4.1 General

In many developing countries, the desperate need for food, due to population explosion, forces people to over exploit the soil with the result that they become degraded and unproductive. In India, as in many other parts of the semiarid and humid tropics, there is an urgent need to develop methods for crop production in upland and hilly areas by using scientific land management practices. A major impediment to the development of successful, continuously productive farming system in the semiarid and humid tropics, is soil erosion, which includes both physical removal of surface soil and deterioration in soil physical properties, resulting in low productivity. The need for factual, quantitative information to determine soil erosion rates under a variety of climatic, physiographic, land use, and soil management situations, led to the establishment of small test plots in the United States early in the century. Today, such factual information exists on the erosion rates and processes because of the improved instrumentation of these field plots.

Data from plot studies on sheet erosion, made it possible to develop general relationships that could be used by soil and water resource planners to predict the long-term erosion rate, for a given field under a variety of land use strategies. Zingg (72) related steepness and length of
slope to soil loss. Smith (60) considered such factors as soil erodibility and land management. These factors were further evaluated and consolidated and a rainfall parameter added to obtain the empirical equation described by Musgrave (52). The parameters of Musgrave equation were not readily adaptable to many of the land use conditions that were encountered. A prediction model that would improve the representation of erodibility and cropping factors and overcome the deficiency of a single rainfall-intensity factor that is not closely related to the number of erosion rain storms per year was needed. The prediction model, known as the UNIVERSAL SOIL LOSS EQUATION was developed to overcome the above mentioned deficiencies by Wischmeier et al (69).

4.2 Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE) has the general form

\[ A = R K L S C P \]

in which \( A \) is the average annual soil loss, in tons per hectare and \( R \) is a factor expressing the erosion potential of average annual rainfall in the locality. It is also called the index of erosivity, erosion index etc. \( R \) is calculated as the summation of the individual storm products of the kinetic energy of rainfall (metre-tonnes/hectare) and the maximum 30 minutes rainfall intensity (cm, per hour) for all significant storms, on an average annual
basis (29,67,68). K is the soil erodibility factor, that represents the average soil loss, in tons per hectare per unit of rainfall factor R from a particular soil in cultivated continuous fallow with a standard plot length and a percent slope, arbitrarily selected as 22 metres and 9 percent respectively. S and L are topographic factors for adjusting the estimated soil loss for a specific land gradient (S) and length of slope (L). The land gradient (slope) is measured as a percentage. Slope length is defined as the average distance in metres, from the point of origin of overland flow to whichever of the following limiting conditions occurs first. The point where slope decreases to the extent that deposition begins, or the point where runoff enters well defined channels. C is the cropping management factor and represents the ratio of soil quantities eroded from land that is cropped under specified conditions to that which is eroded from clean-tilled fallow under identical slope and rainfall conditions, and P is the supporting conservation practice factor (Strip cropping, contouring etc.) (69,70). For straight row farming P = 1.0 (28,29,36,37,50,52,60,61,62,67,68,69,70,71 and 72).

4.3 Soil Loss Computation

Prediction of soil erosion using the universal soil loss equation, as proposed by Wischmeier has been attempted for the watersheds of the Bhavani. The effect of land use change on soil loss has also been studied (28,29). The
results obtained have enabled to identify the areas susceptible to erosion.

Test Watersheds

Sixteen subwatersheds thirteen from hills and three from plains (B9, 11 and 23) were selected for the detailed computation of the parameters R, K, L, S, C and P (Figs. 2.4, 3.1, 3.2, 4.1 to 4.9 and 4.11). The location, geology, geomorphology, soils and land use pattern for the sixteen sub-watersheds are given in Table 4.1. The rainfall erosion factor (R) is equal to EI/100 where EI is the erosion index value. The energy-intensity product (EI value) of storm was computed from recording raingauge chart with the help of energy table Wischmeier et al (67). The rainfall energy in metric system is

$$Y = 210.3 + 89 \log_{10} X$$

where Y is the kinetic energy in metre tonnes per hectare centimetre and X is the rainfall intensity in cm/hr. Wischmeier et al (70). Using the above equation, hourly, daily, and monthly rainfall kinetic energies were computed. Maximum intensity of 30 minutes rainfall for the month was noted from the rainfall recorded chart and multiplied by the monthly rainfall kinetic energy to get the erosion index (EI) for that month. Using a polynomial fit and chi-square criterion, the monthly erosion index values for each watershed have been correlated with the monthly rainfall. An average EI value was then obtained for each one of the test watersheds based upon the average monthly rainfall.
## TABLE 4.1 DESCRIPTION OF TEST WATERSHEDS

<table>
<thead>
<tr>
<th>No.</th>
<th>Area (ha)</th>
<th>Description of Watershed</th>
<th>Location and Boundaries</th>
<th>Moreland's Rainfall Classifications</th>
<th>Geology</th>
<th>Groundwater</th>
<th>Soils</th>
<th>Land Use/Elevation</th>
<th>Perforation and peaing</th>
<th>Orangery and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.39</td>
<td>Located in Kigali Plateau.</td>
<td>From 1100m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>2</td>
<td>12.12</td>
<td>Located in Kigali Plateau.</td>
<td>From 1200m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>3</td>
<td>11.75</td>
<td>Located in Kigali Plateau.</td>
<td>From 1200m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>4</td>
<td>10.96</td>
<td>Located in Kigali Plateau.</td>
<td>From 1200m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>5</td>
<td>9.95</td>
<td>Located in Kigali Plateau.</td>
<td>From 1200m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>6</td>
<td>8.80</td>
<td>Located in Kigali Plateau.</td>
<td>From 1200m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>7</td>
<td>7.35</td>
<td>Located in Kigali Plateau.</td>
<td>From 1200m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>8</td>
<td>6.90</td>
<td>Located in Kigali Plateau.</td>
<td>From 1200m to 2000m above MSL.</td>
<td>Average annual rainfall is 1500mm</td>
<td>Volcanic</td>
<td>0.94%</td>
<td>Papyrus swamp</td>
<td>5.97%</td>
<td>11.90%</td>
<td>18.00%</td>
</tr>
<tr>
<td>------------</td>
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<td>----------------</td>
<td>---------</td>
<td>-----------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>11.20 to 14.4</td>
<td>12.10 north to 16.20</td>
<td>13.60 east to 17.30</td>
<td>14.40</td>
<td>Varies from 15.20 to 17.30</td>
<td>15.20</td>
<td>16.30</td>
<td>17.50</td>
<td>18.20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.1 (Contd.)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11.20 to 14.4</td>
<td>12.10 north to 16.20</td>
<td>13.60 east to 17.30</td>
<td>14.40</td>
<td>Varies from 15.20 to 17.30</td>
<td>15.20</td>
<td>16.30</td>
<td>17.50</td>
<td>18.20</td>
<td></td>
</tr>
</tbody>
</table>
FIG. 4-5
KUKKALATHORAI HALLA LOWER & GUNDAGAL HALLA

REFERENCE
D.H.G. = MEASURING WEIR
S.R.G. = ROAD METALLED
SYMONS PRIVATE = FOOT PATH

SCALE 1" = 1 MILE

KUKKALATHORAI HALLA LOWER & GUNDAGAL HALLA

76° 55'
For those watersheds which do not have recording raingauges, the polynomial equations obtained for the nearest watershed were used and the EI values computed. The average R values computed for hills and plain areas in the Bhavani basin are 886 and 593 respectively.

The factor K is a measure of the erodibility of a given soil and is evaluated independently of the effects of topography IS, cover and management C, and supplementary practice P. (7,36,37,60,61,71). When these conditions of independence are met, then ISCP becomes equal to one and K equals A/R. From the results of plot studies, a graph is plotted between A and R and K is taken as the slope of fitted straight line. The values of K factor for hills range from 0.0001 (forests) to 0.2058 (cultivated and urban) and that of plains is 0.01 (forests) to 0.30 (cultivated and urban). The slope length (L) is determined from the equation, \( L = \left( \frac{\ell}{22.0} \right)^{0.3} \) where \( \ell \) is the average length of the first order channels in the watershed. The slope factor S is determined from the following regressive equations.

\[
S = \frac{(0.043 + 0.30G + 0.043G^2)}{6.613} \text{ for } G \leq 9
\]

\[
S = \left( \frac{G}{9} \right)^{1.3} \text{ for } G > 9
\]

where G is percent slope. The topographic maps released by the Survey of India were used to work out the combined IS factor. The combined CP factor has been taken from
the literature published by the Indian Council of Agricultural Research (62)... The average CP value for hills ranges from 0.0002 (forest) to 0.1 (cultivated and urban) and for plains from 0.001 (forests) to 0.1 (cultivated and urban). The land use information for the basin was obtained from the land use classification map prepared on a scale of 1:500,000 for the entire Bhavani basin using landsat False Colour Composites (FCC) of path 154 to 155 and row 052 (Figs. 2.1, 2.2, 2.20, 2.21). With the data collected, the following computations were made using the Universal Soil Loss Equation.

1. The soil loss in individual subwatersheds (50 in numbers) for the present land use pattern.

ii. The soil loss in individual watersheds assuming scientific land management is adopted. The scientific management consists of soil and water conservation works in the watershed involving bench terraces, contour bunds, trenches, gully and channel erosion control measures, crop rotation and afforestation, and grassland management practices with adequate percentage of natural and man-made forests.

iii. The soil loss in individual watershed (if 50 percent of the existing forest in these watersheds is converted into agricultural lands, with the present as well as with the scientific land management).
iv. The sediment delivery ratio of a few typical watersheds having sediment yield data.

4.4 Results and Discussions

4.4.1 Soil Loss

Average annual values of rainfall erosivity factor $R = RI/100$ for the Bhavani basin, is given in Fig. 4.10. High $R$ values are observed in western Nilgiris, medium values in eastern Nilgiris and low values in Bhavani plains.

The soil loss was calculated using universal soil loss equation. The results indicate that the soil loss in the basin has been broadly subdivided into eight categories namely extremely low (<0.01), very low (0.01 to 1.0), low (1.0 to 5.0), moderately low to medium (5.0 to 10.0), moderately medium to high (10.0 to 25.0), high (25.0 to 50.0), very high (50.0 to 100) and extremely high >100 t/ha/annum. The results for the test watersheds are presented in Table 4.2 and that for the whole Bhavani basin in Fig. 4.11.
LEGEND
BASIN BOUNDARY
SUB BASIN No.

FIG.4-10 AVERAGE ANNUAL VALUES OF RAINFALL EROSIVITY FACTOR, R, (R=E/I/100), IN BHAVANI BASIN
FIG. 411  SOIL LOSS IN BHAVANI BASIN

SOIL LOSS IN TONS/ha/YEAR

- LESS THAN 0.01
- 0.01 TO 1.0
- 1.0 TO 5.0
- 5.0 TO 10.0
- 10.0 TO 25.0
- 25.0 TO 50.0
- 50.0 TO 100.0
- MORE THAN 100

B22/9, B22 SUB BASIN No.

9  SOIL LOSS OF 9T/ha/YEAR

SCALE

8  4  4  8 MILES

OR 1:500,000

LEGEND

- SUB BASIN BOUNDARY
- BASIN BOUNDARY

A  PRESENT SOIL LOSS
B  PRESENT SCIENTIFIC MANAGEMENT
C  50% FOREST TO FORMING

FIG. 411  SOIL LOSS IN BHAVANI BASIN
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Watershed</th>
<th>Soil Loss at Normal (tonnes/ha/annum)</th>
<th>Soil Loss at Scientific (tonnes/ha/annum)</th>
<th>Soil Loss at 50% forest converted to farming (tonnes/ha/annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Coonoor</td>
<td>102.340</td>
<td>1.556</td>
<td>104.919</td>
</tr>
<tr>
<td>2.</td>
<td>Upper Moyar</td>
<td>7.491</td>
<td>0.311</td>
<td>24.192</td>
</tr>
<tr>
<td>3.</td>
<td>Sigur Lower</td>
<td>12.595</td>
<td>0.226</td>
<td>23.375</td>
</tr>
<tr>
<td>4.</td>
<td>Katery</td>
<td>55.556</td>
<td>1.422</td>
<td>56.711</td>
</tr>
<tr>
<td>5.</td>
<td>Kukkalathorai halla (upper)</td>
<td>57.243</td>
<td>0.875</td>
<td>61.637</td>
</tr>
<tr>
<td>6.</td>
<td>Kukkalathorai halla (lower)</td>
<td>53.194</td>
<td>0.779</td>
<td>60.778</td>
</tr>
<tr>
<td>7.</td>
<td>Kedarihalla Lower</td>
<td>8.569</td>
<td>0.125</td>
<td>11.970</td>
</tr>
<tr>
<td>8.</td>
<td>Alladahalla</td>
<td>15.807</td>
<td>1.942</td>
<td>19.938</td>
</tr>
<tr>
<td>9.</td>
<td>Gundagal halla</td>
<td>63.390</td>
<td>1.000</td>
<td>145.688</td>
</tr>
<tr>
<td>10.</td>
<td>East Varahapallam</td>
<td>9.440</td>
<td>0.635</td>
<td>27.910</td>
</tr>
<tr>
<td>11.</td>
<td>Yemmavipuzha</td>
<td>0.385</td>
<td>0.376</td>
<td>25.993</td>
</tr>
<tr>
<td>12.</td>
<td>Kotagiri halla</td>
<td>22.174</td>
<td>0.851</td>
<td>39.926</td>
</tr>
<tr>
<td>15.</td>
<td>Mettupalayam</td>
<td>27.831</td>
<td>5.827</td>
<td>45.787</td>
</tr>
<tr>
<td>17.</td>
<td>Bhavani as a whole basin</td>
<td>27.417</td>
<td>1.411</td>
<td>62.615</td>
</tr>
</tbody>
</table>
1 NATURAL FOREST AND GRASSLAND M-19
2,3 NATURAL FOREST AND GRASSLAND AND MANMADE
   FOREST- M1 & YEMMAVIPUZHA
4 NATURAL FOREST AND GRASSLAND MANMADE FOREST
   AND WELL MANAGED TEA B-29
5 SCIENTIFIC MANAGEMENT - BHAVANI BASIN
6,7 WATERSHED IN PLAINS - BHAVANI TOWN AND
   GOBICHETYPALAYAM
8 PARTIALLY WELL MANAGED, RURAL - ALLADAHALLA
9 MIXED LAND USE - SIGUR LOWER
10 FAIRLY MANAGED TEA - KOTHAGIRIHALLA
11 POORLY MANAGED TEA - M12
12 ILL MANAGED RURAL - KATERY

FIG. 4.12 SOIL LOSS OBSERVED AND CALCULATED
The study shows that the highly protective natural forest fall under extremely low soil loss, followed by mixed, rural and urban watersheds. Predominantly rural and urban watersheds in the Bhavani basin, with a very low percentage of forest (0.5 to 2.5 percent) are the main areas of erosion (28,29,59). Here the soil loss, ranges from 50 to 133 tons/ha/annum and require immediate attention. The study has revealed that improper rural and urban management is the root cause of erosion. The present soil loss in the Bhavani basin is 27.4 tons/ha/annum and this can be reduced to 1.4 tons/ha/annum which is within the permissible limit of 1.0 to 1.5 tons/ha/annum associated with rigid scientific conservation and management practices. If due to population pressure and socio-economic factors, the present forest area is reduced by 50 percent at a future date, the soil loss with the present land use practices, will increase to 62.615 tons/ha/annum. If scientific management is adopted, it will drop to 1.7947 tons/ha/annum. Soil loss data obtained from plot studies closely correlate with calculated soil loss of certain land uses (Fig. 4.12).

4.4.2 Sediment Delivery Ratio

\[
\text{Sediment delivery ratio (IR)} = \frac{S_y}{(\text{Sheet erosion} + \text{gully erosion} + \text{channel erosion})}
\]

where \( S_y = \) sediment yield in tons/ha
The channel and gully erosions have been assumed to be 75 and 50 percent respectively of the estimates of sheet erosion obtained using the universal soil loss equation. Sediment delivery ratios for the Coonoor, Katery, Mettupalayam, Pykara, Glenmorgan and Bhavani hills were calculated using the data furnished by the Public Works, Electricity Board and Agricultural Department of the Government of Tamil Nadu and ICAR are given in Table 4.3.

**TABLE 4.3: SEDIMENT YIELD AND DELIVERY RATIO IN BHAVANI BASIN**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Watershed and land use</th>
<th>Sediment yield (t/ha)</th>
<th>Sheet erosion (t/ha)</th>
<th>Channel and gully erosion (t/ha)</th>
<th>Total DR (t/ha)</th>
<th>DR (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Coonoor (Urban)</td>
<td>19.00</td>
<td>102.3410</td>
<td>127.926</td>
<td>230.2600</td>
<td>0.0825</td>
</tr>
<tr>
<td>2.</td>
<td>Katery (Rural)</td>
<td>13.95</td>
<td>55.5560</td>
<td>79.550</td>
<td>125.0000</td>
<td>0.1116</td>
</tr>
<tr>
<td>3.</td>
<td>Mettupalayam (Low Hills-mixed landuse)</td>
<td>3.19</td>
<td>27.7960</td>
<td>34.745</td>
<td>62.5400</td>
<td>0.0510</td>
</tr>
<tr>
<td>4.</td>
<td>Nilgiri hills (mixed landuse)</td>
<td>5.85</td>
<td>55.3760</td>
<td>69.220</td>
<td>124.5900</td>
<td>0.0470</td>
</tr>
<tr>
<td>5.</td>
<td>Pykara (Forest)</td>
<td>0.00</td>
<td>0.5867</td>
<td>0.7334</td>
<td>1.3201</td>
<td>0.0000</td>
</tr>
<tr>
<td>6.</td>
<td>Glenmorgan (Forest)</td>
<td>0.00</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0005</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

The delivery ratio obtained for these watersheds are similar to those obtained for humid and semi-arid watersheds in other countries (29). As regards sediment yields, these
are all in forest land use (0.0) followed by mixed land use (3.19), rural (13.95), and urban (19.0). The entire Nilgiri hills, consisting of forest, agriculture, plantations and urban land use, has a sediment yield of 5.85 tons/ha and delivery ratio 0.047. The suggested control measures for all the land uses of the Bhavani basin is given in the next section.

4.4.3 Erosion Control Measures

Erosion is severe in the Bhavani basin and is considerably affected by the land use pattern. It has been extensively studied by a number of research workers, and conservation practices recommended (15,16,17,18,19,59,62,63). To check severe erosion and high sediment yield erosion, control measures are to be carried out on watershed basis. The overall objective of the watershed approach, is to increase infiltration, control excessive runoff and utilise it for useful purposes. In any erosion control measure, the following four phases are involved.

i. Recognition Phase: This involves a survey of the area, to determine the extent, location, and severity of deterioration, due to erosion.

ii. Restoration Phase: It includes correction of the unstable conditions, causing erosion and floods by vegetation and engineering methods.
iii. Protection Phase: It involves protection from biotic factors such as fire, grazing, illicit felling, and bad management practices, which the area is subjected to.

iv. Improvement Phase: Herein, water yield is increased by land use and plant cover changes. The soil in the basin serves as an efficient storage reservoir.

Erosion control measures in Bhavani basin, depends to a large extent on slope, land use and plant cover. A brief description of the suggested control measures is given below.

4.4.5.1 Forests

Forests which are categorized, as natural and man-made forests are controlled and managed by the Government. The erosion control measures of forests are varied. Well managed forests cause no erosion. Ill managed and degraded forests cause severe erosion. They are afforested, with fast growing tree species of bluegum, Mysoregum, redgum, wattle, cypress, pines etc. with continuous or staggered contour trenches of 0.5 m top width, 0.3 bottom width and 0.3m depth (Fig. 4.15). Mulching is done around the tree seedlings with grass, brushwood and stone to increase infiltration and soil moisture. Gulleys in the area, are protected by providing diversion drain, and constructing masonry loose stone and brushwood vegetative check dams. Then grasses, shrubs and trees are planted along the gulleys,
STABILIZATION OF LANDSLIDE OF PURE SOIL

SECTION

(a) STABILIZATION OF LANDSLIDE OF PURE SOIL

(b) STABILIZATION OF LANDSLIDES OF SOIL AND BOULDERS

(c) STABILIZATION OF 1 TO 5 M HIGH LANDSLIPS

(d) STABILIZATION OF RIVER BANK FROM LANDSLIPS (VEGETATIVE)
and protected from grazing and fire (Fig. 4.14). Streams or channel bank erosion in the forest, is controlled by afforestation and grass planting on both sides of stream for a width of 5 to 50 m (Fig. 4.13). Stream banks can be strengthened by constructing masonry loose stone, and vegetative spurs. Land slides and land slips are common in degraded forests (22). They can be tackled by vegetative and engineering means, by providing proper drainage, constructing walls or embankments and planting trees, shrubs and grasses (Fig. 4.13, 4.15) (22,30,49,54,65).

4.4.3.2 Grasslands

Grasslands occur under various stages of ecological succession. Climax type of grasslands records no erosion. Colonisers are indicators of severe erosion, overgrazing and degradation (30). These degraded grasslands require shallow contour furrows at 1 to 3 m interval. The inter space is planted with high yielding grasses and legumes with adequate fertilizer, plant protection and management practices (16,19). The common grasses used are hybrid napier, dallis, cocksfoot, orchard, tall feacue, kolkattai, bluepanic, and crab grass. Gullies, stream banks and land slides in these grasslands are controlled as described earlier.

4.4.3.3 Farming

The farm lands are subjected to serious erosion, due to bad land use. They are divided into rainfed and irrigated farming lands.
PLANTING ALONG GULLIES IN PLAINS AND HILLS OF BHAVANI BASIN

FIG. 4.14

DIVERSION DRAIN (OR) BUND

LIVE HEDGE REINFORCEMENT (1 TO 2 ROWS)
STONE CHECK DAM

TWO ROWS OF AGAVE IN PART

ONE ROW OF TREES

CHECK DAM OF STONES SUPPLEMENTED BY PLANTING LIVE HEDGE OF
1 AGAVE AMERICANA
2 IPOMEA CORNEA
3 VITEX NEGUNDO
4 ARUNDO DONAX
5 FRINCPIA UTILIS
6 TRIPSACUM LAXUM

PIT 0.5 X 0.5 X 0.5 M

GRASS TO BE PLANTED

NOT TO SCALE
(a) Stabilization of River Bank from Landslips (by Revetment)

(b) Steep Slope under Forests

(c) Staggered Trenches

Contour Trenches

(d) Properly Planned and Maintained Roads and Rail Roads

FIG 4.15
Rainfed farming in plains with less than 800 mm rainfall is subjected to severe drought and erosion. Rains are erratic, ill distributed, and of high intensity. The dry land crops grown are, cholam, cumbu, ragi, thenai, redgram, horsegram, castor, cotton, gingilly, sunflower etc. Erosion control measures consist of contour bunds, graded bunds, narrow base terraces on red and alluvial soils. They are of 0.45 m top width, and 1.6 to 2.4 m bottom width and 0.45 m height at an interval of 45 to 90 m on 2 to 6 percent slope. Cultivation is done on contour. In black soils broad based terraces and vertical mulching can be adopted. Crop rotation and strip cropping should be followed (30).

Rainfed farming in hills, is always a success because of the rainfall being 1000 mm and above. Cropping is not permitted on slopes without adequate soil and water conservation measures, such as contour or graded bunds on 2 to 6 percent slope. In swamps of 1 to 3 percent, slope cultivation is done by providing vertical drains of 0.6 to 0.9 m wide and 0.9 to 1.1 m deep, 6 to 24 m apart. These reclaimed swamps are highly fertile with two to three crops of potato or vegetable, grown in a year. In slopes of 6 to 16 percent graded trenches of 0.6 m top width, 0.3 m bottom width and 0.45 to 0.6 m deep at 1.8 to 2.5 m vertical interval are dug. The intertrenched area is cultivated on contour with potato. Bench terraces are constructed on 16 to 33 percent slopes (Fig. 4(16)). They are of 122 m length at 1.6 m vertical interval. Inward graded terraces are constructed in high
BENCH TERRACE FORMATION

(a)

CUT & FILL

VERTICAL INTERVAL 1.53M (5')

SLOPE

BENCH TERRACE
WITH CROP AFTER FORMATION

(b)

POTATO

CONTOUR FURROW

GRASS

INWARD DRAIN

FIG. 4-16
BENCH TERRACE WITH CROP AFTER FORMATION
rainfall areas of above 1300 mm and level terraces in lower rainfall zones of 900 to 1000 mm. The terraces have 0.75 to 1.0 percent longitudinal gradient with drains, and drop pits turfed with grass. The terrace embankments are stone pitched, or provided with 1:1 or 1:2 slopes and planted with love, dallis, cocksfoot, crab, napier or tall fescue grass for protection and fodder (Fig. 4.16). Bench terraces can be constructed in one operation or slowly over 2 to 3 years by pushing the soil down hill side to form bench terrace (Fig. 4.17). Contour cultivation, high yielding variety of crops, fertilizers and plant protection are needed to give better response to soil and water conservation measures. Crop rotation recommended is potato, followed by wheat, oats or vegetables. Land with slope greater than 35 percent should not be cultivated (8,15,16,17,22,27).

A wide spectrum of crops are irrigated in the basin by canals, wells and tanks. The main irrigated crops are paddy, sugarcane, banana, tapioca, cholam, cumbu, cotton, ragi in plains and potato and vegetables in hills. Intensive farming with 2 to 3 crops in a year is common. Erosion control in these lands is done along irrigation channel field bothies and irrigated field with adequate water conservation measures after land levelling. Crop rotation of cereals, and tuber crops like paddy cholam, potato, followed by legumes like cowpea, redgram, pea etc. are the best. Planting fodder grass, shrubs, trees along channel reduces erosion and provide fodder to cattle.
SEQUENTI ONAL CONSTRUCTION OF BENCH TERRACES
BY BUNDS OR NARROW BASE TERRACE

(a)

SEQUENTI ONAL CONSTRUCTION OF BENCH TERRACES
WITH GRASS

(b)

FIG. 4-17

SLOW CONSTRUCTION OF BENCH TERRACES
BY BUNDS OR NARROW BASE TERRACES
4.4.3.4 Plantation

Plantation crops in hills consist of tea and coffee and they too require soil and water conservation measures. Soil conservation measures advocated are staggered continuous contour trenches or staggered trenches or stone terraces with shade trees, mulching, and planting tea bushes on contour (18).

4.4.3.5 Orchard

To check erosion, all the orchard crops require contour or graded bunds and level terraces along with good mulch and cover crop. Inter cropping of vegetable, cereals, and legumes are beneficial and essential for soil and water conservation.

4.4.3.6 Urban

Urban conglomeration in the Bhavani basin are springing up at a fast rate, around Mettupalayam, Ooty, Coonoor and Kotagiri. Bad roads, coupled with improper urban planning, result in heavy sediment load in streams. These streams are choked up at culvert points, resulting in flood and land slide. The control measures are, enforcement of urban planning, constructing stone revetments along road cutting and house sites (Fig. 4.15), planning grasses, shrubs and trees along roads and providing proper drainage for draining flood water during monsoon. Urban areas should be aesthetic and free from pollution (22,65).
4.4.4 Summary

It is concluded that scientific land management with mixed forest, rural and urban land use is the final answer for the erosion control in the Bhavani basin. The Universal Soil Loss Equation can profitably be applied to mountainous regions of tropics for erosion prediction.