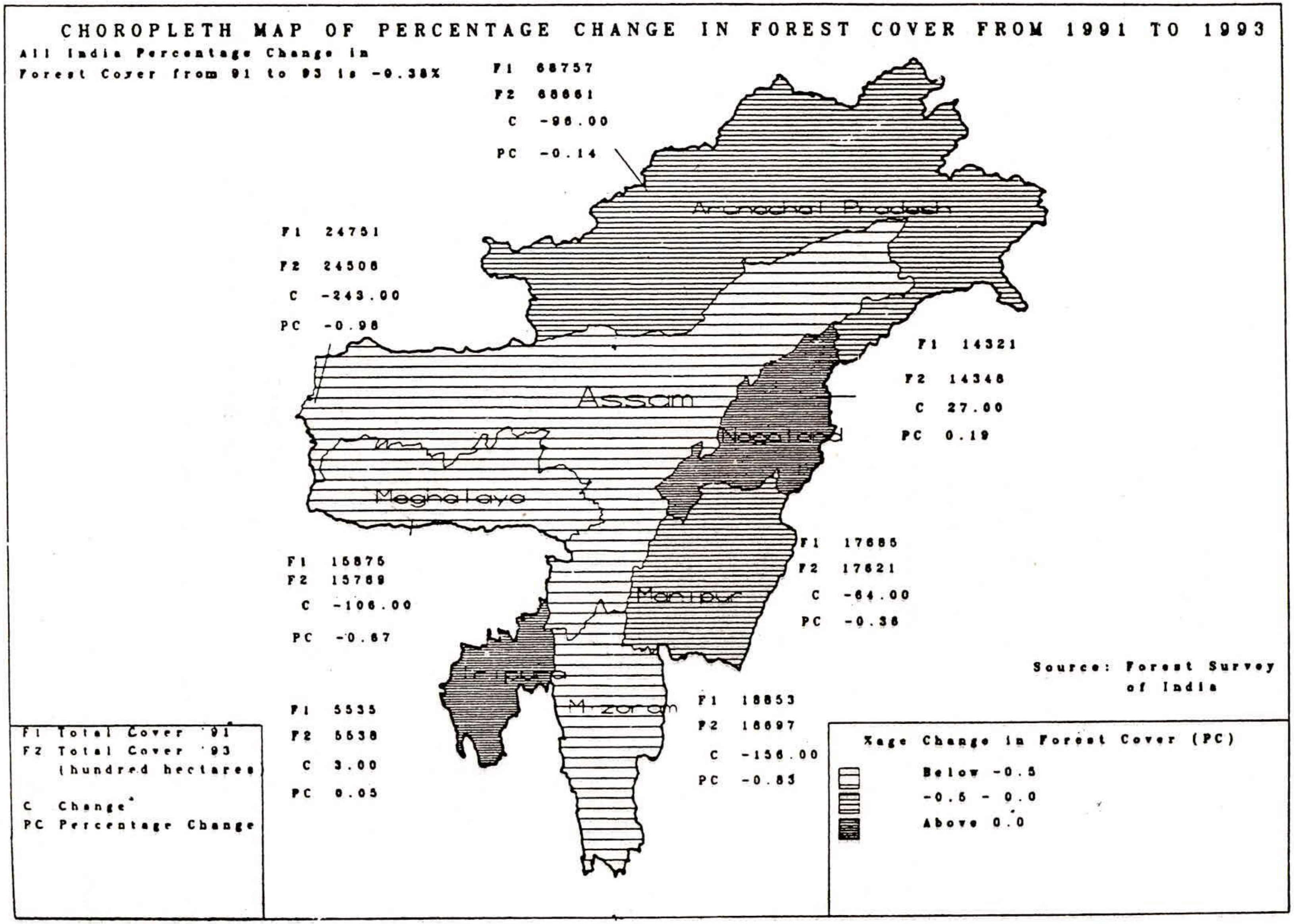
| State | Forest Area in 000 Hect. | Forest Area in per cent |
|---|---|---|
| Arunachal | 51.5 | 61.7 |
| Assam | 28.5 | 36.4 |
| Manipur | 15.2 | 67.8 |
| Meghalaya | 08.2 | 38.9 |
| Mizoram | 07.1 | 58.0 |
| Nagaland | 02.9 | 17.4 |
| Tripura | 06.0 | 57.4 |
| Total | 119.5 | 49.0 |

**Fig.3.3** shows the percentage change of forest cover from 1991 to 1993 and coverage of good forest area-1990 for NEHR **is detailed** in **Appendix-V** as reported by NEC in its publication 'Basic Statistics for North Eastern Region, 1995.

## 3.5 Soils of North Eastern Region :

### 3.5.1 General :

Different type of soils such as red loamy, laterite, red and yellow, recent




*Source : Basic statistics of NE Region, NEC(1995)*

*Fig.3.3 Choropleth Map of Percentage change in Forest Cover From 1991 to 1995* alluvium, calcareous alluvium, old alluvium and brown hill soils have been found in this region **(Fig.3.4)**. Landscape configuration has given rise to various types of soil catenas characterized by weathered Ultisols. Oxisols have been identified around Byrnihat (Meghalaya), Konaban and Harishnagar (Tripura) on hill slopes. Oxisols occur in Naga hills bordering Assam. Alfisols have been reported to occur at Kombong and Tadiu (Arunachal Pradesh), Nongsdor and Barapani (Meghalaya), Richu Kola (Sikkim) and Inceptisols at Kombong and Tadiu (Arunachal Pradesh), Berdepa (Tripura) Boyendoba (Garo hills), Kohima, Wokha, Mokokchung and Mon areas in Nagaland. In sub-temperate region, Spodosols occur in Phek, Zunhebota and Mon areas of Nagaland and parts of northern Sikkim and Arunachal Pradesh. Entisols are found in the entire valley of Assam, Manipur and narrow valleys in the hills of N.E.H. Region.

### 3.5.2 Physical Properties :

The hill soils display wider variation in the mechanical composition. Textural classes vary from sandy loam to clay loam. Old alluvium soils of Brahmaputra valley are sandy loam to clay in texture, while the new alluvium soils are mostly sandy, silty loam or clay loam. The valley soils of Manipur are clay loam to clay in texture. The narrow valley soils of Meghalaya and Tripura contain less amount of clay and richer in organic carbon than their upland counterparts. The texture of soils in rice fields, orchards and potato fields of Nagaland are loam to clay. The percentage of clay varies from 10 to 31 per cent.

### 3.5.3 Chemical Properties :

The soils of entire region are acidic in nature. The pH of old alluvium soils ranges from 4.5-5.0. pH of the soils close to Brahmaputra ranges from 6.0 to 7.0, while it varies from 5.0 to 6.0 in the soils of old flood plains. The soils of high altitudes are more acidic than the low elevations. Fifty per cent of Sikkim soils are having pH 5.0 or below, about 45 per cent between 5 to 6, the rest 6 or above.

Acidity in these soils is attributed to the presence of aluminum ion on the

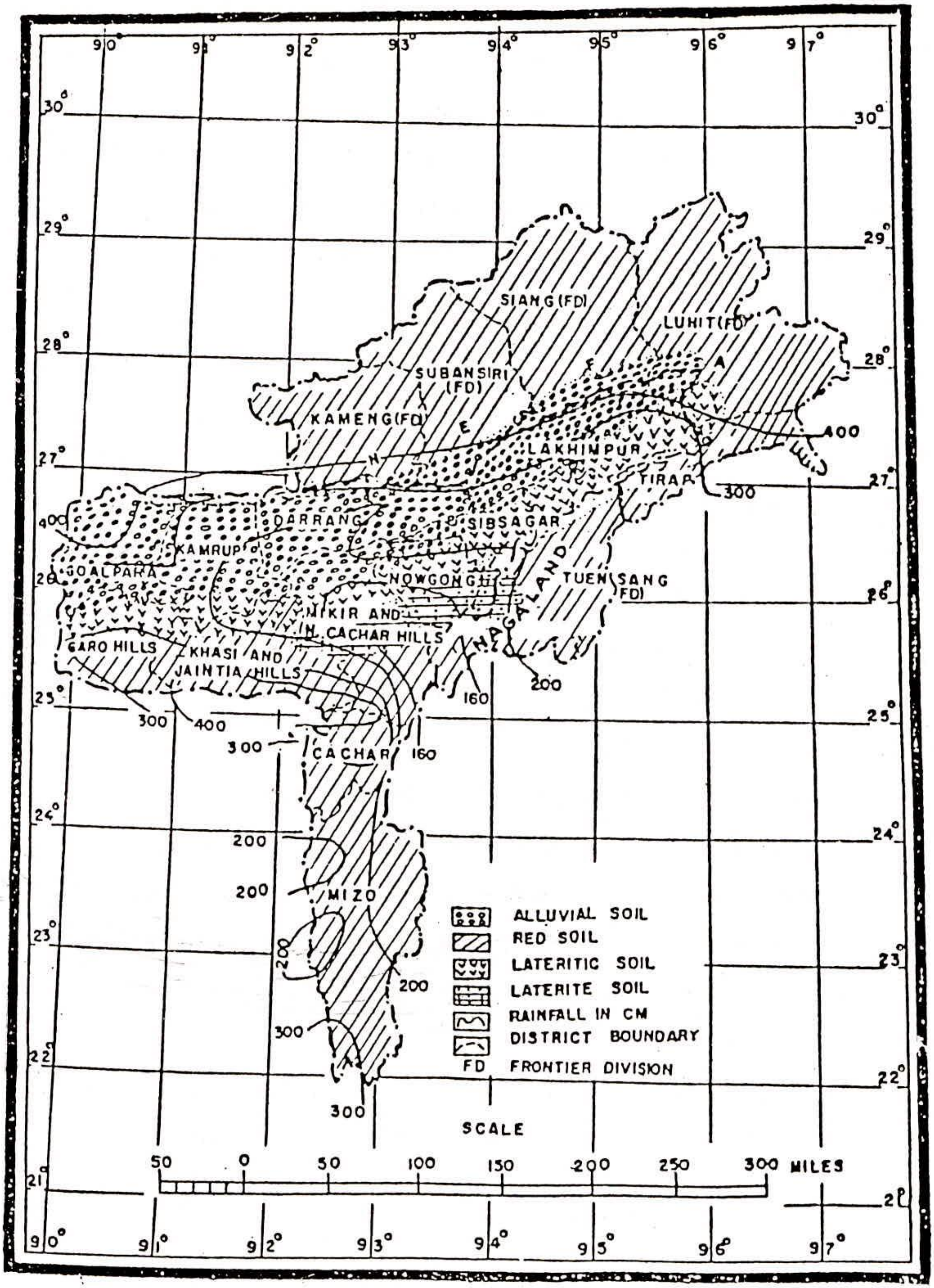



*Fig.3.4 Soil Map of Assam*

clay complex. Base saturation of soils of Meghalaya and Arunachal Pradesh varied from 30.8 to 84.6 and 23.6 to 80.3 per cent respectively. Soils of citrus belt of north Cachar hills has shown low base saturation (average 22.9 %). The combined electric conductivity (CEC) of the soils of the hills region varies from 8.8 to 27.9, 9.6 to 22.4, 5.6 to 20.0, 7.2 to 20.0, 7.2 to 29.2, 6.6 to 23.2 and 2.2 to 42.3 meq/100g soil in Sikkim, Mizoram, Tripura, Manipur, Meghalaya, Arunachal Pradesh and Nagaland, respectively. It bears positive relationship with silt, clay and organic carbon contents of soils. The CEC in the soils of Barak valley, northern and southern bank of Brahmaputra, recent flood plain and flood plain varies from 7.9 to 14.2, 6.2 to 10.8, 6.3 to 9.9 and 3.0 to 12.5 meq/100g soil, respectively. The soils exhibited high fixation capacity for water soluble phosphate. Illite and Kaolinite are dominant clay minerals in soils of the region.

**3.5.4 Land Capability Classifications :**

The standard norms of land capability classification, developed in the U.S.A., may require some modification for the hills of the North Eastern Region because of the fact that the climatic conditions are different in this region. Because of high rainfall and soil type, vegetation establish themselves much quicker in this region. For this reason 5 land capability classifications have been tried out in the North Eastern Region(31). These are,

Class A-I: 0 to 5 per cent slopes suitable for cultivation without special soil conservation measures.

Class A-II : 6 to 50 per cent slopes suitable for cultivation with special soil conservation measures.

Class B-I: 51 to 100 per cent slopes shallow soils (>1.75 meters) suitable for pastures and fodder.

Class B-II 51 to 100 per cent slopes, having more than 1.75 meters suitable for orchards, cash crops and plantation crops.

Class C : Above 100 per cent slopes, suitable for forests.

Aforesaid classification appears to be logical since farmers are cultivating the soils with 100 per cent slopes in Garo hills (Meghalaya). Terraces were made with 100 per cent slopes in Sikkim, Kohima (Nagaland) and some parts of Manipur for rice cultivation.

The suggestion for bench terracing upto 33 per cent slopes, 33 to 50 per cent for horticulture, agro-forestry and agro-horticulture, 50 to 100 per cent slopes for forestry including farm forestry and above 100 per cent slopes for preservation of forest needs further modification.

National Bureau of soil Survey and Land Use Planning and Government of Arunachal Pradesh surveyed limited area (194ha) in Meghalaya (Barapani), Richu Kola watershed (3000ha) in Sikkim (east District) and Popum Poma watershed (1581 ha) in Arunachal Pradesh (Lower Subansiri). Only about 20 per cent of the area of Barapani Popum Poma has been classified in land capability classes B-I and the remaining falls under B-II and C. Due to abrupt rise of land from the drainage channel, land capability classes A-I to B-I are very limited. Except for land near stream bank, the valleys and plateaus, the land is not suitable for permanent vegetation and plantation crops.

### 3.6 Soil And Water Conservation Problems in NEH Region:

The quality of land and water is deteriorating due to increasing degradation brought about by various factors. These include soil erosion due to general mis-management, over grazing, shifting cultivation, large scale deforestation, desertification, water logging, salinity & alkalinity, toxic effects, reckless mining activities and road construction etc. In the North Eastern Region the major cause of degradation of land is soil erosion. Such soil erosion leads to degradation of soil physical properties and loss of plant nutrients. Extensive erosion and run off in the catchment areas lead to siltation of reservoirs, thereby adversely affecting the irrigation and power potential. Such erosion and run-off are also one of the causes of floods in the plains and valleys. All these facts of soil erosion directly affect agricultural production. In addition, it also adversely affects forest production, and availability of water both for irrigation and drinking besides bringing about a disturbance in the soil and water balance.

There has been gradual reduction of available land masses for agriculture and allied sectors due to increase in population and developmental needs. Against this background if there be a continuous degradation of the land mass with consequent effect on water resources, it will lead to a crisis of enormous magnitude. Planning for scientific land and water management, therefore assumes great significance.

**3.6.1 Soil Erosion Problems :**

Soil erosion is a serious problem in north-eastern hill region. In early days i.e. about 9000 years ago when man took up agriculture, he adopted slash and burn technique for clearing of forest and grew crop over the cleared land. Under the system only small portion of land remained under cultivation and was well adapted to low population densities and standard of living. Land normally remained under 20 to 30 years of fallow. This system of farming known as jhumming still continues in the region. During those days the system must have had little soil erosion hazard, otherwise, it would have been unstable and would have died out. With the increase in population more and more area was brought under cultivation and the period of fallowing also decreased gradually. To day, the jhum cycle has reduced to 3 to 6 years (Borthakur et. al. 1977). As the system still continues without any modification, it has become destructive in terms of degradation of resource. Besides, large scale deforestation for timber, fuel and other commercial uses and construction of roads, etc. are further adding to the problem of resource degradation.

Drainage of hilly topography is so good that the soil wash is quickly disposed off to river system and one may not notice unless he specifically looks into. Blockage of roads/ drainage system due to land slides, deep turbid water flowing in the streams during monsoon period and disappearance of agricultural practices in certain pockets due to exposure of rocks are indicative of seriousness of soil erosion problem. The situation in the region is almost similar to other hilly region of the country where area under agriculture is expanding and water sources are preventing the farming systems which can provide sustained production and ecological safeguard.

In N.E.H. Region, soil erosion is caused by rainfall, shifting cultivation, cultivation of crops along the slope, land slide etc. Annual soil loss estimates of NEHR in comparison to different regions of India and the problem areas of the North Eastern Region have been detailed in **Appendix-VI**. The major factors that contribute to the extent of soil losses are :

a)The Climate Factor : The major climatic factors that influence runoff and erosion are rainfall, temperature, solar energy, and wind. Rainfall is the most important factor. Temperature in the temperate zone exerts its primary influence through changes in the absorptive properties of the soil for water. In the winter months, the soil freezes to varying depths, which prevents infiltration. Temperature determines whether the precipitation will be rain or snow. It also causes snow-melting to produce runoff, which can result in microchannel erosion on an unprotected shallow, thawed surface layer. During the remainder of the year, temperature, as an index of solar energy, plays a significant role in evapotranspiration process that regulate the amount of water in the soil at the time of precipitation. Soil losses from erosion plots correlate with rainfall intensity only when the effective soil moisture at the time of precipitation is considered as one of the parameters.

Wind affects the erosion process primarily through the angle and velocity of impact of raindrops. It also influences evapotranspiration and consequently the moisture content of the soil. Confining our attention to precipitation as rain, we find that the amount, intensity, and distribution of the rainfall help to determine the dispersive action of the rain upon the soil, the amount and velocity of runoff, and the losses due to erosion. A large total rainfall may not cause excessive erosion if the intensity is low. Similarly, an intensive rain of extremely short duration may not cause much soil loss, because there is not enough rainfall to produce runoff.

b)The Topographic Factor : Slope characteristics are important factors in determining the amount of runoff and erosion. Erosion is usually not a problem on extremely flat lands. As soon as the topography becomes slightly rolling, erosion begins to be serious. The degree and length of the slope are the two essential features of topography that are concerned in runoff and erosion. The uniformity of slope is often important in determining the relative ease or difficulty of establishing suitable erosion-control practices.

Of the two characteristics of slope, degree is usually more important than length from the standpoint of the severity of erosion. Experiments have shown that on slopes below about 10 percent the amount of erosion approximately doubled as the degree of slope doubled. The effect of length of slope on erosion varies considerably with the type of soil. Generally speaking, longer slopes have less runoff than shorter ones. This especially true of permeably soils.

c)The Vegetation Factor: A good vegetative cover, such as a thick sod or a dense forest, offsets the effects of climate, topography, and soil on erosion. The major effects of vegetation may be classified into at least four distinct categories:

(i)Interception of rainfall by the vegetative canopy.

(ii)Decrease of velocity of runoff and cutting action of water.

(iii)Root effects in increasing granulation, porosity, & biological activities associated with vegetative growth and their influence on soil porosity.

(iv)Transpiration of water leading to subsequent drying out of the soil.

d)Erosion by Water: The effects of soil properties by water erosion are manifested in two ways. First, there are those properties that determine the rate with which rainfall enters the soil, second, there are these properties that resist dispersion and erosion during rainfall and runoff. Although these two phases of the soil factor are definitely related, the former is by far the more important.

e)Shifting Cultivation : Shifting cultivation (jhuming) in the NEH Region, is in practice since ancient time(7000 B.C.(13). It is hazardous and associated with continued degradation of production base- the soil. It has been estimated that of the total reporting area of about 2.7 m ha in the hills and forest, 1.8 m ha is exploited for shifting cultivation and as a result vast area of the region has been denudated. Soil loss due to shifting cultivation in NEH Region is shown in **Fig.3.5.** Recent available information about the extent of shifting cultivation in NEHR are shown in **Fig.3.6** and area estimates are detailed in **Appendix-V.**

Soil erosion on hill having 50 to 60 percent slopes under first year jhum, second year jhum and bamboo forest has been estimated as 147, 170 and 30 tones/ha, respectively. Putting soil above the dried vegetation in the form of raised beds along the slope, burning of the covered vegetation and planting of tuber crops results in soil loss of 50 tones/ha/year. Cultivation of pineapple on sloppy land causes soil loss to the tune of 24 to 64 tones/ha/year during the first year of establishment. However, during second year soil loss gets reduced to 6 tones/ha/year.

The area under forest in the hills have already gone down. With large scale deforestation in shifting cultivation there occurs undesirable ecological changes. Further, since the hill tops, particularly the catchment areas, are the source of water, deforestation in the hills had led to elimination of the sources of water while increasing the run-off due to consequent inability of the soil to retain the water. Adverse effects of shifting cultivation on soil erosion, crop production and elimination of important free species as well as genetic resources in the region know no bound. **Fig.3.7** outlines(13) these adverse effects.

### 3.7 Soil & Water Conservation Practices in NEH Region :

Soil and water conservation practices are considered to be those measures that provide for the management of water and soil in such a way as to insure the most effective use of each. These conservation practices involve the soil, the plant, and the climate, each of which is of utmost importance.

The soil and water conservation work in the North Eastern Region, presently being carried out can be divided into three groups of programs:

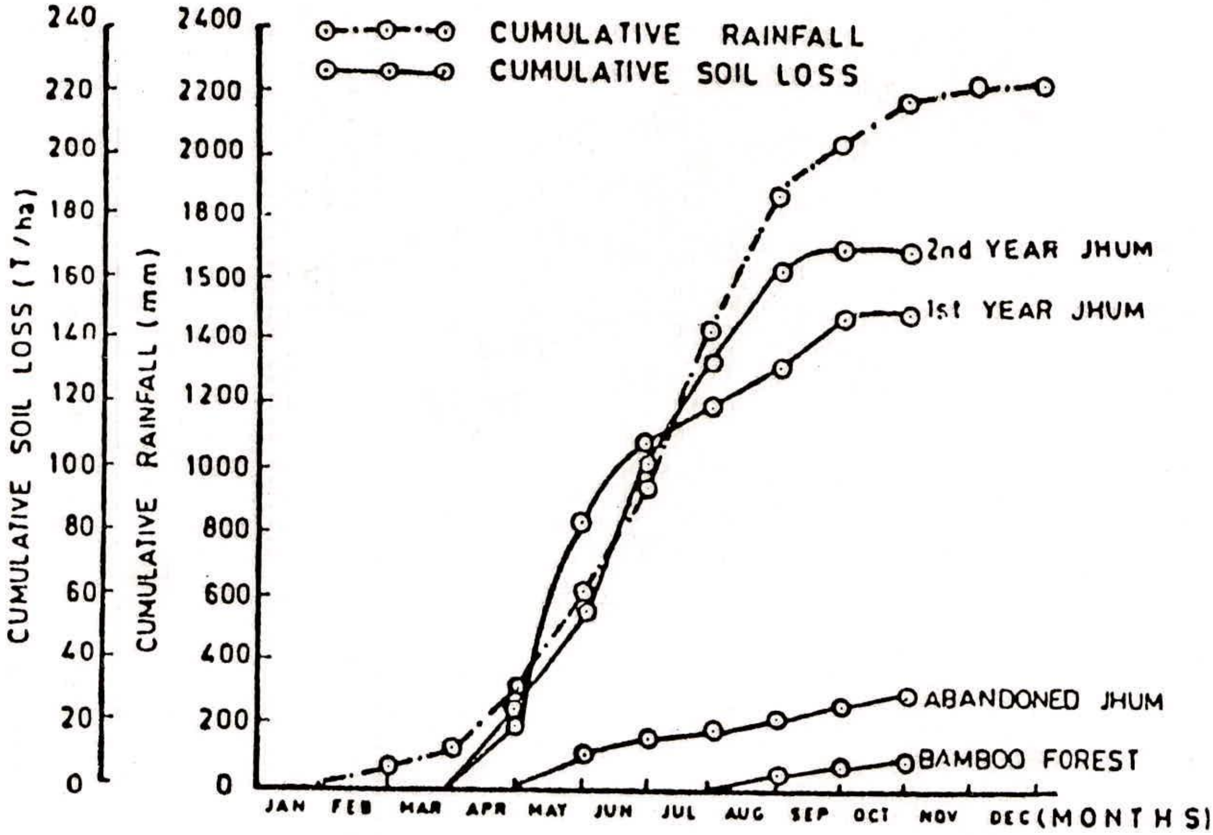
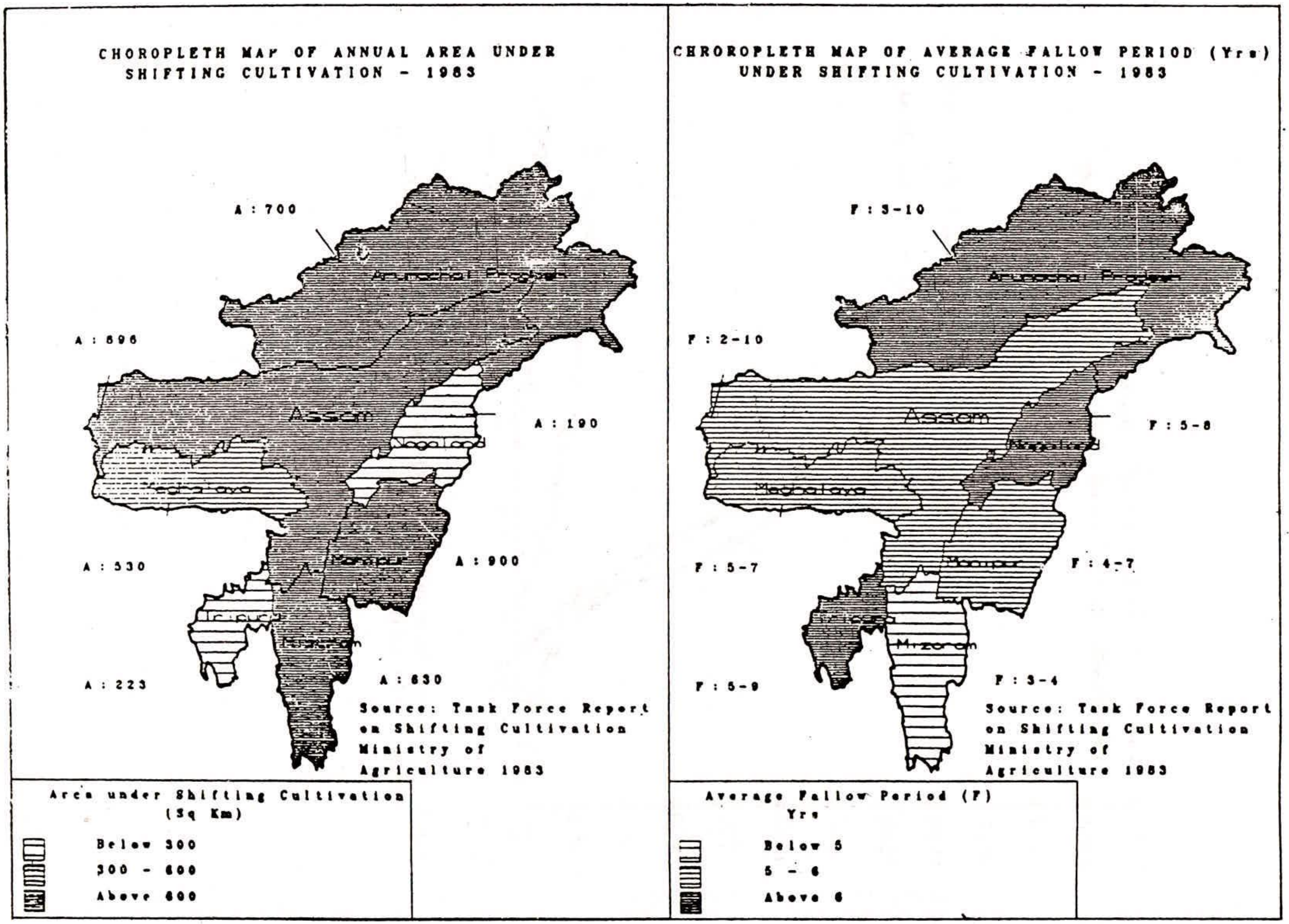



*Fig.3.5 Soil Loss from 60%-70 % Slope Under Various Stages of Jhum Cultivation*




*Source : Basic statistics of NE Region, NEC(1995)*

*Fig.3.6 Choropleth Map of Annual Area Under Shifting Cultivation -1983*

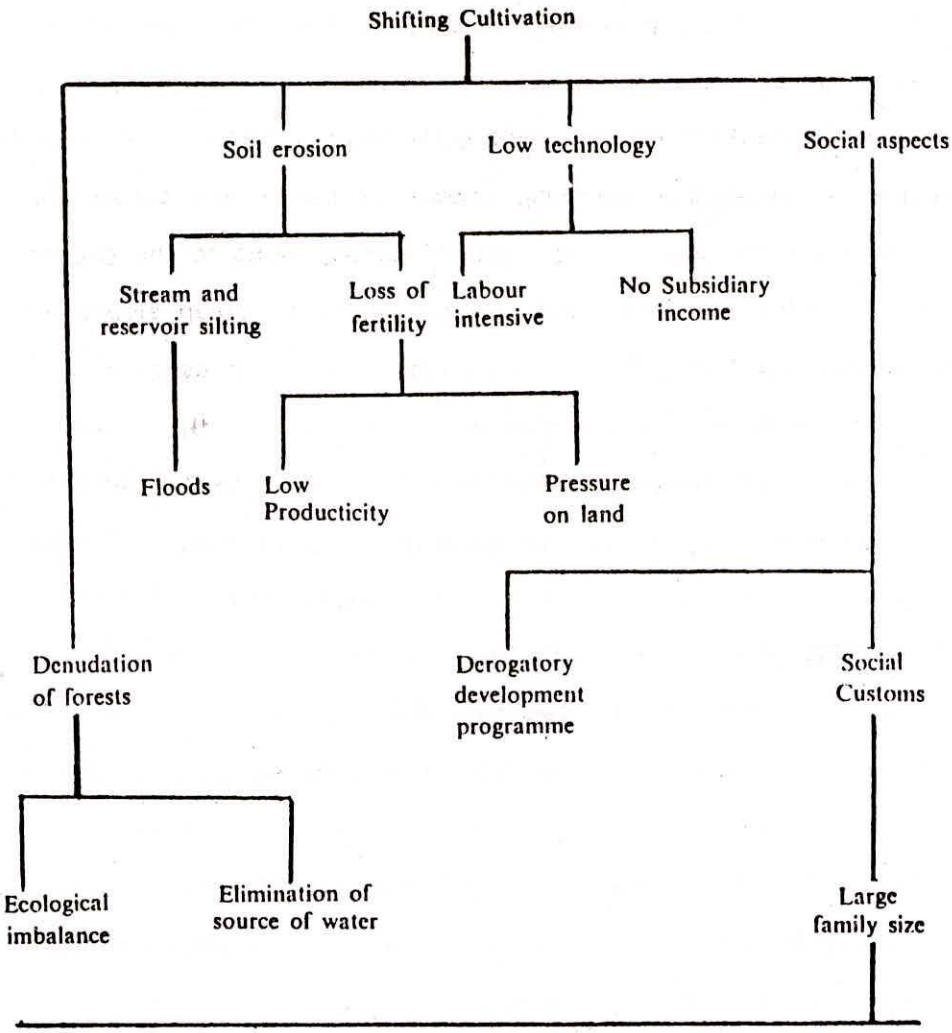



*Fig.3.7 Adverse Effects of Shifting Cultivation(13)*

The First Group includes various conservation measures such as (a) Erosion control works to protect existing cultivation lands,(b) Land development works such as construction of terraces and reclamation of valley land for permanent cultivation, (c) Contour bunding and gully plugging. To conserve waters in hills, mechanical or vegetative barriers, known as bunds are constructed across the slope with a aim to divert excess run off during rains to the grassed water ways and retain eroded soil with bunds. These bunds on steep slopes are constructed by excavating parabolic channel (0.3 m top and 0.2 m deep) on contour keeping dug out soil in form of a bund at the lower edge of the channel. These bunds require care in maintenance during first two years. It is found that vegetative barriers alone does not serve the purpose on steep slopes. The vertical interval of these bunds vary from 0.5 m to 5.0 m depending on the land use and soil depth. (d) Bench Terrace which are the flat beds constructed across the hill slope. The space between the two contours are levelled on the principle of cut and fill. In micro water sheds involving steep slopes, few benches are constructed to produce food crops through intensive cropping. The vertical interval of such terrace are maintained at 1 m interval, (e) Stream or river banks erosion control works by construction of spurs and rivetment walls,(f) Aforestation works and (g) Raising of fodder and pasture wherever possible.

The Second Group of work consists of various jhum control schemes being carried out in the region.

The Third Group consists of various experimental and indigenous methods.

Largely, there appears to be no conscience on the part of land users about the progressive decline in the production potentiality of the land (mainly hill slopes) except in few pockets where excellent land and water management techniques are being used as discussed in brief below:

Bench Terracing: Bench terraces are well adopted and successfully used in the region, where irrigation facilities are available. Excellent terraced land cultivation system is widely practiced in Sikkim and Nagaland. However, the system in certain pockets particularly where taken up as scheme for jhum control and irrigation is not available, has not become popular. Almost in all cases, excess water disposal and irrigation water application system consists of allowing the water to flow from one terrace to another by way of providing opening in the ridge bunds. Though, in some cases bench terraces are so nicely built but stability is ruined due to lack of proper water disposal system. In most of the cases, scrapping of vegetation from terrace risers every year with spade is common which may not be good practice on long term interest. Bench terrace cultivation with availability of irrigation water particularly in Nagaland, presents excellent example of using very steep slopes (above 100 %) and even rocky lands where even small quantity of soil available have been used for making bench terraces.

Contour Bunds : Contour bunds are widely used on slopes where farmers have tried to develop settled agriculture. Though the main idea of this particular measure is to convert the slopes into level benches in due course of time but the purpose is hardly served. Due to lack of maintenance, most of the eroded soil escapes out and the system leads to heavy loss of soil.

Longitudinal Beds: Small bunds like structures constructed on hill slopes are used for raising crops. The system locally known as bund method of cultivation involves putting of dried vegetation in a form of bund along the slopes, covering the same with soil (collected from the surroundings), burning of the covered vegetation and planting of tuber crops. Though, good crop yield is obtained, the system leads to 40 to 50 tones/ha of soil loss annually. It has been observed that as the years pass, the horizontal spacing in between two bunds goes on increasing due to lack of soil and finally the land is abandoned and even grasses fail to grow over the land due to exposure of bed rocks.

Half-Moon Terraces: Half -moon terraces are used on slopes for planting of horticulture crops. It is an excellent measure which provides conducive environment for initial establishment of seedings and provides protection against soil erosion on slopes.

Bamboo Drip Irrigation System : Water application on slopes for irrigation of plantation crops poses a serious problem of soil erosion. Tribal farmers in Muktapur, Jaintia hills district of Mail have evolved indigenous techniques of bamboo drip irrigation(13). Betel leaf crop planted with arecanut is irrigated with this system in which water trickles/drip drop by drop. Such steep slopes having boulders and soil mixture under the plantation could not otherwise have been irrigated so easily. In this system, water from natural streams located at higher elevation is conveyed with the use of bamboo channels supported on ground surface by wooden or bamboo supports, to the site of the plot through gravity flow and discharges up to 25 liters per minute are easily managed.

Water distribution in the system(Fig.3.8) is done with the use of bamboo channels, channel supports, water diversion pipes and the bamboo strips. The whole system enables the distribution of 15 to 25 liters of water per minute entering the main channel to 10 to 80 drops per minute at the site of water application without any leakage at any point.

Contour Guide Lines: In contouring, tillage operations are carried out as nearly as practical on the contour. A guide line is laid out for each plow land, and the back-furrows or dead-furrows are plowed on these lines. On small fields of uniform size, several lines may be required to assure that all tillage rows remain within the usual limits of 1 to 2 ft of fall per 100 ft. Contouring operations must be laid out carefully if they are to be effective. Contour guide rows, terraces, and contour strip boundaries establish the pattern and accuracy of all subsequent contouring operations. In changing field boundaries for contour farming, fences should be relocated on contour or moved so as to eliminate odd-shaped fields that would result in short, variable-length rows, called point rows.

### 3.8 Review of Remedial Measures :

There are many experimental/demonstration and field works of various departments like ICAR, Barapani, Soil Conservation Deptt, Forest Deptt, Agriculture Deptt(through NWDPRA) and academic/research institutes of the region to

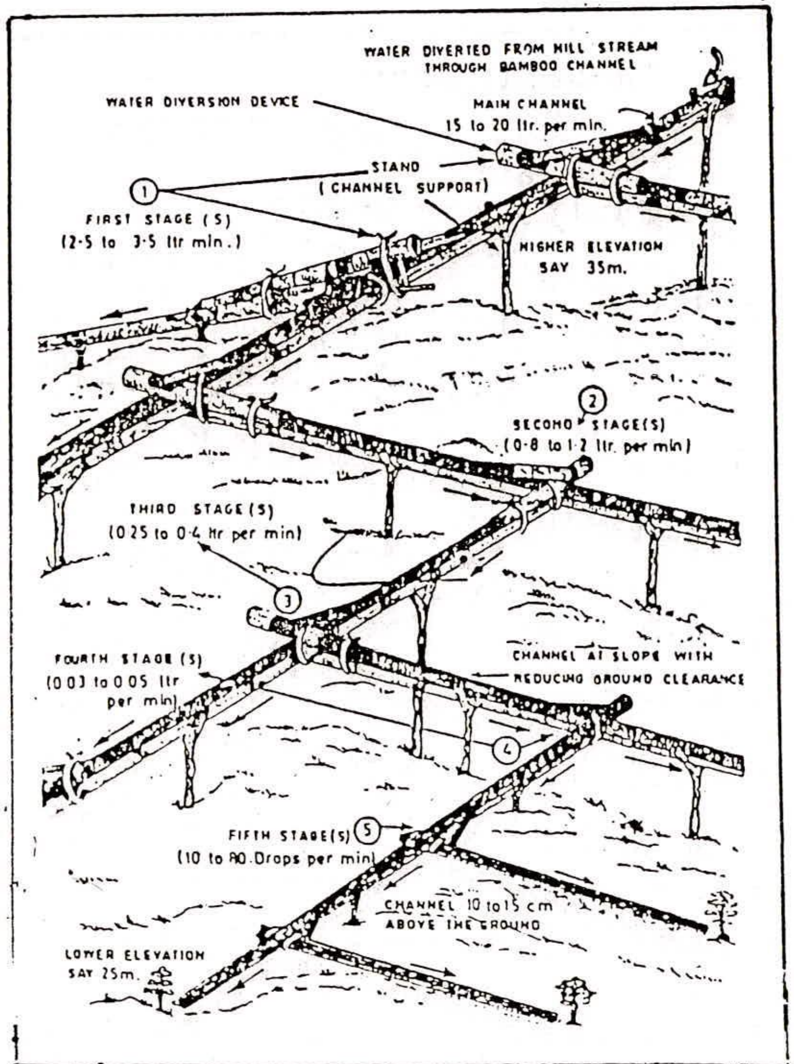



*Fig.3.8 Principle of Water Distribution in Bamboo Drip Irrigation (Shown in five stages)*

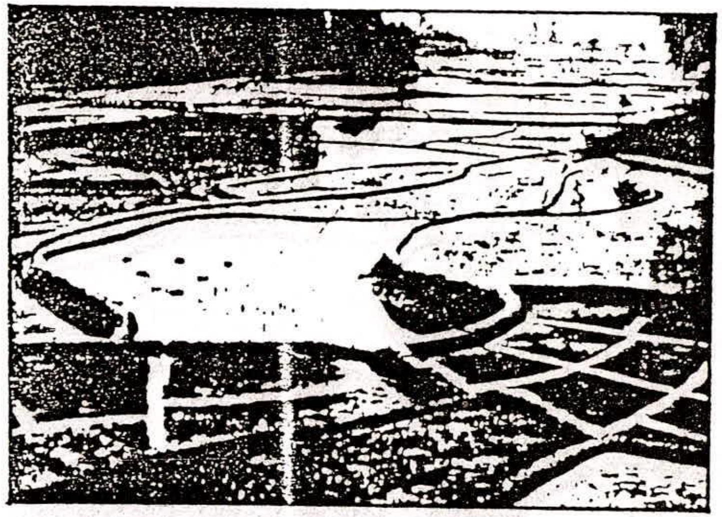


*Fig.3.9 Layout of Plots And Water Management at Apatani Plateau (Arunanchal Pradesh)*

evolve suitable remedial measures to the soil & water conservation problems. The works mainly include:

- Land improvement(contour bunding)
- Gully control works
- Afforestation works
- Grass land development
- Soil conservation engineering works

In most of the cases it lacks integrated approach(due to involvement of multi-disciplines) and results/conclusions are not readily available.

The ICAR Research complex located at Shillong is also undertaking some model watershed for control of shifting cultivation and for solution to other soil & water related problems.

It is worthwhile to mention that in consideration of agricultural, ecological and socio-economic concern the National Watershed Development Project for Rain-fed Areas(NWDPRA) is expanded to create models of scientific land use through development of integrated farming systems on the principles of watershed management in each development Block throughout the states where less than 30% arable area is under assured means of irrigation.

An integrated land use system at Burnihat (Meghalaya) was developed(31) as a strategy aiming at the eventual self-sufficiency in foodgrains, feed, fodder and fuel requirements through mixed farming system and also to restore ecological balance, conserve soil and water in situ.

About one third area of the hill slope towards foot-hills has been terraced in such a way that the top soil is kept on the surface of terraces. This is feasible if terracing is started from the foot-hill. The portion has been assigned to agriculture wherein rice is grown in the lower terraces while maize, tapioca, oilseeds and pulses are grown in the upper terraces. Middle third portion of the hill slope is put under horticulture crops, viz., citrus, pineapple and banana. The fruit trees are planted in half moon terraces and pineapple on the contour bunds. The top third portion of the hill slope is utilized for fodder-cum-fuel plantation (silvi-pastoral). Stylosanthes quyanensis, Stylosanthes hamata and

Centrosema pubescens have been planted as perennial legume in between the fodder and fuel trees. The soil losses from silvi-pastoral and horticulture are arrested in the lower terraces resulting in no soil and run-off loss from the hill.

Researches on soil and water conservation have been primarily carried out in the country by the Central Soil and Water Conservation Resources and Training Institute at Dehradun. Such studies have been undertaken in the Northern Eastern Region by the ICAR Resources Complex for N.E.H. Region. The research institute at Dehradun has developed a package of soil and water conservation measures, which include water harvesting practices, soil and water conservation practices on agricultural lands, forests and grass lands in watersheds. Such recommended practices are:

Agriculture Lands:

1. *Slopes less than 3 percent*:

-Contour cultivation alongwith suitable crop grometry and cultural practices.

2. *Slopes ranging between 3 to 6 percent:*

-Contour bunding where soils have favourable infiltration and permeability rates and with less than 500 mm of annual rainfall. Graded bunds may be adopted on soils having relatively low infiltration rates and rainfall exceeding 500 mm annually so that adequate surface drainage is provided. In deep vertisols, conservation ditches can be adopted.

3. *Slopes between 6 to 33 percent:*

-Where the soils are favourable, contour trenching can be adopted. For raising crops like potato, etc., bench terracing with suitable vertical intervals may be adopted on steeply sloping lands. The terrace risers are to be protected with suitable vegetative measures or stone

Non-Agricultural Lands:

-These lands often constitute to be a major componenent of almost all the watersheds in the country, have many limitations such as slopes (greater than 33 percent), erosion, rockiness, shallowness of soils etc. Such areas are unsuitable for cultivation of agricultureal crops.

## 4.0 CONCLUDING REMARKS & RECOMMENDATIONS :

Soil & water conservation problems in North Eastern Hill Region is largely associated with intensive human activity related to agriculture and construction of roads and paths. Occurrence of geological erosion due to typical terrain is quite prominent. Though, there are limited scientific evidences to show the extent yet general consciousness prevails about the seriousness of soil erosion problem in the region.

Washing of fertile top soil and exposure of rocks due to soil wash as a result of shifting cultivation around habitats with intense human activities are occurring everyday. One could easily imagine the change which has occurred during the last 50 to 100 years when he looks back to little past. An unimaginable change has taken place in ecological system and it may not be exaggeration in concluding that resources degradation in the region is in the increasing order. Where interference is minimal and the areas are at very high altitude, one would see slow and gradual process of soil erosion, exposed rocks on hills and dying of lakes. Preliminary studies indicate that soil erosion problems in jhum land is of mainly splash and wash. As crops are taken in mixture on zero slopes, erosion is a result of initial intensive human activity, disturbances due to weeding, splash and wash.

In North Eastern Hill region about 50 m.ham of water is flowing waste into the sea without being put to beneficial use. Unfortunately, no big conservation reservoirs have been created in this region except few small dams for power generation. Scientific watershed management and creation of conservation storages small or big are yet to see its beginning in almost all problem areas. As a result inspite of its huge water resources many areas, like even Cherrapunji the wettest region of the world, suffer from acute shortage of drinking water during winter.

The engineering approach to soil and water conservation problems involves the physical integration of soil, water, plants in the design of a co-ordinated water management system based upon the best physical information available. It is important that specialist in the various aspects of conservation have an appreciation of one another's techniques, as there are few problems that can be solved within the limits of any one field.

Selection of soil and water conservation measures in the hilly areas needs essentially to be viewed in combination with the land use and hydrological behaviour of the area. Research conducted in the region by various organizations indicated that:

*a)Cultivation on steep slopes, though hazardous due to serious problems,yet high infiltration is maintained.*

*b)Once the slopes are converted into bench terraces, the infiltration characteristics of the soil surface changes and reduce with the passage of time. Such lands may yield more runoff as compared to sloppy land. The runoff will remain silt free.*

*c)Mechanical soil and water conservation measures are active in the hill slopes. It appears feasible to use 100 % local resources such as soil, vegetations, manpower for developing suitable soil and water developing suitable soil and water conservation measures for managément of agricultural land in the hills, in most of the cases.*

*d)People's participation in the conservation measures has the direct bearing on the success of such measures in the long run.*

Research as carried out in the region, has led to identification of suitable fodder-cum fuel tress suited to the region, besides development of cropping pattern with improved verities, pasture development programs, water harvesting technology and specific farming systems suited to the situations. Such advanced technology need to be introduced in the watershed management projects for soil and water conservation.

Departments have arrangements for training their Surveyors and field workers including village level workers in soil and water conservation. While the need for strengthening facilities men and material for such training cannot be over-emphasized, it is suggested that along with training the visits to successful Soil & Water Conservation Projects both in the States and outside the States should be incorporated with this training programme. This will help the grass root level workers to develop proper vision for understanding the field job they have to perform.

One of the deficiencies of the soil and water conservation programme is the lack of proper maintenance of soil conservation works. After completion of the projects, the works are handed over to cultivators for maintenance and operation. Both National Commission on Agriculture and Rastriya Bar Ayog have emphasized the need for maintenance of Soil Conservation works for some years by the implementing agencies. However, in the ultimate analysis, it is the beneficiary (farmer) who has to own, maintain and operate the works and assets created through watershed management projects. Probably in no State there is specific arrangement for farmers training in soil and water conservation program. It is essential that training for farmers in soil and water conservation in their own language and simple form should be initiated as early as possible. This informal type of training may be started right from the planning stage and carried on through the implementation and maintenance stages. The visit of beneficiaries to a successful soil conservation project both in the State and outside the State should be an integral part of this training so that by seeing themselves they are convinced about the real benefits of soil and water conservation works.

For optimizing yield in the region, some of the missing links in the available technology suggested by researchers as listed below should be filled up:

***Proper land capability classification system, farming system for entire watershed keeping in view the farmers'requirement for food,fuel and fiber and ecological balance.*

***Status of micro-nutrients in soils and plants.*

***Effect of different cropping systems on the soil physico-chemical properties and nutrient losses.*

***Effects of tillage, irrigation, mulching and green manure on soil-properties and so on.*

On the basis of works(29) of some of the engineers experienced with the present scenario of NEH Region a few ***conceptual*** types of water harvesting structures with illustrations are presented below:

*1.The Check Dam(conceptual) as shown in Appendix-VII can be constructed at suitable places in a small river/stream with locally available materials.*

*2.The **Underground Check Dam** shown in **Appendix-VIII** has the advantage that it does not interfere with the natural overland flow. The location should be such that sand/gravel materials are available at upstream and it should be taken to imperious strata below. This increases recharge to the well in the vicinity.*

*3.**Micro Catchment Water Harvesting Structure** as per plan shown in **Appendix-IX** is suitable for semi-arid region. Its dimension depends on rainfall intensity, catchment area, evaporation and the quantity of water to be stored as per requirement.*

*4.**Water Harvesting Tank with Diversion Weir** shown in **Appendix-X** is used for supplemental irrigation and drinking water needs and is suitable for high rainfall areas which face shortage of water during winter/non-monsoon months.*

*5.**Diversion Arrangement of Water from Higher Elevation** as shown in **Appendix-XI** is made in hills by constructing a small weir & storing the water in a reservoir in the down stream at lower elevation. The water from the stream is conveyed from the weir to the reservoir by gravity during monsoon and stored for use in the non-monsoon months. This suitable for hilly regions where rivers are mostly dry during non-monsoon.*

*6.**Rain Water Harvesting from Roof** as shown in **Appendix-XII** is suitable for areas with moderate to high rainfall. In the illustration, a forest rest house requiring water for 16 persons was facing shortage of water supply during four months even though the rainfall was 3000mm(Andamans. which is similar to NEH Region in respect of topography and rainfall). The method suggested would solve the water supply problem and there is scope for increasing the capacity from 100$^{m3}$ to 200$^{m3}$.*

As an exemplary case, the Cherrapunji area of Meghalaya, the heaviest rainfall zone of the world suffers from acute shortage of drinking water in the winter months. It has been the serious concern of the people and the Government since long past to undertake suitable soil and water conservation measures in the hill catchments. However, no such comprehensive and sustainable effort is visible at site as yet. It will be only a test of time to concert efforts of all concerned to moot out viable projects that would attract the people, encourage them to participate and enable them to maintain it within the reasonable resources availability in the area and also give quick relief to the vexed problem.

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*APPENDICES*

## IMPORTANT WATERSHED CHARACTERISTICS – DATA REQUIRED FOR PLANNING

| Sl. No. | Characteristics | Required for | Parameters and Indices | Source & means to obtain |
|---|---|---|---|---|
| 1. | Size | Average precipitation, runoff and sedimentation (rate & volume); production potential; workload and investment | Standard area units | Topo-maps, aerial photos |
| 2. | Shape | Runoff & Sedimentation (rate and volume); operational schedules and conveniences | a) Geometric form<br>b) Shape Index<br>c) Compactness co-efficient<br>d) Form factor | From map by using respective formulae or available regression equations. |
| 3. | Relief | Runnoff & sedimentation (rate and volume); treatment details; surface storage, operational convenience. | a) Mean elevation<br>b) Average slope<br>c) Geomorphic units<br>d) Total relief<br>e) Relief ratio | Topographic, maps, aerial photos and block diagrams (using respective formulae). |
| 4. | Drainage | Runoff and sedimentation channel treatment, surface storage, operational convenience | a) Drainage pattern<br>b) Stream order<br>c) Drainage density | Topo maps and aerial Photos using respective formulae |
| 5. | Geology | Sedimentation and runoff, ground water, construction material, structure foundation | a) Type of rocks<br>b) Stratigraphy | Geological maps, reports, field surveys. |
| 6. | Soils | Runoff and sedimentation; treatment details, production potential, proper land use, operational convenience | a) Soil series and soil phases<br>b) Morphological, physical. and chemical properties<br>c) Hydrologic soil groups<br>d) Soil moisture regime | Soil survey reports and maps; field surveys |
| 7. | Climate | Runoff and sedimentation; treatment details; proper land use, production potential; operational convenience. | a) Precipitation<br>b) Temperature<br>c) Humidity<br>d) Wind velocity<br>e) Sunshine hours | Meterological records, reports and other publications |
| 8. | Surface Conditions and land use | Runoff and sedimentation ground water; soil moisture treatment details, operational conveniences. | a) Present land use condition<br>b) Natural vegetation<br>c) Canopy percent<br>d) Hydrologic cover conditions<br>e) Existing tanks<br>f) Communications. | Revenue records, forest working plans and reports, topo sheets, aerial photos and ground surveys. |
| 9. | Ground water | Runoff; production potential, operational conveniences, treatment details | a) Water table contours or depths<br>b) Quality of ground water. | Ground water survey reports; existing wells. |
| 10. | Social & legal status | Treatment details, operational conveniences, watershed sufficiency/deficiency in food, fodder & fuel; animal and manpower, acceptance, follow up and maintenance of programmes runoff and sedimentation | a) Human & animal population<br>b) Land holdings and tenure laws<br>c) Existing management level<br>d) Land and water development legislation | Census reports, revenue records, district gazetteers |

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## GUIDELINES FOR PREPARATION OF PROJECTS ON WATERSHED MANAGEMENT :

Watershed Management project for specific areas will depend on the physiography of the land, hydrological behaviour, and the needs of the people etc. However some of the important aspects required to be considered in developing watershed management project, in general, are mentioned here. Guidelines for such projects have also been issued by the Government of India on various occasions and are already available. However the different aspects discussed here take into consideration some of the peculiarities of the North Eastern Region which need to be considered in developing such project.

**1. Location and Size :**

It is felt that priority for locating watershed management projects in the North Eastern Region should be given initially to the areas already adversely affected by shifting cultivation, and other faulty land uses including natural adversities. Although macro-watersheds of around 1000 ha. or above should be the ideal size for such projects yet there is also a need for large scale demonstration at the level of micro-watersheds..

**2. Delineation of Watershed :**

Delineation of the catchment areas and compilation of informations such as physiography, slope-gradient, drainage intensity, soil depth, soil texture, infiltration rate, soil moisture storage capacity, surface cover conditions, existing land use, soil erodibility and such other problems and potentials are necessary before planning the project.

**3. Bench Mark Survey :**

Format for bench mark survey for preparation of watershed management projects are already available with the development departments from the guidelines issued by the Government of India and Research Institutes etc. Besides informations on watershed characteristics, various other informations such as irrigation potentiality, existing crop and cropping pattern and farming systems and practices, socio economic constraints, special problem of the area, existence of financing agencies/institutions, marketing facilities, land ownership pattern, available labour force per family etc. are very relevant while making the bench mark survey.

**4. Approach to Project Planning :**

After compilation of the required information and assessment of the needs of the local people the approach to the project planning should be made preferably involving the community to ensure their active participation. Detailed planning for treatment of the land, water resources development and scientific land use should then be prepared.

**5. Market :**

One of the major lacuna in improving agriculture in the region and providing incentive to the farmars is the lack of post harvest facilities and marketing in the region as a whole and in the rural areas in particular. Any programme for planned agricultural production and more particularly of horticultural produce, including perishable commodities, will not have the desired success unless there is an avenue for disposing off the excess production without the fear of being spoiled or damaged. It is therefore very essential to plan for proper marketing facilities, if not already available or to establish such linkages with the market while planning large scale watershed management project involving a production programme. In many cases the assessment of income from the project and net return per family per year as indicated in the project plan will have no significance unless a reasonable price through a market is ensured.

**6. Awareness :**

Yet another reason for failure of such projects in the rural areas and not receiving proper participation from the farmers or even for the lack of proper involvement of the executing officers, is the lack of awareness about the programme and its utility. As such proper planning should be made while developing such projects for not only bringing about awareness about the project amongest the beneficiary farmers but also to ensure their active involvement and participation from the beginning. As a matter of fact, the involvement of the beneficiaries is essential in the planning process of the project itself. Similarly proper orientation and training of the executing personnel is also required. Provision should therefore be made accordingly for such programme in the project itself.

**7. Inter-Sectoral Co-Ordination :**

Adequate inbuilt provision and arrangement should be made in the project for ensuring inter departmental co-ordination while executing the project. Otherwise a multi-disciplinary project like the watershed management project may not produce the desired result due to lack of active co-operation amongst the various departments involved in the project.

**8. Time Frame :**

Time Frame of 3 to 5 years is good enough for such watershed management projects.

**9. Finance :**

Financial involvement in such multi-disciplinary projects involving land treatment and land use etc. will surely be higher than other such agricultural progremmes. It is therefore very essential to ensure that there is no duplication of efforts through different dpartments or through different projects taken up or already being cintinued in the area. There are many projects including the centrally assisted project such as Integrated Rural Development project (IRDP), National Rural Employment Programme (NREP), IRTP, Jawahar Rojgar Yojana, and TRYSEM etc. Many of these projects have similar objectives as are planned in the watershed development projects. The benefits offered by such programme including the assistance provided under these programmes in cash or kind should be taken into account so as to avoid duplication as well as to reduce the cost in the watershed management project. Making use of such facilities and their incorporation while developing the project will reduce the financial burden of the project while avoiding unnecessary duplication. The estimates should be prepared both programme-wise and year-wise to come to the total financial involvement.

**10. Monitoring and Evaluation :**

Provision should be made in the project for regular monitoring and evaluation and for incorporation of mid-operation changes as may ne necessary. This is particularly relevant since such projects are of multi-disciplinary nature involving activities in various sectors and are planned on a long term basis.

**11. Maps and Designs :**

It would be convenient to plan the programmes effectively if the detailed topographical map of the village area is prepared in advance. The present land use details and suitability of the land for various uses may be indicated in such maps. Such maps will also help to plan the areas to be handed over to the farmers. This will also help in working out the technical assistance to be provided to each farmer and to decide the remaining land of the area which need to be managed with the help of farmer's society under supervision of the executing authorities.

Drawings and designs of all engineering works contemplated should ne suitably prepared and included in the project so that realistic estimates can be included based on such drawings and desings.

**12. Technology Component :**

It should be essured that the latest and improved technology as recommended through research and experience are incorporated in the programme. If necessary, development plan for each farmer's land and for the community land may be prepared separately. The emphasis with every production system and land use should be on conservation so as to reduce the rate of resources degradation. Quantitative values, for each item planned, need to be worked out and made a part of the project report.

Some of the relevant components of technology that needs to be specially looked into in the North Eastern Region are indicated below:

i) Scientific treatment of the land as desirable based on local conditions. As already indicated it is not always necessary to terrace the entire area. Terraces, contour bunds or half moon terraces should be provided for as desirable. This is particularly important since land reclamation and terraces require lots of money increasing the cost of the project.

ii) Water harvesting utilising local available resources should be included wherever feasible.

iii) Reliance should be more on indigenous materials and resources to be utilised in the project specifically in the rural areas. Such measures will not only be easier for the farmers to take care of but will also reduce the total cost involved.

iv) Wherever terraces are made, toposequences for cultivation of crops should be followed so that crops requiring less water/moisture be put in the upper terraces while crops requiring more water such as rice be cultivated in the lower terraces.

v) Wherever terraces are made, the terrace risers should be utilised for growing recommended perennial fodder grasses and legumes. This will help in supporting the subsidiary sources of income from animal husbandry while protecting the risers from erosion.

vi) Improved tools and implements should be provided to the farmers for increasing the available energy per ha. as well as to reduce the drudgery of work.

vii) Appropriate improved varieties of crops should be included and steps should be taken to ensure supply of inputs in time.

viii) Innovative technology, such as, paddy cum fish culture should be encouraged wherever the land permits such use.

ix) Intercropping should be followed invariably wherever such cropping system is feasible. For example, intercropping of pulses, bean or soybean should be followed wherever maize is grown as the main crop.

x) In areas where the supply of water is not assured specific technology for rainfed agriculture should be incorporated.

**13. General :**

i) The land ownership pattern in the North Eastern Region, in many cases does not provide incentives to individual farmers for scientific land use. As such allotment of specific land to individual farmers will help in bringing about an involvement of the farmers in development of the area. In consideration of the very poor economic background of many of the farmers particularly in the rural areas, it would be desirable to allot the land so that the farmer utilises the land property for the purpose for which the same has been alloted. This is particularly important in the initial years.

ii) Capability of the farming families in terms of available horsepower or labour force should be kept in view while developing the programme. Otherwise there may be overloading leading to non fulfilment of the target.

iii) In general it would be desirable to include such crops and farming practices only as are being utilised or practiced by the farmers. Deviation should only be made when (a) there is a potentiality for a crop or livestock with an assured market nearby, (b) when a crop can be introduced additionally in the existing crop sequence or (c) when a crop deserves to be introduced for improving the nutritional status of the people or such other situations.

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APPENDIX-III

*Table I — Land utilisation pattern in N.E.H. Region (Area in '000 ha)*

| | Assam | Arunachal Pradesh | Manipur | Meghalaya | Nagaland | Tripura | Maizoram | Sikkim | Total |
|---|---|---|---|---|---|---|---|---|---|
| Total geographical area | 7844 | 8374 | 2233 | 2243 | 1658 | 1049 | 2108 | 710 | 26219 |
| Reporting area for land utilisation statistics | 7842 | 5550 | 2211 | 2243 | 1099 | 1048 | 2102 | 710 | 22805 |
| Forest | 1985 | 5154 | 602 | 812 | 286 | 578 | 1303 | 262 | 10982 |
| Not available for cultivation | 2453 | 19 | 1445 | 316 | 28 | 120 | 211 | 254 | 4846 |
| Other uncultivated land excluding fallow land | 541 | 135 | 24 | 616 | 267 | 100 | 81 | 117 | 1881 |
| Fallow Land | 177 | 130 | — | 312 | 365 | 4 | 442 | — | 1430 |
| Net area sown | 2696 | 112 | 140 | 193 | 153 | 246 | 65 | 86 | 3691 |
| Area sown more than once | 743 | 40 | 100 | 10 | 11 | 134 | 3 | 6 | 1047 |
| Total cropped area | 3439 | 152 | 240 | 203 | 164 | 380 | 68 | 92 | 4738 |
| Area available for shifting cultivation | 498 | 248 | 100 | 416 | 608 | 605 | 221 | — | 2696 |

Cropping system in N.E.H. region

| State | Zone/situation | Cropping system |
|---|---|---|
| Assam | Flood-free irrigated area | Rice-rice-mustard<br>rice-rice-potato<br>rice-rice-pulses |
| | Flood-affected irrigated area | Rice-mustard, rice-potato, rice-pulses |
| | Flood-free rainfed area | Rice-wheat, jute-wheat, jute-mustard, *Ahu* rice-*sali* rice, *ahu* rice-rice, jute-potato, sugarcane |
| | Flood-affected rainfed area | *Ahu* rice-wheat, jute-wheat<br>*ahu* rice-mustard, jute-mustard, *ahu* rice-pulses |
| Tripura | Plain high or *tilla* land | *Aus* rice-groundnut/soyabean, sugarcane-baishakhi green gram or sesamum-groundnut-pulse, jute-cowpea, jute-sugarcane, sesamum/maize-groundnut |
| | Medium highland (rainfed) | *Aus* rice-mustard/cowpea, jute-mustard/cowpea, seasamum-mustard /cowpea, rice-wheat, sugarcane, rice-groundnut |
| | Medium highland (irrigated) | Rice-rice-potato/wheat/cole vegetables/mustard/pulses, jute-rice-pulses, rice-cauliflower/potato-vegetables, baishakhi green gram/cowpea (vegetable)—rice-cole vegetables/potato/wheat, rice-wheat |
| | lowlying plain (rainfed) | Rice-rice-gram/wheat. |
| | Lowlying plain (irrigated) | Rice-Rice, rice-*aman* rice-*boro* rice, rice-rice-wheat |
| | Lowlying upland | Rice-rice-rice; rice-rice |
| Meghalaya | High altitude upland | Potato-cole vegetables/ sweet potato/rice |
| | High altitude lowland | Potato-rice |
| Manipur | Valley | Rice-mustard/wheat/potato |
| Sikkim | Terrace | Rice/maize-mustard/wheat |

## Shifting cultivation in N.E. Region

| State | Annual Area under shifting cultivation (Sq. Kms.) | Fellow period (in years) | Minimum Area under shifting cultivation one time or other (Sq. Kms.) | No. of Families practising shifting cultivation |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| Arunachal Pradesh .. | 700 | 3 - 10 | 2,100 | 54,000 |
| Assam .. | 696 | 2 - 10 | 1,392 | 58,000 |
| Manipur .. | 900 | 4 - 7 | 3,600 | 70,00 |
| Meghalaya .. | 530 | 5 - 7 | 2,650 | 52,290 |
| Mizoram .. | 630 | - 4 | 1,890 | 50,000 |
| Nagaland .. | 190 | 5 - 8 | 1,913 | 1,16,046 |
| Tripura .. | 223 | 5 - 9 | 1,115 | 43,000 |
| | 3,869 (1.5 per cent) | | 14,660 (5.7 per cent) | 4,43,336 |

Source :- Basic statistics of N.E. Region, NEC, 1995

## TABLE - 20

### Coverage of Good Forest Area - 1990

(Thousand Hectare)

| State | Geographical Area | Forest Area | | Forest Area as % of | |
|---|---|---|---|---|---|
| | | Legally Notified | Actual Forest Coverage (1985 - 87 Based on Imagery) | Legally Notified | Based on Imagery |
| 1 | 2 | 3 | 4 | 5 | 6 |
| Arunachal Pradesh | 8358 | 5154 | 6876 | 61.7 | 82.3 |
| Assam | 7852 | 3071 | 2606 | 39.1 | 33.2 |
| Manipur | 2236 | 1516 | 1789 | 67.8 | 80.0 |
| Meghalaya | 2249 | 851 | 1569 | 37.8 | 69.8 |
| Mizoram | 2109 | 1593 | 1818 | 75.5 | 86.2 |
| Nagaland | 1653 | 863 | 1436 | 52.2 | 86.9 |
| Tripura | 1048 | 628 | 533 | 59.9 | 50.9 |
| Total | 25,505 | 13,676 | 16,627 | 53.62 | 65.19 |
| All India | 328,780 | 75,185 | 64,013 | 22.9 | 19.5 |

Source :- Basic statistics of N.E. Region, NEC, 1995

Annual Soil Loss Estimates in Different Regions of India

| Land Resource Region | Area ('000 km$^2$) | Soil loss (t/km$^2$) | Major Land-use |
|---|---|---|---|
| North Himalayan | 131.70 | 287 | Forest |
| Punjab-Haryana | 101.25 | 330 | Agriculture alluvial plains |
| Upper Gangetic alluvial plains | 200.00 | 1,440-3,320 | Agriculture and wasteland |
| Lower Gangetic | 145.00 | 287-940 | Agriculture/ alluvial plains |
| North-Eastern forest region | 161.00 | 2,780-4,095 | Agriculture/ shifting cultivation |
| Gujarat alluvial | 62.75 | 240-3,320 | Agriculture plain region (include ravines) |
| Red soil region | 68.80 | 240-360 | Agriculture |
| Black soil region | 67.34 | 2,370-11,250 | Agriculture |
| Lateritic soils | 61.0 | 3,930 | Agriculture |

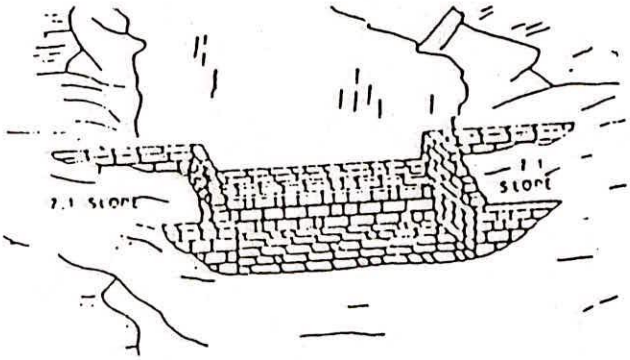
Problem Areas of Soil in N.E. Region (in lakh ha.)

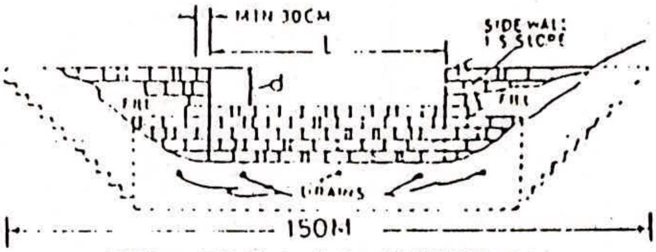
| State | due to erosion | Land degradation | Total |
|---|---|---|---|
| Arunachal Pradesh | 24.44 | 2.10 | 26.54 |
| Assam | 22.17 | 7.82 | 29.99 |
| Manipur | 3.74 | 3.60 | 7.34 |
| Meghalaya | 8.37 | 2.65 | 11.02 |
| Mizoram | 4.21 | 1.89 | 6.10 |
| Nagaland | 4.05 | 0.77 | 4.82 |
| Tripura | 1.67 | 1.12 | 2.79 |
| Total | 68.65 | 19.95 | 88.60 |

# TYPICAL MODEL OF CHECK DAM

## USING LOCALLY AVAILABLE RUBBLE

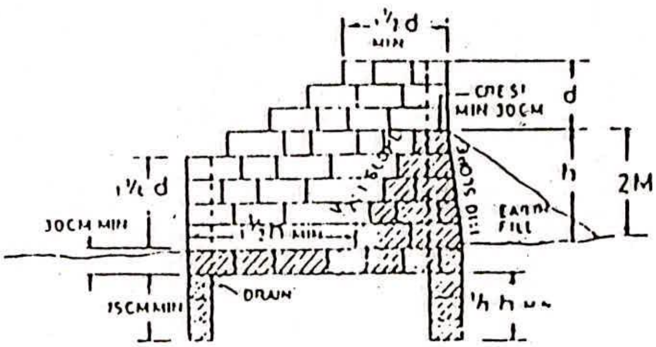
HEIGHT 1.5 TO 2M.



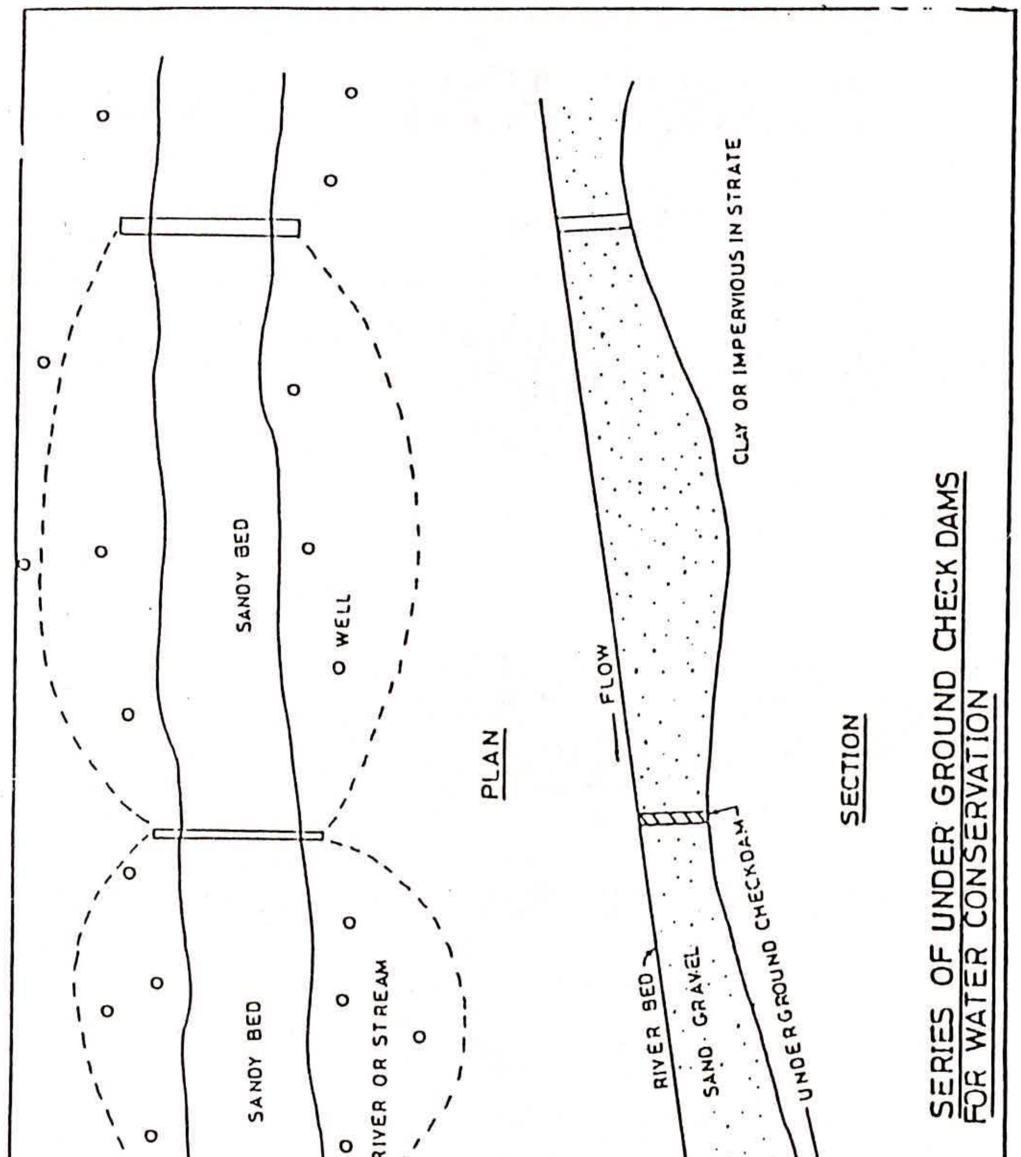



VIEW FROM DOWNSTREAM

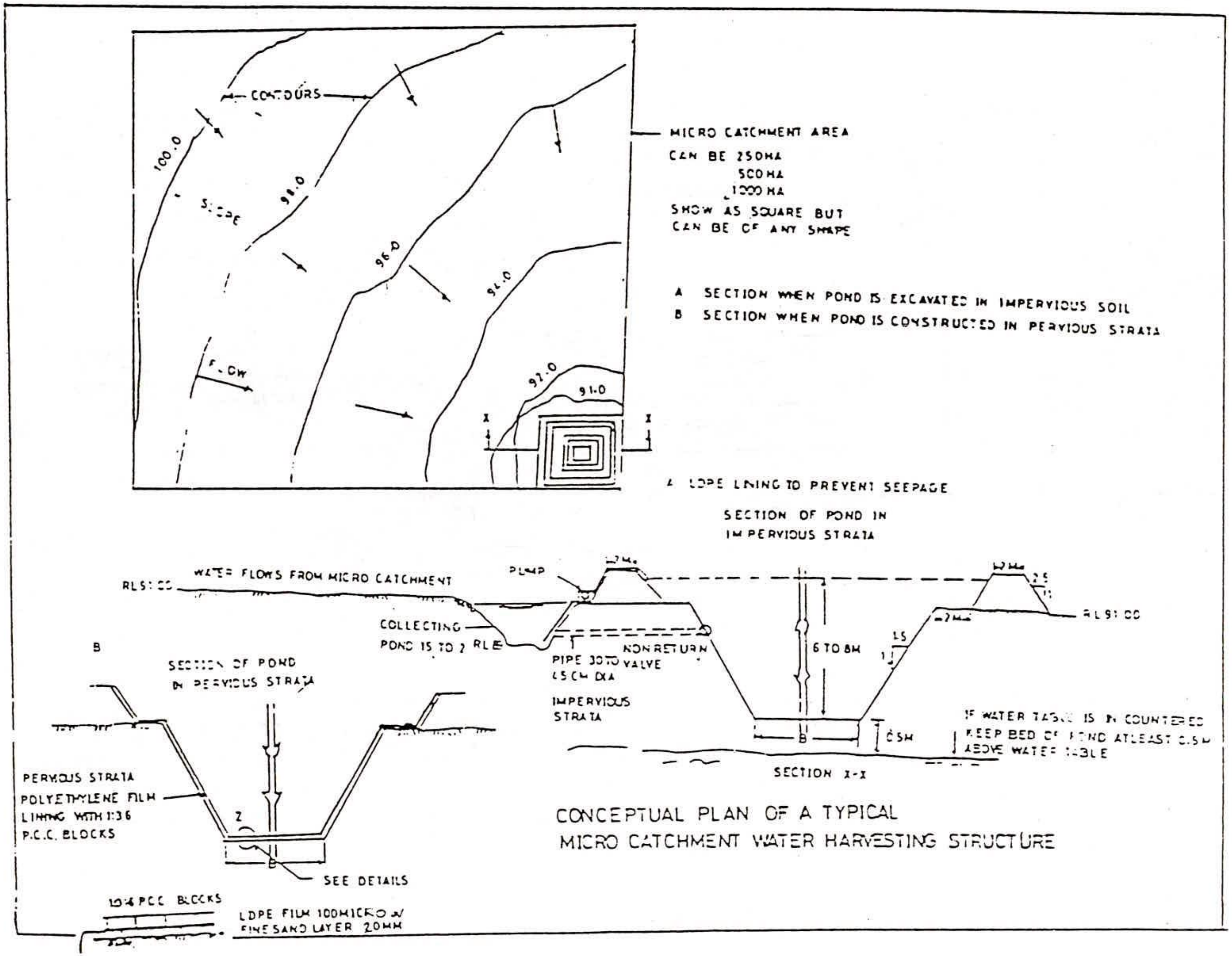
l= 50M
(range 50-100M)



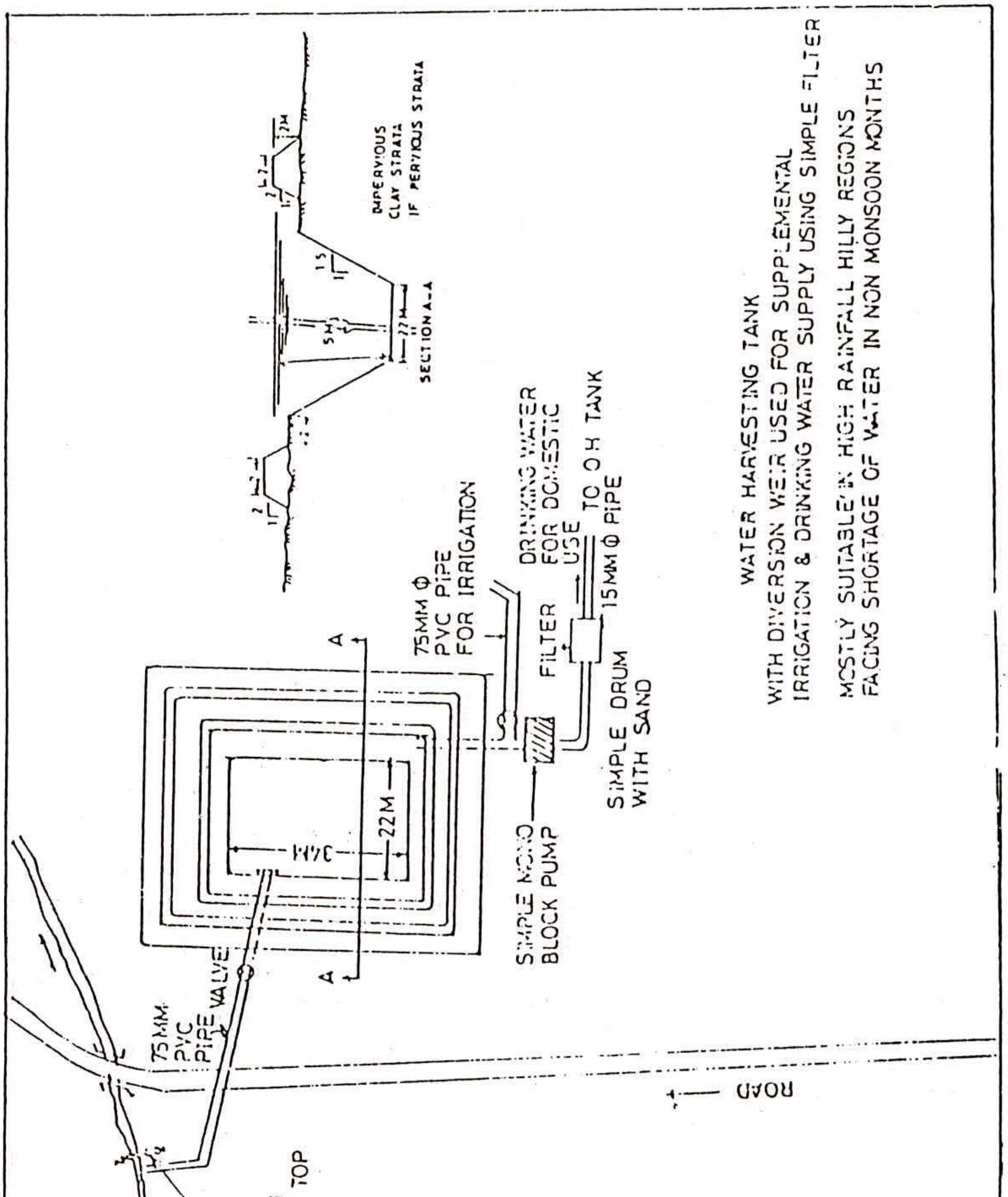

CROSS SECTION




SERIES OF UNDER GROUND CHECK DAMS FOR WATER CONSERVATION

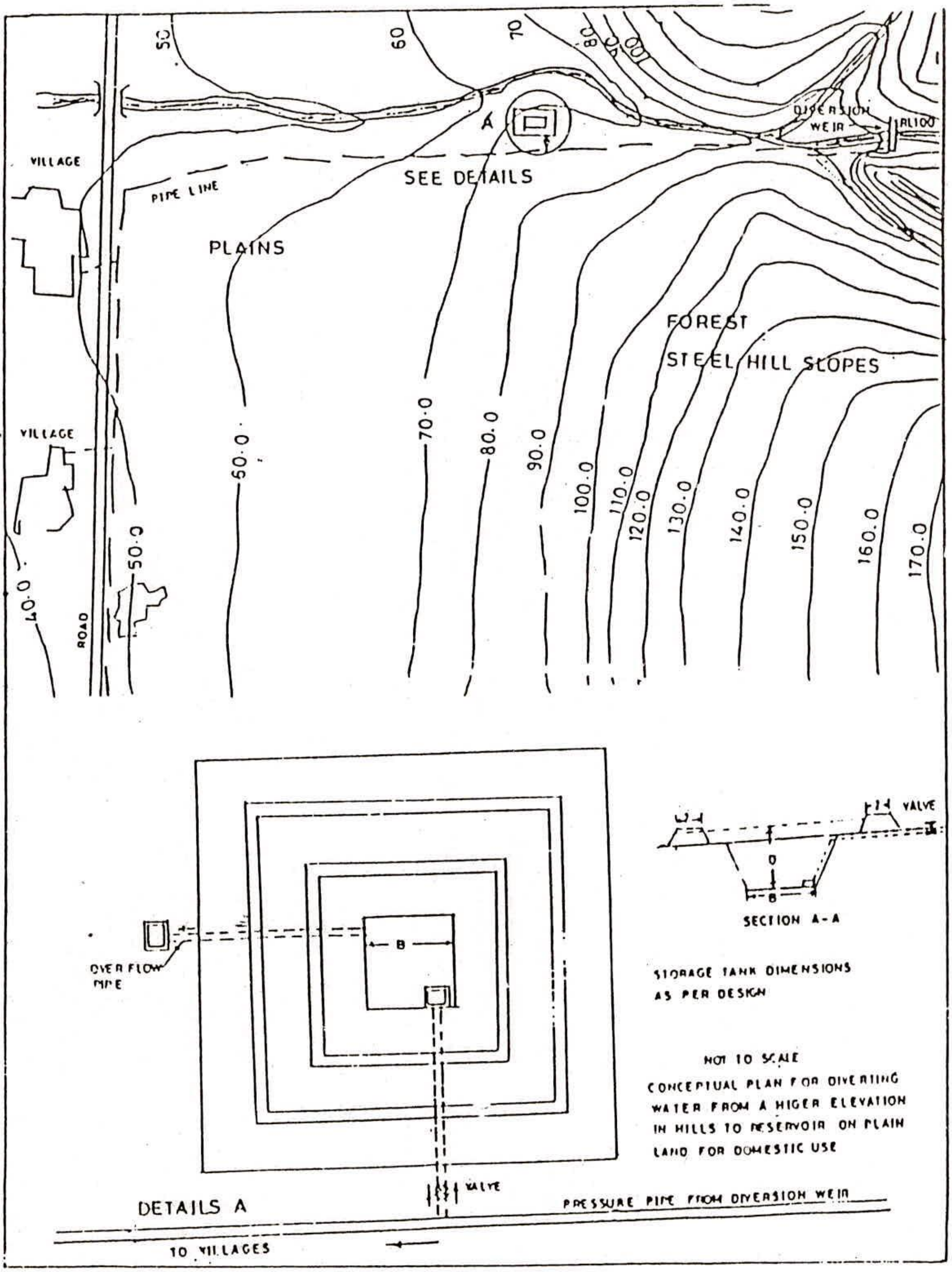


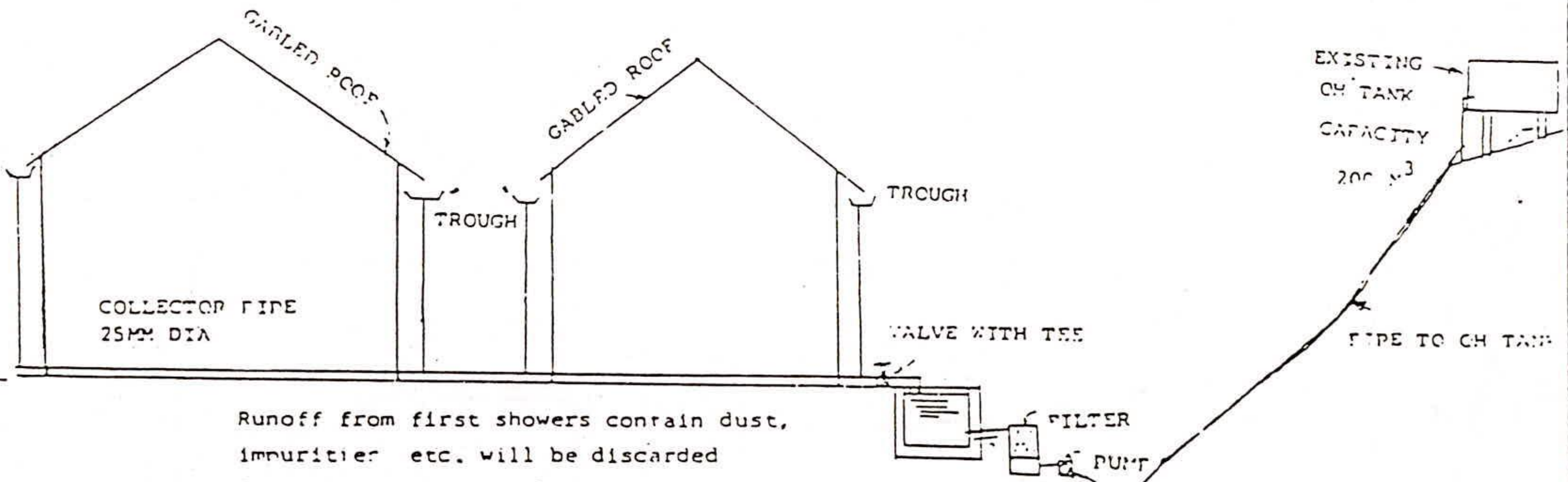

CONCEPTUAL PLAN OF A TYPICAL
MICRO CATCHMENT WATER HARVESTING STRUCTURE




WATER HARVESTING TANK
WITH DIVERSION WEIR USED FOR SUPPLEMENTAL IRRIGATION & DRINKING WATER SUPPLY USING SIMPLE FILTER

MOSTLY SUITABLE IN HIGH RAINFALL HILLY REGIONS FACING SHORTAGE OF WATER IN NON MONSOON MONTHS


DIVERSION WEIR
RL100
A
SEE DETAILS
VILLAGE
PIPE LINE
PLAINS
FOREST
STEEL HILL SLOPES
VILLAGE
ROAD
50
60
70
80
90
100
40.0
50.0
50.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
150.0
160.0
170.0
VALVE
D
B
SECTION A-A
OVER FLOW PIPE
B
STORAGE TANK DIMENSIONS AS PER DESIGN
NOT TO SCALE
CONCEPTUAL PLAN FOR DIVERTING WATER FROM A HIGER ELEVATION IN HILLS TO RESERVOIR ON PLAIN LAND FOR DOMESTIC USE
VALVE
DETAILS A
PRESSURE PIPE FROM DIVERSION WEIR
TO VILLAGES




Runoff from first showers contain dust,
impurities etc. will be discarded
For this purpose a valve with tee
is provided

RCC or steel tank made of plates
Capacity 100 $M^3$ I Stage .II stage
expansion to 200 $M^3$ possible
as yield is available

This illustration is for a forest rest
house with 70 $M^2$ Roof area
Rain fall = 3000mm gives 200 $M^3$ yield
No of persons 32 (future)
Present 16 persons
Water Shortage from Jan to April
For 4 months @ 40 LPD requirement
of 16 persons = 80 $M^3$
for 32 persons = 160 $M^3$

ARRANGEMENT FOR RAIN HARVESTING FROM
ROOF TOP OF BUILDINGS FOR DOMESTIC USE

**TITLE OF THE REPORT : SOIL AND WATER CONSERVATION WITH SPECIAL REFERENCE TO N.E. REGION**

**DIVISION : NORTH EASTERN REGIONAL CENTRE, NIH, GUWAHATI, 1995-96**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