# Micro-level Planning for Sustainable Land and Water Management: Bharathamala-Vattakkotta Watershed

**P.K. Suresh Kumar**

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# Micro-level Planning for Sustainable Land and Water Management: Bharathamala-Vattakkotta Watershed

P.K. Suresh Kumar*

## 1. Introduction

Kerala is one of the States, which receive the highest rainfall in India, more than 3000 mm annually on the average. Despite abundant rainfall and a network of 44 rivers, the State faces drought during summer and flood during monsoons causing heavy economic loss and expenditure of enormous funds for relief programmes.

The reasons for recurrence of such natural calamities include increasing density of population, increasing pressure on land, lack of awareness of conservation of land resources, and unscientific exploitation of natural wealth. Unscientific exploitation of land has caused soil erosion in more than 70 percent of the area of the State. Soil erosion poses a great challenge to the sustainability of its land and water resources.

Of late, comprehensive area development plans are prepared and implemented in several countries. Areas for development planning are delineated by natural boundaries. Natural boundary is the most suited for delineating areas for physical infrastructure development and utilisation of human resources. Thus, watersheds or sub-watersheds have become the natural, basic unit for conservation of natural resources like land, water, and biotic systems.

A watershed is a drainage area on earth's surface from which runoff resulting from precipitation flows past a single point into a larger stream viz., a river, a lake or an ocean.

Several definitions have emerged in recent years for the term 'watershed'. Generally, the terms watershed, catchment area or drainage basin are used synonymously.

Most of the factors of development are related to the nature of the drainage basin and the extent to which development activities are co-ordinated within the delineated boundary.

Only in a watershed can all the resources be conserved and controlled, from the highest

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ridge to the lowest land without interference by outside forces in the ecological balance to achieve their sustained and profitable use.

Watershed management involves management of the land surface and vegetation so as to conserve and utilise water that falls on the watershed and to conserve soil for immediate and long-term benefits of the farmer, community, and society.

Thus, watershed management is an integration of resources within the natural boundaries on a drainage area for development of land, water, and plant resources to meet the basic minimum needs of the people in a sustained manner.

The present study was conducted with a view to popularising the concept of watershed management and to preparing a resource-based development plan for sustainable development of a selected area. The study was carried out at the Bharathamala-Vattakkotta watershed situated in Kodakara Block of Thrissur district.

**Objectives**

The following are the major objectives of the study:

(i) To conduct micro-level studies on soil and water resources with people's participation in a micro-watershed of Karuvannur river basin;

(ii) To evolve criteria for sustainable land use and water management in the selected watershed;

(iii) (a) To propose development plan for protection, conservation, and improvement of the land resources for efficient and sustained agricultural production;
(b) To suggest sustainable plans to protect and enhance water resources, moderate floods, and to conserve rainwater for mitigating droughts; and
(c) To enhance people's awareness on the importance of an integrated approach to conservation of soil and water resources.

(iv) To find out the relation between rainfall and evapo-transpiration; and

(v) To suggest a sustainable cropping pattern for the watershed utilising the available land and water resources.

**Design of the report**

The sources of data and the methods of analysis are discussed in Section 2. Section 3 details the physical and climatic resources of the watershed. The socio-economic conditions of the sample households and the socio-economic overheads in the watershed are examined in Section 4. Questions of resource management are investigated in Section 5. In the concluding section a blueprint of the watershed development plan and its organisational structure are presented.

## 2. Data and Method

A micro-watershed in the Karuvannur river basin was selected for the study, which shows the typical characteristics of a midland watershed, on the fringes of the highland. This watershed is typical of the majority of watersheds in the State.

### Data

The most important secondary data collected was the climatological data for the past 14 years from the meteorological station, Kerala Agricultural University, Vellanikkara, which is the existing meteorological station located near the selected watershed. Since the distance from the watershed to the meteorological station (KAU) is less than 12 km, the data is applicable to the watershed also.

The data collected from the nearest meteorological station were on rainfall, temperature (maximum and minimum), relative humidity, wind speed, evaporation, and bright sunshine hours of the past 14 years (Table I.1 – I.7 of Appendix I).

The information regarding physiography, relief, and soil type was collected from the Soil Survey Department, Thrissur (Table 2.1).

**Table 2.1 Types of soil series and extent of area in the watershed**

| Soil series | Area, ha |
|---|---|
| Koottala | 1005 |
| Kozhukkully | 553 |
| Painkulam | 262 |
| Mariakkal | 195 |

Primary data were collected from the watershed on rainfall, run-off, and sediment yield, during 1997 and 1998.

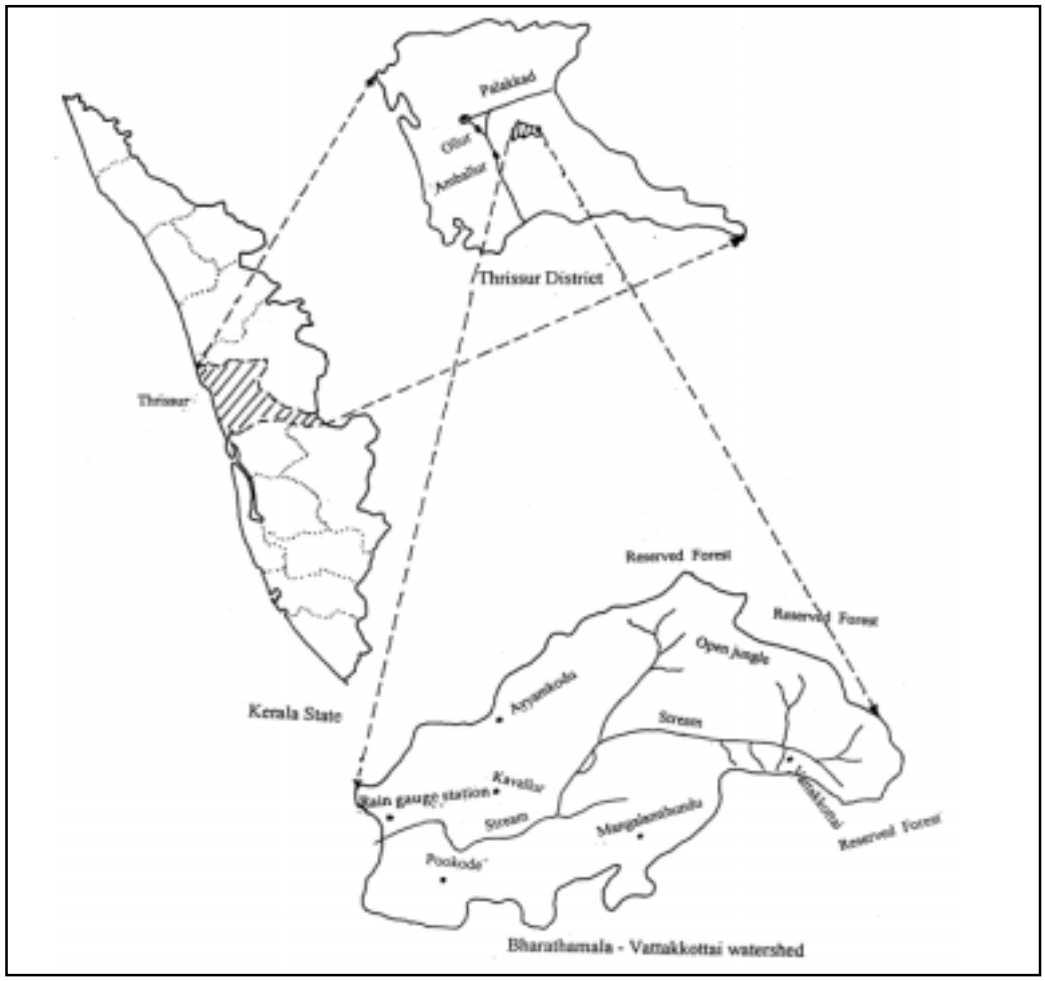
### Rainfall

The daily rainfall data from the watershed were collected by installing a non-recording or standard rain gauge station at Pachalippuram, a representative area of the watershed. The location of rain gauge station is shown in Figure 2.1. Non-recording type rain gauges were used in conjunction with a suitable graduated measuring glass for the total rainfall between two consecutive observations in mm or cm. Usually observations were taken at 8.30 am every day. The rainfall so recorded was for the preceding 24-hour period (I.S.T). The readings were recorded from 1 January 1997 to 31 July 1998.

### Run-off

Run-off is that portion of precipitation that makes its way to stream channels as surface or

**Figure 2.1 Location of Rain Guage Station**




sub-surface flow. The peak run-off rate and run-off volume are of great importance in the planning and design of soil conservation works.

In the present study, the main source of run-off from the watershed was a stream originated from Bharathamala and flowing westward for about 7.5 km, till it crosses the watershed at Vattanathara, which is the outlet of the watershed. Another stream of three km-length originated from Vattakkotta and joins the mainstream at Alengad. A third stream of one-km length, which started from Mangalam Thundu and joins the mainstream also contributed to run-off from the watershed. Thus, the total length of stream flow through the watershed was about 11.5 km.

For the measurement of run-off, the outlet of the stream was modified into a prismatic section. A stream gauge, which can read up to 3 m, was installed at this outlet. The depth of flow through the outlet was measured thrice a day, at 8.00 am, 1.00 pm, and 5.00 pm. The run-off from the stream was measured by velocity area method. Run-off was determined by

multiplying the cross sectional area of the stream by an average velocity of flow of the stream.

That is,

$Q = AV$

Where,

Q = Discharge through the outlet, $m^3/s$

A = Area of cross section of flow, $m^2$

V = Average velocity of flow, m/s.

The velocity of flow was measured by float method. In this method an empty bottle was used as the surface float. The mean velocity was worked out by multiplying by a factor of 0.89 the average surface velocity of flow, since the values of surface velocity obtained by surface float are usually higher.

Average run-off in $m^3$ per second through the outlet was calculated by the above method.

Thus, the total run-off volume per day is

$Q_{per\ day}$ = Average run-off per second x 3600 x $24 m^3$/day

Therefore, the run-off from the watershed is

$$Q = \frac{Q_{per\ day} \times 1000}{\text{Area of watershed in ha}} \text{ mm/day}$$

The daily run-off through the watershed was computed by the above method.

**Sediment yield**

Sediment is the fragmented material that originated from chemical or physical disintegration of rocks. In the watershed, the process of transportation of soil particles from land surface was mainly due to the action of rainfall. The impact of rain drops breaks down the large soil lumps into single grains, which may be thrown upward by the energy of raindrops and carried in suspension by the overland flow. The force of the water flowing over the land surface may loosen additional particles and transport them towards the stream channels.

In the present study, soil erosion from the watershed through run-off was estimated by measuring the amount of sediment presented in the stream flow. 'Punjab water sampler' was used to estimate the sediment yield in the stream flow. Sediment suspension, one litre each, was collected from three different stream depths such as surface, mid-depth and bottom, and the samples were mixed thoroughly. One litre of the mixed sample was taken for estimating the sediment yield. The sediment was obtained by drying up the sample in an oven at $105^0$ for 24 hours and weighed in an electronic balance. Thus, the weight of sediment in gm/litre was obtained. This was divided by 1.4 (density of sediment) to obtain the sediment yield in

cubic centimetre (cc)/litre. Since the most commonly accepted unit of sediment yield is hectare metre, it is necessary to convert the above unit into hectare metre. This was done as follows:

$$\frac{\text{wegiht of sediment in cc/ litre}}{100\text{x}100\text{x}100\text{x}10000} \text{ ha.m/ litre}$$

$$\frac{\text{wegiht of sediment in cc/ litrex}1000}{100\text{x}100\text{x}100\text{x}10000} \text{ ha.m/ m}^3$$

Therefore,

Sediment yield=weight of suspended sediment in cc/litre x $10^{-7}$ ha.m/$m^3$

Total suspended sediment yield per day

= run-off in $m^3$/day x weight of suspended sediment yield in cc/litre x $10^{-7}$ ha.m/day

assuming the bed load as 10 per cent of suspended sediment yield.
Thus, the total amount of sediment production per day for an area of 2015 ha is total suspended sediment yield per day + bed load.

**Identification of water resources in the watershed**

Reconnaissance survey was conducted by visiting the watershed and interacting with local people to identify the major water resources, both surface and groundwater sources, in the watershed. The following information was gathered during the field visits.

(i) Details of vented cross bars (VCBs) across the stream flowing through the watershed such as present status, specifications, availability of repair, and maintenance facilities;
(ii) Information on public ponds;
(iii) Details of ground water resources such as public open wells and tube wells; and
(iv) Details of irrigation canal traversing through the watershed.

**Land use pattern**

A record of present land use pattern followed by the farmers in a region is essential for further planning and reorganisation of land use according to its land use capability classification to achieve sustained production.

Information regarding the present land use pattern of the watershed was collected by visiting the entire area of the watershed and interacting with local people and analysing the data obtained from the *Krishi Bhavans* located in the watershed. Details regarding the extent of wetland, dry land, and forest were collected. Information on the extent of area under each crop cultivated in the watershed was also collected with the help of local people and Agricultural Assistants of the concerned *Krishi Bhavans* in the watershed.

**Relationship between rainfall and evapo-transpiration**

Relationship between rainfall and evapo-transpirtation was established to compute the surplus and deficit of water in the watershed. Evapo-transpiration was calculated by multiplying the pan evaporation and crop factor for each crop in the watershed (Michael, 1985).
i.e., evaporation = pan evaporation x crop factor

The pan evaporation data for the past 14 years were collected from the nearest meteorological station, Kerala Agricultural University, Thrissur. The monthly mean evaporation was calculated and then multiplied with the crop factor and the respective area of cultivation of each crop. The product was divided by the total area of the watershed to get the monthly evapo-transpiration of the watershed.

That is,

$$\text{Monthly evapo-transpiration} = \frac{\Sigma\ (\text{Monthly average evapotranspiration x crop factor of each crop x area of cultivation of the respective crop})}{\text{Total area of the watershed}}$$

A preliminary idea of water surplus and deficit in the watershed was computed from the relationship between rainfall and evapo-transpiration.

**Land capability classification**

Land capability is the suitability of land for use without causing it any damage. It is a systematic arrangement of the different kinds of land based on its slope for purposes of production on a sustained basis. This classification of land includes both lands suitable and unsuitable for cultivation.

Scientific survey and classification of soils are the primary requirements for grouping them according to their capability for use under various intensities. There are eight land capability classes, which are defined according to the inherent characteristics of soils and their limitations. Class I is the best, free of any limitations, suitable for intensive cultivation to all climatically adopted crops. Classes II to VIII have progressively increasing hazards and limitations and require increasingly intensive effect at cultivation.

Land capability classes are again divided into sub-classes according to hazards such as erosion (e), root-zone limitations (s), climatological limitations (c), and excess water (w). These sub-classes provide information about the kind of problems involved. Standard land capability classes based on land slope and their adapted land use are given in Table 2.2 [IS 6748: (Part I) – 1973].

The land capability classification of the watershed was attempted through frequent visits to the area in association with soil scientists, and experts from soil and water conservation engineering wings of the Soil Conservation Department.

**Table 2.2 Standard land capability classes**

| Class of land | Slope (percent) | Adapted land use and soil conservation measures |
|---|---|---|
| 1. Land suitable for cultivation | | |
| Class I | 0-3 | Any crop with proper crop rotation and green manuring to maintain soil fertility |
| Class II | 3-5 | Contour farming, contour strip cropping and cover cropping, contour bunding or terracing |
| Class III | 5-10 | Intensive agronomical measures such as contour cropping, contour strip cropping, and cover cropping. terracing or contour bunding. |
| Class IV | 10-33 | Contour bunding or terracing and intensive agronomic measures. Mostly soil building and soil maintaining crops are to be grown |
| 2.Land not suitable for cultivation | | |
| Class V | wet | Permanent pasture with controlled grazing |
| Class VI | 33 & above | Pasture, grasses and forestry. Grazing should be restricted |
| Class VII | ” | Forests with restricted felling contour trenching as conservation measure |
| Class VIII | ” | Forests with complete closure to grazing and felling of trees. |

**Training programmes for beneficiaries in watershed**

Owing to the multi-disciplinary nature of the watershed development programme, involvement and co-operation of local people, voluntary organisations, and local bodies are essential for its success. Involvement of the watershed community and its active participation in the entire exercise is essential right from the planning stage for ensuring their involvement and participation. Creation of awareness about the multi-disciplinary approach of watershed development programme through training, discussions, and workshop is inevitable.

Training classes were conducted at ward level for all the beneficiaries in the watershed to make them aware of the various techniques involved in scientific watershed management programme. Since a comprehensive area development programme needs large amounts of finance and co-ordination among the various administrative units, there should be a suitable organisation for planning and implementing the development plan. A ‘watershed development committee’ was formed in the watershed to co-ordinate the various activities including the implementation of the suggestions of this study.

**Socio-economic survey**

In the preparation of community development plans, detailed information on various aspects of the community life is necessary. The socio-economic background of a region is an important factor, which would suggest the types and the timings of development activities. The best way to bring about urgently needed changes in the rural society and its environment is to combine and develop physical and human resources of that region through an integrated approach.

In the present study 10 percent of the total households in the watershed were selected as the sample for conducting a socio-economic survey. The method adopted was stratified random sampling based on land holdings giving representation to all the wards in the watershed and by considering the topographical features. The details of land holdings were collected from the concerned village office. Mean and standard deviation of the data were calculated; land holdings were categorised into three classes, viz., low, medium, and high – below mean-standard deviation as low, between mean-standard deviation, and mean + standard deviation as medium, and above mean + standard deviation as high. From each group, 10 percent of the households were randomly selected giving due weightage to the topographical features of the watershed.

The survey was done using a structured questionnaire. The following details were collected: size and composition of the households, community, housing conditions, electrification, cooking fuel (firewood, forest fuel, biogas, oil, etc), availability of water for drinking and other purposes (tap water, well, public well, tube well, ponds and streams), educational, occupational, and health status and size and nature of holdings. Information was collected also on the socio-economic overheads, soil and water conservation practices, and industrial structure of the watershed.

**Preparation of watershed work plan**

Based on the information gathered during the detailed climatological and socio-economic survey and data generated through experimentation, a variety of combinations and inter-relationships of the parameters were worked out to draw conclusions and to make suitable cost-effective and technically viable recommendations for effective management and development of the watershed. The activities recommended were based on agriculture and fodder plants, forestry, crop management practices, surface water harvesting and recycling, ground water exploitation and recharge, and soil and water conservation. Generation of employment opportunities was also suggested in allied sectors like animal husbandry, poultry, and cottage and small-scale industries.

## 3. Natural Resources and their Use Patterns

### Selection of the watershed

The watershed selected for the present study was located in Kodakara block of Thrissur district. The name of the watershed is Bharathamala-Vattakkotta since the main stream flowing through the watershed originates from Bharathamala and Vattakkotta located in the watershed.

The Bharathamala-Vattakkotta watershed is located in the central-eastern region of Thrissur district and the area drains to a tributary of Manali River, which originates from the Western Ghats. The total geographical area of the watershed was 2015 ha and located between $10^0$26'–$10^0$28' North latitude and $76^0$ 17'–$76^0$21' East longitude.

The watershed was located in two *panchayats*, i.e., Alagappanagar (wards VIII, IX, X, and XI) and Thrikkur, (wards VI, VII, VIII, and IX).

### Physical features

The surface of the watershed gathered into slopes and clustering hills with numerous valleys in between. The undulating midland with laterite formation has rubber plantations on them, whereas the low laterite hills were occupied with rice and coconut. The contour map of the watershed is shown in Map No. 1.

The elevation of the watershed area was found to be from 40 - 230m above MSL from valley to ridge top. The area was divided into the following physiographic divisions.

(i) Strong to steep side-slopes of low hills,
(ii) Gentle to moderate foot slopes, and
(iii) Very gently sloping valleys.

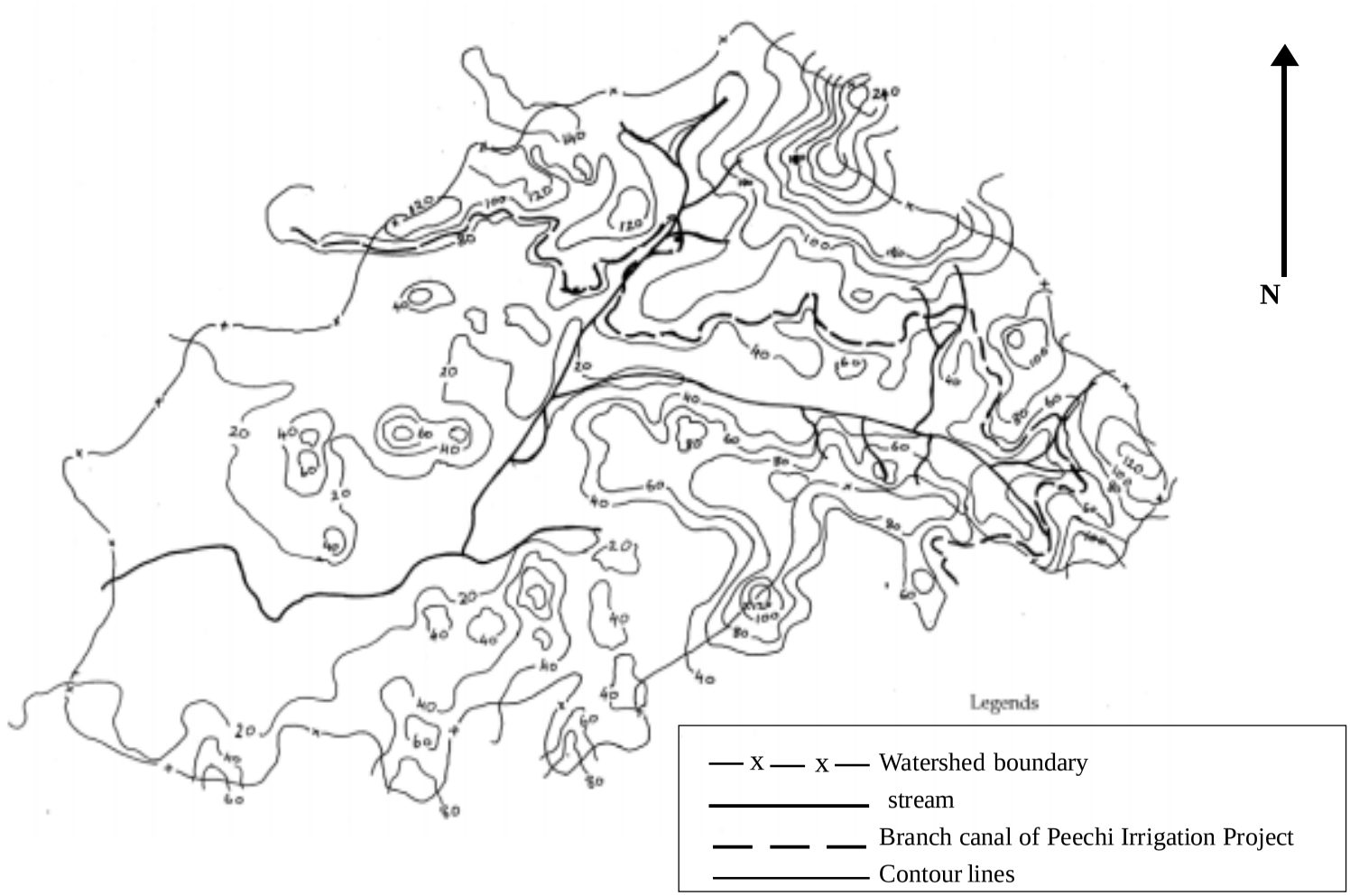
The entire area of the watershed is well drained except the valley portions, where drainage is impeded during the monsoon season (Map No.2). The area is drained to a number of small streams originating from the side slopes of the surrounding hills and developing into Bharathamala-Vattanathra stream, which finally empties into Manali River. The total length of the stream flowing through the watershed is 11.5 km.

### Soils

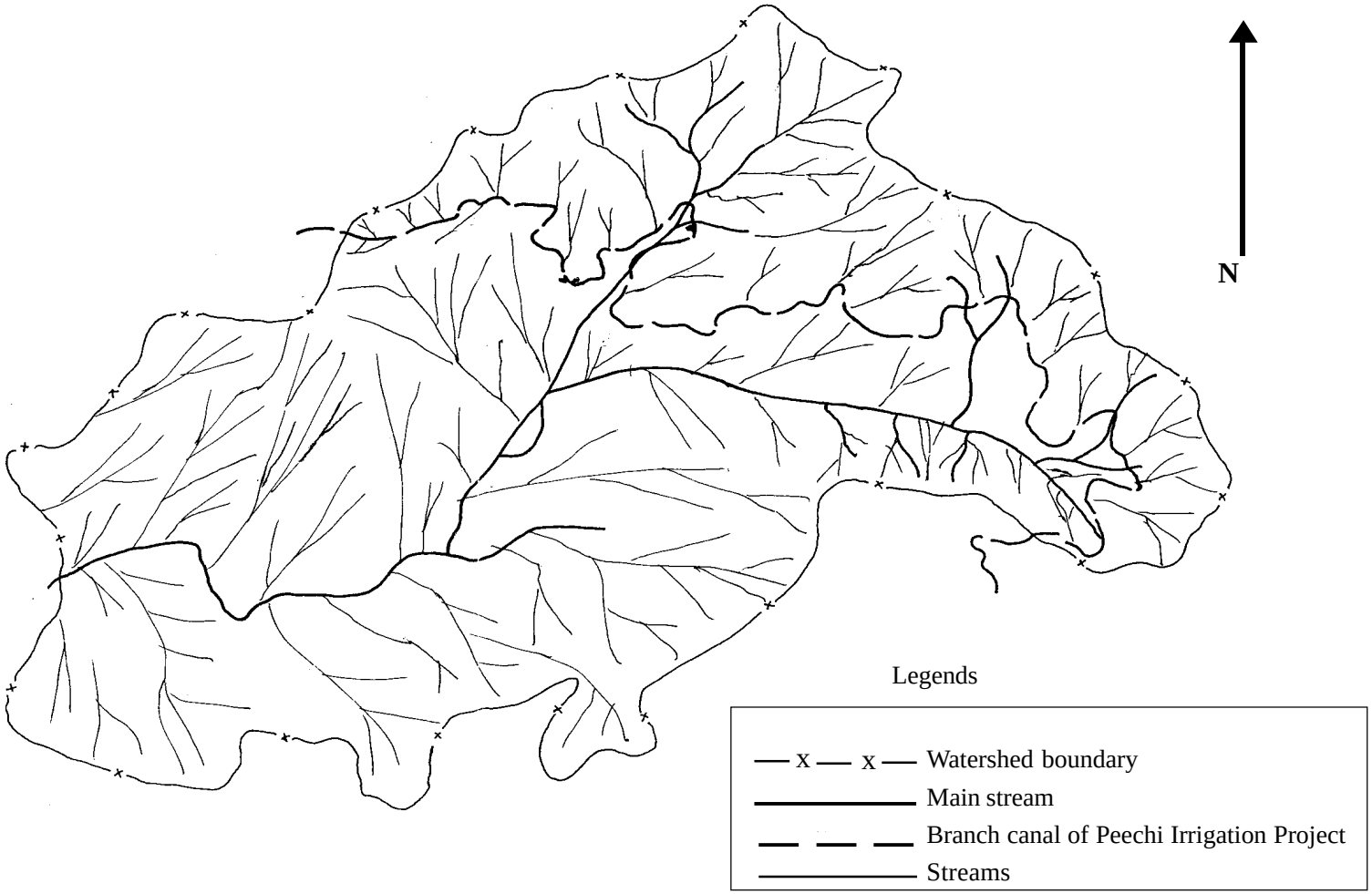
Four types of soil series were identified and mapped in the watershed viz., *Koottala*, *Kozhukkully*, *Painkulam*, and *Mariakkal* series by the Soil Survey Department, Thrissur (Map No.3). The area of distribution of soil series is tabulated in Table 2.1.

*Koottala* soils were developed on a mixture of laterite and gneiss with very deep and gravelly

**Map No.1 Contour map of Bharathamala- Vattakkotta watershed**



**Map No.2 Drainge map of Bharathamala-Vattakkotta watershed**



## Map No.3 Soil Map of Bharathamala-Vattakkotta watershed

Legend

1. *Mariakkal* series: soils grouped under this series are very deep, very dark brown to very dark grayish brown in colour with silty clay loam to gravelly loam surface texture underlined by silty clay loam to clay sub soils. The sub soils are conspicuous in having higher clay percentage and few medium sized quartz gravels. Structural development is weak and poor horizonation.

2. *Koottala* series: This series represents well drained, very deep, dark brown to very dark grayish brown, sandy loam to loamy soils that are developed over charnolaite. These soils are found to occur in the hill slopes and foot hill areas with 10-20 percent slope.

3. *Kozhukkully* series: *Kozhukkully* series comprise of deep to very deep, excessively drained, dark brown to dark reddish brown soils occurring on hill and foot slopes of Western ghat. These are characterized by the presence of partly weathered gneissic stones in abundance both in the surface as well as in the profile. Surface soils are sandy clay loam to gravelly clay loam sub soils. These soils are generally found to occur on moderately steep to steeply sloping hillocks with a slope gradient of 20-50 per cent.

4. *Painkulam* series: Soils grouped under this series are located in the mountainous region along the hills and hill slopes having a slope gradient of more than 30 percent. They are very deep and dark brown in colour with clay loam sub soils. The soils are underlined by gravely clay loam sub soils and are developed under warm humid tropical climate.

—— x —— x —— - Watershed boundary

——————— - Stream

- Soilunit

clay loam to clay loam texture. Clay content increases with depth whereas gravel fraction is less in deeper layers.

*Kozhukkully* soils are deep to very deep excessively drained and characterised by the presence of partially weathered gneissic stones in abundance both in the surface as well as in the profile. Surface soils were found to be sandy clay loam to gravelly clay loam occurring on hills and foot slopes of the Western Ghats.

*Painkulam* soils were observed as well-drained, very deep, and dark brown in colour with clay loam textured surface soil underlain by gravelly clay sub-soils occurring on mountainous region along the hills and hill slopes with moderate permeability.

*Maraikkal* soils were found to be very deep, developed from colluvial and occur on low-lying, very gently sloping narrow valleys. The surface texture ranges from silty clay loam to gravelly loam underlain by silty clay loam to clay subsoils. The typical profile and major constituents of each of the soil types is presented in Appendix II.

***Climate***

Data of many years are required for planning and designing watershed development programmes. In the present study, climatological data such as rainfall, temperature (maximum and minimum), relative humidity, wind speed, evaporation, and bright sunshine hours were collected for the past 14 years from the nearest meteorological station, of Kerala Agricultural University. The climatological data for the past 14 years are presented in Table I.1- I.7 of Appendix I.

***Rainfall***

Daily rainfall data were collected from the standard rain gauge installed at Pachalippuram, a representative area of the watershed (Table 3.1).

The well-identified two rainy seasons namely South-West monsoon (June-September) and North-East monsoon (October-November) were predominant in the watershed. During 1997, the annual rainfall received in the watershed was found to be 3346.97 mm with the highest rainfall of 940.7 mm in July. About 74 percent of the rainfall was received during the South-West monsoon. During 1997, the rainfall received registered an increase of 17.5 percent compared to that of the average rainfall received for the past 14 years (Appendix I).

***Run-off from the watershed***

The streams, which originated from Bharathamala and Vattakkotta of the watershed and flow westwards, constitute the major source of run-off from the watershed. Data on the daily run-off from the watershed, recorded from 29 June 1997 to 31 July 1998, are presented in Table 3.2.

The run-off increased from June to October. There was no run-off during first five months of the year, since the stream is not perennial. The flow starts only with the commencement of the monsoon season. The minimum run-off of 44.844 mm and the maximum of 595.441 mm were observed during June and October respectively. The stream flow during August, September, October, and November was found to be more than that during June and July, though a maximum rainfall of 940.7 mm was received in July followed by 725.50 mm during June. This is due to the base flow generated by the rainfall of earlier months. Our intention is to increase the infiltration of water during the rainfall period and the resultant increase of stream flow during the drought season.

Run-off as proportion of daily rainfall during the period of study is shown in Table 3.3. Though there was a high rainfall of 725.5 mm during June 1997, the run-off started only from 29 June and was found to be very low (44.844 mm), about 6.18 per cent of the rainfall received. The rate of run-off during June is low because the rainwater is infiltrated into the soil filling the void spaces during the period immediately following commencement of the rainy season.

The highest monthly rainfall recorded during 1997 was 940.75 mm in July. Run-off observed was 306.526 mm, which comes to 32.59 percent of the total rainfall. The maximum run-off of 47.628 mm/day was obtained on 19 July, owing to the highest rainfall of 110.50 mm. It was observed that run-off was more than the rainfall on the days subsequent to high rainfall. For example, run-off was 502.93 percent of the rainfall on 20th July, following the previous day's rainfall of 110.50 mm. Similarly on July 25 and 29, the run-off measured was 195.20 and 408 percent of the rainfall received respectively. This was due to the high intensity of rainfall obtained on the 24$^{th}$ (65.25 mm) and 28$^{th}$ (24.25mm) of July.

Though the rainfall received during August 1997 was lower than that received in June and July that year, the flow was much larger. As rainfall continues, soil becomes increasingly saturated and infiltration is stabilised, thereby more water becoming available for run-off.

The total stream flow observed during September was less than that of August. However, the run-off-rainfall ratio (1.403) was found to be higher in September indicating that the run-off was more than the rainfall. The higher run-off was contributed by the rainfall received during August.

The highest monthly run-off of 595.441mm forming 1.59 times the rainfall was recorded during October. The maximum run-off, 38.155 mm/day was obtained on the 16$^{th}$, which was contributed by the 54mm rainfall received on the previous day.

During November the run-off was more than twice the rainfall received during that month, amounting to a run-off of 462.726 mm and rainfall of 200.00 mm. Compared to the previous months, run-off-rainfall ratio was found higher in November, contributed by the previous month's rainfall.

The run-off during December could not be measured because the wooden planks (vented cross bar) in the outlet were replaced to stop the flow of water at the site at which the stream

**Table 3.1 Daily Rainfall (in mm) received in the watershed**

| Date | 1997 | | | | | | | | | | | | 1998 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.50 | 81.25 | 34.25 | 0.00 | 50.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.50 |
| 2 | 0.00 | 0.00 | 0.00 | 8.70 | 15.90 | 0.90 | 68.50 | 0.00 | 0.00 | 0.00 | 4.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.90 | 29.00 | 67.10 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.20 | 21.00 | 53.57 | 0.00 | 24.50 | 6.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.80 | 65.80 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.75 | 19.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.10 | 88.10 |
| 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 81.80 | 30.00 | 0.00 | 0.00 | 19.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.10 | 17.10 |
| 6 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.00 | 19.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.40 | 11.90 |
| 7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.90 | 67.50 | 104.25 | 54.25 | 42.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 42.00 | 3.50 |
| 8 | 0.00 | 0.00 | 0.00 | 0.00 | 19.50 | 0.70 | 30.25 | 70.50 | 0.00 | 6.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.10 | 8.40 |
| 9 | 0.00 | 0.00 | 0.00 | 0.00 | 2.90 | 29.20 | 18.50 | 1.25 | 6.75 | 0.00 | 55.25 | 37.50 | 0.00 | 0.00 | 0.00 | 0.00 | 1.50 | 6.60 | 11.10 |
| 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.70 | 0.00 | 24.50 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.10 | 33.50 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 44.50 | 2.00 | 10.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.60 | 47.10 | 43.20 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.25 | 4.00 | 18.25 | 3.25 | 32.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 71.10 | 17.10 | 25.10 |
| 13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.10 | 2.75 | 0.00 | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.70 | 1.80 | 44.60 |
| 14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 35.70 | 13.50 | 0.00 | 0.00 | 9.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.60 | 2.90 | 0.90 |
| 15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.30 | 24.50 | 0.00 | 0.00 | 54.00 | 23.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.80 | 1.90 | 13.10 |
| 16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.10 | 30.00 | 0.00 | 65.50 | 0.00 | 0.00 | 57.50 | 0.00 | 0.00 | 0.00 | 0.00 | 17.40 | 41.10 | 1.60 |
| 17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.60 | 18.75 | 16.00 | 25.75 | 10.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.30 | 11.50 | 76.60 |
| 18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.10 | 32.75 | 4.25 | 1.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.50 | 89.50 | 9.50 |
| 19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.90 | 110.50 | 5.75 | 21.25 | 0.00 | 2.25 | 80.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.75 | 32.20 | 61.20 |
| 20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.30 | 2.25 | 8.75 | 0.00 | 4.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.10 | 9.90 |
| 21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 24.25 | 8.50 | 28.50 | 0.00 | 15.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.30 | 11.20 | 22.90 |
| 22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 27.75 | 23.50 | 0.00 | 62.75 | 0.00 | 39.00 | 0.00 | 0.00 | 0.00 | 5.20 | 0.00 | 33.90 | 1.20 |
| 23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 21.20 | 5.25 | 57.00 | 11.50 | 41.00 | 12.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 29.10 | 44.20 |
| 24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 42.10 | 65.25 | 23.50 | 5.25 | 0.00 | 13.25 | 0.00 | 0.00 | 0.00 | 0.00 | 8.10 | 0.00 | 46.20 | 9.80 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 45.30 | 5.75 | 0.00 | 0.00 | 9.00 | 17.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.10 | 8.50 | 37.20 | 44.50 |
| 26 | 0.00 | 0.00 | 0.00 | 0.00 | 23.90 | 41.25 | 40.75 | 12.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 25.90 | 0.80 | 50.50 | 31.20 |
| 27 | 0.00 | 0.00 | 0.00 | 0.00 | 3.60 | 70.75 | 35.50 | 17.00 | 0.00 | 0.00 | 3.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 41.10 | 13.40 |
| 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 36.20 | 24.25 | 8.50 | 0.00 | 11.00 | 13.00 | 0.00 | 0.00 | 0.00 | 14.00 | 24.80 | 1.20 | 94.20 | 12.50 |
| 29 | 0.00 | | 0.00 | 0.00 | 0.00 | 95.75 | 3.25 | 54.25 | 0.00 | 16.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 1.70 | 0.50 | 46.30 | 18.50 |
| 30 | 0.00 | | 0.00 | 0.00 | 0.00 | 114.75 | 33.75 | 14.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.60 | 86.20 | 14.10 |
| 31 | 0.00 | | 0.00 | | 0.00 | | 0.00 | 1.50 | | 11.75 | | 0.00 | 0.00 | | 0.00 | | 0.00 | | 11.10 |
| **Total** | **0.00** | **0.00** | **0.00** | **8.70** | **66.50** | **725.50** | **940.75** | **564.07** | **252.00** | **375.45** | **200.00** | **214.00** | **0.00** | **0.00** | **14.00** | **66.80** | **147.05** | **852.30** | **842.10** |

## Table 3.2 Daily streamflow (runoff) in mm/day and m3/s during the period

| Date | 1997 | | | | | | | | | | | | | | | | | | | | | | 1998 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June | | | July | | | August | | | September | | | October | | | November | | | December | | | June | | | July | | |
| | RF | Q | % | RF | Q | % | RF | Q | % | RF | Q | % | RF | Q | % | RF | Q | % | RF | Q | % | RF | Q | % | RF | Q | % |
| 1 | 22.50 | 0 | 0 | 81.25 | 23.774 | 29 | 34.25 | 12.416 | 36 | 0 | 8.837 | | 50.00 | 23.956 | 48 | 0 | 22.143 | | 0 | 8.16 | | 0 | 0 | | 26.50 | 9.96 | 38 |
| 2 | 0.90 | 0 | 0 | 68.50 | 13.061 | 19 | 0 | 1.652 | | 0 | 5.309 | | 0 | 21.933 | | 4.50 | 21.007 | | 0 | 10.91 | | 29.00 | 0 | | 67.10 | 7.94 | 12 |
| 3 | 3.20 | 0 | 0 | 21.00 | 8.602 | 41 | 53.57 | 9.551 | 18 | 0 | 3.105 | | 24.50 | 32.307 | 132 | 6.50 | 17.504 | 269 | 0 | 13.60 | | 4.80 | 0 | | 65.80 | 8.79 | 13 |
| 4 | 0 | 0 | 0 | 20.75 | 2.761 | 13 | 19.00 | 5.129 | 27 | 0 | 1.574 | | 0 | 18.132 | | 0 | 12.281 | | 0 | 16.90 | | 7.10 | 0 | | 88.10 | 9.30 | 11 |
| 5 | 81.80 | 0 | 0 | 30.00 | 3.106 | 10 | 0 | 1.936 | | 0 | 1.171 | | 19.25 | 25.198 | 131 | 0 | 8.409 | | 0 | 18.73 | | 6.10 | 0 | | 17.10 | 13.62 | 80 |
| 6 | 0 | 0 | 0 | 25.00 | 5.852 | 23 | 19.00 | 13.260 | 70 | 0 | 23.744 | | 0 | 29.377 | | 0 | 8.327 | | 0 | 20.44 | | 4.40 | 0 | | 11.90 | 12.22 | 103 |
| 7 | 5.90 | 0 | 0 | 67.50 | 16.789 | 25 | 104.25 | 69.471 | 67 | 54.25 | 16.004 | 30 | 42.50 | 26.728 | 63 | 0 | 13.747 | | 0 | 16.90 | | 42.00 | 0 | | 3.50 | 8.61 | 246 |
| 8 | 0.70 | 0 | 0 | 30.25 | 5.040 | 17 | 70.50 | 29.339 | 42 | 0 | 15.632 | | 6.00 | 7.576 | 126 | 0 | 11.955 | | 0 | 17.20 | | 1.10 | 0 | | 8.40 | 7.94 | 95 |
| 9 | 29.20 | 0 | 0 | 18.50 | 3.905 | 21 | 1.25 | 11.003 | 880 | 6.75 | 15.920 | 236 | 0 | 3.232 | | 55.25 | 24.561 | 44 | 3.75 | 15.68 | 4.18 | 6.60 | 0 | | 11.10 | 7.21 | 65 |
| 10 | 0 | 0 | 0 | 24.50 | 4.463 | 18 | 1.00 | 4.589 | 459 | 0.00 | 14.875 | | 0 | 8.581 | | 0 | 17.203 | | 0 | 17.74 | | 5.10 | 0 | | 33.50 | 7.21 | 22 |
| 11 | 0 | 0 | 0 | 44.50 | 8.349 | 19 | 2.00 | 2.436 | 122 | 10.25 | 22.779 | 222 | 0 | 8.159 | | 0 | 5.236 | | 0 | 16.65 | | 47.10 | 15.14 | 32 | 43.20 | 8.79 | 20 |
| 12 | 0 | 0 | 0 | 8.25 | 3.507 | 43 | 4.00 | 1.652 | 41 | 18.25 | 28.156 | 154 | 3.25 | 17.202 | 529 | 32.75 | 16.234 | 50 | 0 | 0 | 0 | 17.10 | 16.50 | 96 | 25.10 | 12.75 | 51 |
| 13 | 6.10 | 0 | 0 | 2.75 | 1.689 | 61 | 0 | 0.893 | | 3.00 | 11.246 | 375 | 0 | 11.224 | | 0 | 13.529 | | 0 | 0 | 0 | 1.80 | 15.12 | 840 | 44.60 | 12.92 | 29 |
| 14 | 35.70 | 0 | 0 | 13.50 | 1.732 | 13 | 0 | 1.137 | | 0 | 9.179 | | 9.50 | 25.703 | 271 | 0 | 13.284 | | 0 | 0 | 0 | 2.90 | 13.20 | 455 | 0.90 | 9.92 | 1102 |
| 15 | 12.30 | 0 | 0 | 24.50 | 1.796 | 7 | 0 | 2.363 | | 0 | 8.662 | | 54.00 | 44.179 | 82 | 23.25 | 25.565 | 110 | 0 | 0 | 0 | 1.90 | 13.20 | 695 | 13.10 | 9.62 | 73 |
| 16 | 1.10 | 0 | 0 | 30.00 | 2.969 | 10 | 0 | 0.999 | | 65.50 | 27.104 | 41 | 0 | 38.155 | | 0 | 21.466 | | 5.75 | 0 | 0 | 41.10 | 9.35 | 23 | 1.60 | 6.06 | 379 |
| 17 | 4.60 | 0 | 0 | 18.75 | 4.151 | 22 | 16.00 | 2.314 | 14 | 25.75 | 14.875 | 58 | 10.20 | 29.228 | 287 | 0 | 12.946 | | 0 | 0 | 0 | 11.50 | 8.45 | 73 | 76.60 | 5.78 | 8 |
| 18 | 29.10 | 0 | 0 | 32.75 | 5.522 | 17 | 4.25 | 0.728 | 17 | 1.75 | 7.179 | 410 | 0 | 8.662 | | 0 | 12.512 | | 0 | 0 | 0 | 89.50 | 17.02 | 19 | 9.50 | 4.30 | 45 |
| 19 | 1.90 | 0 | 0 | 110.50 | 47.658 | 43 | 5.75 | 3.749 | 65 | 21.25 | 5.852 | 28 | 0 | 3.749 | | 2.25 | 17.006 | 756 | 8.00 | 0 | 0 | 32.20 | 20.66 | 64 | 61.20 | 14.18 | 23 |
| 20 | 22.30 | 0 | 0 | 2.25 | 11.316 | 503 | 8.75 | 7.488 | 86 | 0 | 8.581 | | 4.75 | 3.849 | 81 | 0 | 15.921 | | 0 | 0 | 0 | 25.10 | 19.77 | 79 | 9.90 | 15.55 | 157 |
| 21 | 0.50 | 0 | 0 | 24.25 | 5.852 | 24 | 8.50 | 7.253 | 85 | 28.50 | 21.311 | 75 | 0 | 16.407 | | 15.75 | 17.504 | 111 | 0 | 0 | 0 | 11.20 | 17.02 | 152 | 22.90 | 16.47 | 72 |
| 22 | 0.40 | 0 | 0 | 27.75 | 5.356 | 19 | 23.50 | 36.948 | 157 | 0 | 22.092 | | 62.75 | 21.933 | 35 | 0 | 12.186 | | 3.90 | 0 | 0 | 33.90 | 15.84 | 47 | 1.20 | 15.84 | 1320 |
| 23 | 21.20 | 0 | 0 | 5.25 | 2.314 | 44 | 57.00 | 44.105 | 77 | 11.50 | 16.114 | 140 | 41.00 | 32.915 | 80 | 12.75 | 18.014 | 141 | 0 | 0 | 0 | 29.10 | 16.08 | 55 | 44.20 | 15.51 | 35 |
| 24 | 42.10 | 0 | 0 | 65.25 | 26.420 | 40 | 23.50 | 14.875 | 63 | 5.25 | 18.727 | 357 | 0 | 12.823 | | 13.25 | 21.333 | 161 | 0 | 0 | 0 | 46.20 | 15.60 | 34 | 9.80 | 12.78 | 130 |
| 25 | 45.30 | 0 | 0 | 5.75 | 11.224 | 195 | 0 | 11.316 | | 0 | 8.722 | | 9.00 | 13.771 | 153 | 17.00 | 23.713 | 139 | 0 | 0 | 0 | 37.20 | 14.04 | 38 | 44.50 | 14.47 | 33 |
| 26 | 41.25 | 0 | 0 | 40.75 | 14.496 | 36 | 12.50 | 11.003 | 88 | 0 | 4.191 | | 0 | 11.578 | | 0 | 11.445 | | 0 | 0 | 0 | 50.50 | 14.04 | 28 | 31.20 | 15.55 | 50 |
| 27 | 70.75 | 0 | 0 | 35.50 | 18.202 | 51 | 17.00 | 17.202 | 101 | 0 | 3.448 | | 0 | 21.212 | | 3.75 | 12.945 | 345 | 0 | 0 | 0 | 41.10 | 15.12 | 37 | 13.40 | 16.10 | 120 |
| 28 | 36.20 | 0 | 0 | 24.25 | 15.264 | 63 | 8.50 | 13.401 | 158 | 0 | 3.376 | | 11.00 | 18.561 | 169 | 13.00 | 13.400 | 103 | 0 | 0 | 0 | 94.20 | 16.08 | 17 | 12.50 | 15.55 | 124 |
| 29 | 95.75 | 11.32 | | 3.25 | 13.260 | 408 | 54.25 | 34.301 | 63 | 0 | 3.099 | | 16.00 | 25.875 | 162 | 0 | 12.088 | | 0 | 0 | 0 | 46.30 | 17.31 | 37 | 18.50 | 15.56 | 84 |
| 30 | 114.75 | 33.53 | | 33.75 | 13.771 | 41 | 14.25 | 15.766 | 111 | | 2.605 | | 0 | 17.316 | | | 9.262 | | 0 | 0 | 0 | 86.20 | 17.04 | 20 | 14.10 | 14.86 | 105 |
| 31 | | | | | 4.355 | | 1.50 | 12.066 | 804 | | | | 11.75 | 15.920 | 135 | | | | 0 | 0 | 0 | | | | 11.10 | 14.20 | 128 |
| Total | 725.90 | 44.84 | | 940.75 | 306.56 | | 564.07 | 400.34 | | 252.00 | 353.47 | | 375.45 | 595.44 | | 200.00 | 462.73 | | 21.40 | 172.91 | | 852.30 | 306.58 | | 842.10 | 359.56 | |

mm/d - Milli meter pr day $M^3/s$ - Cubic meter per second

## Table 3.3 Percentage of daily rainfull as stream flow (runoff)

| Date | 1997 | | | | | | | | | | | | | | 1998 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June | | July | | August | | September | | October | | November | | December | | June | | July | |
| | ha m /d | t/d | ha m /d | t/d | ha m /d | t/d | ha m /d | T/d | ha m /d | t/d | ha m /d | t/d | ha m /d | t/d | ha m /d | t/d | ha m /d | t/d |
| 1 | 0 | 0 | 0.0151 | 210.71 | 0.0460 | 643.90 | 0.0164 | 229.12 | 0.0099 | 138.00 | 0.0151 | 210.99 | 0.0052 | 72.32 | 0 | 0 | 0.0043 | 59.57 |
| 2 | 0 | 0 | 0.0088 | 122.95 | 0.0002 | 2.56 | 0.0065 | 90.58 | 0.0521 | 729.03 | 0.0159 | 223.44 | 0.0067 | 94.30 | 0 | 0 | 0.0036 | 50.9923 |
| 3 | 0 | 0 | 0.0061 | 85.30 | 0.0293 | 410.51 | 0.0027 | 37.15 | 0.0266 | 372.25 | 0.0141 | 197.81 | 0.0080 | 111.511 | 0 | 0 | 0.0063 | 87.6473 |
| 4 | 0 | 0 | 0.0010 | 14.07 | 0.0022 | 30.68 | 0.0012 | 16.39 | 0.0154 | 215.94 | 0.0079 | 111.57 | 0.0091 | 127.338 | 0 | 0 | 0.0025 | 35.0214 |
| 5 | 0 | 0 | 0.0012 | 16.51 | 0.0065 | 90.62 | 0.0008 | 11.67 | 0.0139 | 195.45 | 0.0033 | 46.58 | 0.0086 | 120.349 | 0 | 0 | 0.0065 | 90.5605 |
| 6 | 0 | 0 | 0.0034 | 47.99 | 0.0063 | 88.19 | 0.0263 | 368.28 | 0.0213 | 299.45 | 0.0048 | 62.75 | 0.0091 | 126.798 | 0 | 0 | 0.0064 | 89.3619 |
| 7 | 0 | 0 | 0.0045 | 63.24 | 0.0459 | 643.54 | 0.0694 | 971.62 | 0.0152 | 213.21 | 0.0059 | 82.25 | 0.0083 | 116.102 | 0 | 0 | 0.0022 | 30.5276 |
| 8 | 0 | 0 | 0.0023 | 32.38 | 0.0491 | 687.01 | 0.0457 | 640.73 | 0.0041 | 57.09 | 0.0017 | 23.84 | 0.0087 | 121.977 | 0 | 0 | 0.0048 | 66.8175 |
| 9 | 0 | 0 | 0.0024 | 33.05 | 0.0404 | 565.65 | 0.0289 | 405.72 | 0.0045 | 62.33 | 0.0494 | 691.21 | 0.0084 | 118.157 | 0 | 0 | 0.0056 | 78.2742 |
| 10 | 0 | 0 | 0.0011 | 15.83 | 0.0094 | 131.15 | 0.0214 | 299.95 | 0.0084 | 117.88 | 0.0022 | 30.50 | 0.0093 | 129.688 | 0 | 0 | 0.0042 | 59.105 |
| 11 | 0 | 0 | 0.0025 | 31.45 | 0.0139 | 194.83 | 0.0137 | 191.80 | 0.0045 | 63.29 | 0.0045 | 6.96 | 0.0082 | 114.375 | 0.0096 | 134.20 | 0.0028 | 38.9543 |
| 12 | 0 | 0 | 0.0017 | 23.32 | 0.0097 | 136.09 | 0.0289 | 405.53 | 0.0054 | 76.24 | 0.0128 | 179.87 | 0 | 0 | 0.0081 | 113.340 | 0.0063 | 87.5886 |
| 13 | 0 | 0 | 0.0009 | 12.35 | 0.0027 | 38.34 | 0.0107 | 149.54 | 0.0088 | 123.33 | 0.0081 | 113.92 | 0 | 0 | 0.0067 | 93.81 | 0.0008 | 11.4491 |
| 14 | 0 | 0 | 0.0010 | 14.59 | 0.0030 | 42.30 | 0.0077 | 107.82 | 0.0101 | 142.38 | 0.0065 | 91.25 | 0 | 0 | 0.0050 | 70.1844 | 0.0283 | 395.638 |
| 15 | 0 | 0 | 0.0023 | 31.85 | 0.0017 | 23.56 | 0.0092 | 128.53 | 0.0203 | 283.90 | 0.0190 | 266.25 | 0 | 0 | 0.0061 | 84.8061 | 0.0190 | 266.527 |
| 16 | 0 | 0 | 0.0023 | 32.27 | 0.0046 | 63.98 | 0.0403 | 564.57 | 0.0121 | 169.09 | 0.0143 | 199.78 | 0 | 0 | 0.0067 | 93.2095 | 0.0083 | 116.769 |
| 17 | 0 | 0 | 0.0024 | 34.03 | 0.0024 | 33.80 | 0.0414 | 580.13 | 0.0162 | 226.68 | 0.0079 | 111.88 | 0 | 0 | 0.0021 | 29.9649 | 0.0097 | 135.874 |
| 18 | 0 | 0 | 0.0017 | 24.48 | 0.0022 | 30.99 | 0.0077 | 108.16 | 0.0023 | 32.61 | 0.0087 | 121.99 | 0 | 0 | 0.0046 | 64.1069 | 0.0092 | 128.584 |
| 19 | 0 | 0 | 0.0024 | 33.97 | 0.0172 | 240.83 | 0.0086 | 120.62 | 0.0010 | 14.12 | 0.0121 | 169.58 | 0 | 0 | 0.0108 | 151.072 | 0.0202 | 282.824 |
| 20 | 0 | 0 | 0.0444 | 621.87 | 0.0232 | 325.17 | 0.0183 | 256.68 | 0.0047 | 65.70 | 0.0118 | 165.82 | 0 | 0 | 0.0119 | 166.463 | 0.0214 | 299.798 |
| 21 | 0 | 0 | 0.0034 | 47.79 | 0.0115 | 160.77 | 0.0637 | 892.35 | 0.0018 | 25.45 | 0.0136 | 190.05 | 0 | 0 | 0.0215 | 301.679 | 0.0229 | 321.211 |
| 22 | 0 | 0 | 0.0102 | 142.41 | 0.0536 | 751.23 | 0.0220 | 308.41 | 0.0219 | 306.19 | 0.0069 | 97.22 | 0 | 0 | 0.0123 | 171.941 | 0.0326 | 456.171 |
| 23 | 0 | 0 | 0.0018 | 25.61 | 0.0873 | 1221.69 | 0.0127 | 178.54 | 0.0141 | 196.93 | 0.0111 | 155.68 | 0 | 0 | 0.0094 | 131.801 | 0.0245 | 343.597 |
| 24 | 0 | 0 | 0.0576 | 806.28 | 0.0184 | 257.10 | 0.0172 | 240.67 | 0.0191 | 267.06 | 0.0145 | 203.27 | 0 | 0 | 0.0049 | 69.119 | 0.0158 | 220.849 |
| 25 | 0 | 0 | 0.0155 | 216.50 | 0.0149 | 208.13 | 0.0057 | 79.24 | 0.0065 | 91.56 | 0.0191 | 267.98 | 0 | 0 | 0.0113 | 158.657 | 0.0183 | 256.532 |
| 26 | 0 | 0 | 0.0413 | 578.76 | 0.0115 | 160.92 | 0.0011 | 14.85 | 0.0044 | 61.57 | 0.0074 | 103.98 | 0 | 0 | 0.0109 | 152.435 | 0.0178 | 249.143 |
| 27 | 0 | 0 | 0.0308 | 430.68 | 0.0299 | 419.33 | 0.0013 | 17.57 | 0.0131 | 183.32 | 0.0082 | 114.74 | 0 | 0 | 0.0120 | 167.512 | 0.0190 | 265.767 |
| 28 | 0 | 0 | 0.0442 | 618.85 | 0.0244 | 341.47 | 0.0013 | 18.70 | 0.0120 | 168.65 | 0.0089 | 124.71 | 0 | 0 | 0.0476 | 666.133 | 0.0202 | 282.568 |
| 29 | 0.0091 | 127.88 | 0.0052 | 73.45 | 0.0642 | 899.48 | 0.0016 | 21.98 | 0.02 | 252.27 | 0.0078 | 109.82 | 0 | 0 | 0.029 | 406.592 | 0.0261 | 365.418 |
| 30 | 0.0079 | 111.44 | 0.0222 | 311.21 | 0.0349 | 489.13 | 0.0010 | 13.84 | 0.01 | 134.29 | 0.0057 | 80.04 | 0 | 0 | 0.0067 | 94.4102 | 0.0216 | 302.887 |
| 31 | | | 0.0062 | 86.90 | 0.02 | 342.25 | | | 0.01 | 179.93 | | | 0 | 0 | | | 0.027 | 377.534 |
| Total | 0.0170 | 239.33 | 0.3459 | 4840.63 | 0.6909 | 9675.23 | 0.5334 | 7470.74 | 0.3901 | 5465.17 | 0.3292 | 4555.72 | 0.0896 | 1252.92 | 0.2372 | 3321.44 | 0.4182 | 5853.56 |

RF - Rainfall, mm Q-Stream flow (runoff), mm

gauge was installed to measure the depth of flow. This vented cross bar served as a good water-storage structure and maintains the water level in nearby areas.

The stream was completely drained up by the end of January 1998 since the flow through the stream was not perennial. The flow was nil during January, February, March, April, and May in 1998. It resumed on 11th June with a flow of 20.66 mm/day (4.818 m3/s), which came to 64.16 percent of the rainfall received on that day. The total stream flow recorded during June 1998 was 306.55 mm (71.49 $m^3$/s), which came to about 36 percent of the rainfall received during the month.

The stream flow recorded during July 1998 was 359.532 mm (83.46$m^3$/s), amounting 42.7 percent of the rainfall received in that period. The maximum run-off of 16.47 mm/day (3.842 $m^3$/s) was recorded on 21st July, which has about 71.93 percent of the rainfall received on that day. The run-off in July 1998 was higher by 17.3 percent of that recorded in July 1997 (306.526 mm). The increase must have been due to the high rain fall (852.3mm) received during June 1998.

Monthly rainfall, run-off, and the percentage of rainfall as run-off are shown in Table 3.4.

**Table 3.4 Monthly rainfall, runoff and percentage of rainfall as runoff from the watershed**

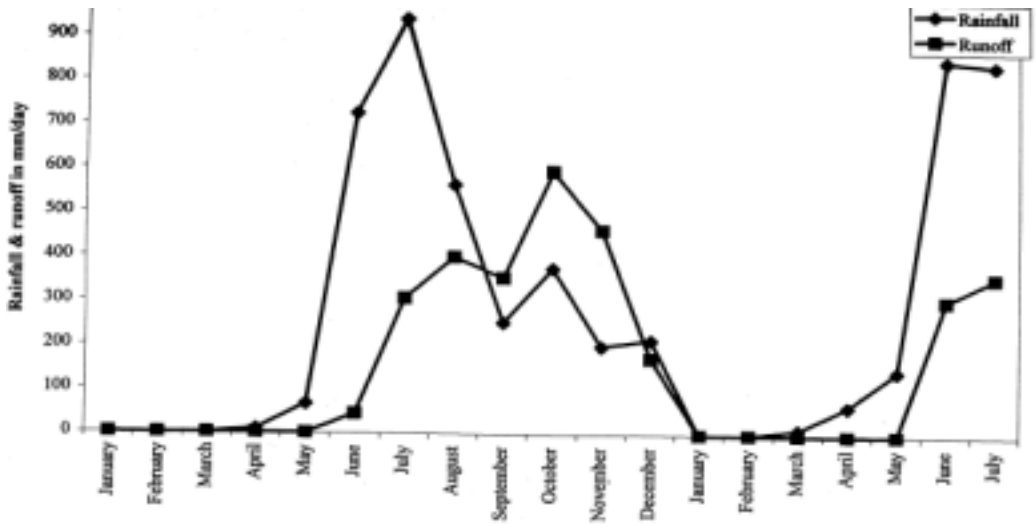
| Year | Month | Rainfall (mm/day) | Run-off (mm/day) | Per cent |
|---|---|---|---|---|
| *1997* | January | 0 | 0 | _ |
| | February | 0 | 0 | _ |
| | March | 0 | 0 | _ |
| | April | 8.70 | 0 | _ |
| | May | 66.50 | 0 | _ |
| | June | 725.50 | 44.84 | 6.18 |
| | July | 940.75 | 306.53 | 32.58 |
| | August | 564.07 | 400.34 | 70.97 |
| | September | 252.00 | 353.47 | 140.27 |
| | October | 375.45 | 595.44 | 158.59 |
| | November | 200.00 | 462.73 | 231.36 |
| | December | 214.00 | 172.91 | 80.80 |
| *1998* | January | 0 | 0 | _ |
| | February | 0 | 0 | _ |
| | March | 14.00 | 0 | _ |
| | April | 66.80 | 0 | _ |
| | May | 147.05 | 0 | |
| | June | 852.30 | 306.55 | 35.97 |
| | July | 842.10 | 359.53 | 42.69 |

The proportion of run-off to rain fall increased from 6.18 percent in June to 231.36 percent in November, though the rainfall showed a decreasing trend during the period. Though the rainfall was low during October and November, run-off was higher than during July, August, and September, mainly due to the effect of the high rainfall received during July to September. The relationship between rainfall and run-off is shown in Fig. 3.1.

When the rainfall was less than 25 mm, the proportion of run-off to rainfall was in the range of 100-200 percent, between 25 to 30mm of rainfall, the corresponding proportion was in the range of 50-100 percent; for 50-100mm of rain, the proportion was even lower, only 20-50 percent. The immediate effect of high-intensity rainfall was found to disappear from the third day onwards.

The run-off observed during 1997 was 69.80 percent of the rainfall received; this proportion can be reduced to 30 percent by proper land and water management (Central Soil & Water Conservation Research Institute - CSWCRI, Udhakkamandalam, 1980).

**Figure 3.1 Relationship between rainfall and runoff**




After the cessation of rainfall, the flow was about 1.5-2.0 $m^3/s$ (1.296 x 105 - 1.728 x 105 $m^3$/day) and it was completely stopped during January. Our intention was to stop the surface flow for a rainfall up to 80mm. In order to achieve this goal, proper land management practices had to be adopted. The excess water caused by rainfall over 80mm is supposed to spill over as overland flow, which would favour agricultural operations, habitation practices, and road networks.

The stream flow in the project area is getting reduced during summer season every year because of sedimentation, reduced infiltration, and choking of waterways by fallen thick and thorny vegetative cover. Since the streams and waterways flowing through the watershed are seasonal in nature, they are completely drained up during January-February and the next flow occurs only with the start of the monsoon season. Moreover, the water storage devices,

reservoirs, and ponds are not maintained properly for conserving water. Hence, the availability of surface water from the stream is mainly restricted to the monsoon periods. Since the storage devices are inadequate, rainwater is allowed to flow as run-off to the Manali River during the monsoon period.

**Sediment yield from the watershed**

The daily sediment production estimated by measuring the stream flow from the watershed is presented in Table 3.5. The sediment yield estimated during June 1997 was 239.326 tonnes was the minimum for any month during the survey period. The minimum quantity of sediment yield was due to the low amount of run-off experienced during this period.

In June, the maximum sediment yield was recorded as 806.277 tonnes/day (0.0576 ha.m / day) on the 24$^{th}$ followed by 621.866 tonnes/day (0.444 ha.m/day) on the 28$^{th}$. The quantity of sedimentation increased from the beginning to the end of the month due to continuous rainfall during the period. The total sediment yield estimated during the month of July was found as 4840.626 tonnes (0.3465 ha. m/month).

During August 1997, the maximum sediment yield was observed as 1221.694 tonnes /day (0.0873 ha. m/day) on the 23$^{rd}$ f ollowed by 899.483 tonnes /day (0.0642 ha. m /day) on the 29$^{th}$ of the month. The total sediment yield estimated in August was 9765.229 tonnes (0.6909 ha. m /month), which is the maximum among all the months of the year 1997. It was found that in August sediment loss was higher on almost all days than during the previous months. This may be due to high soil movement together with surface flow at the time of inter-cultural operations, which cause great disturbance to the soil surface in the watershed.

The maximum daily sediment yield in September 1997 was estimated as 971.624 tonnes/ day (0.0694 ha.m/day) on the 7$^{th}$ followed by 892.353 tonnes/day (0.0637 ha.m/day) on the 21$^{st}$. The sediment loss was found to be more than 100 tonnes/ day. However, towards the end of the month, sediment yield was found to have decreased due to reduced stream flow.

The maximum sediment yield observed in October was 729.026 tonnes/day (0.0521 ha.m/ day) on the 2$^{nd}$ day of the month and that in November; it was 91.214 tonnes/day (0.0494 ha.m/day) on the 9$^{th}$ day of the month. During October and November, the sediment yield was found to have decreased mainly because of small run-off due to low-intensity rainfall.

The sediment yield observed during June 1998 is 3321.44 tonnes (0.237 ha.m/month), which comes to about 13 times more than that in the same period of the previous year, June 1997. This increased amount of sediment yield is due to the high run-off. In July 1998 the sediment yield recorded was 5853.57 tonnes (0.418 ha.m/month), much more than that of July 1997. After 14$^{th}$ July 1998 almost all the days recorded high sediment loss, more than 250 tonnes/ day.

## Table 3.5 Daily sediment yield estimated in ha.m/day and tons/day

| Date | 1997 | | | | | | | | | | | | | | 1998 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June | | July | | August | | September | | October | | November | | December | | June | | July | |
| | *ha m/d* | *t/d* | *ha m/d* | *t/d* | *ha m/d* | *t/d* | *ha m/d* | *T/d* | *ha m/d* | *t/d* | *ha m/d* | *t/d* | *ha m/d* | *t/d* | *ha m/d* | *t/d* | *ha m/d* | *t/d* |
| 1 | 0 | 0 | 0.0151 | 210.71 | 0.0460 | 643.90 | 0.0164 | 229.12 | 0.0099 | 138.00 | 0.0151 | 210.99 | 0.0052 | 72.32 | 0 | 0 | 0.0043 | 59.57 |
| 2 | 0 | 0 | 0.0088 | 122.95 | 0.0002 | 2.56 | 0.0065 | 90.58 | 0.0521 | 729.03 | 0.0159 | 223.44 | 0.0067 | 94.30 | 0 | 0 | 0.0036 | 50.9923 |
| 3 | 0 | 0 | 0.0061 | 85.30 | 0.0293 | 410.51 | 0.0027 | 37.15 | 0.0266 | 372.25 | 0.0141 | 197.81 | 0.0080 | 111.511 | 0 | 0 | 0.0063 | 87.6473 |
| 4 | 0 | 0 | 0.0010 | 14.07 | 0.0022 | 30.68 | 0.0012 | 16.39 | 0.0154 | 215.94 | 0.0079 | 111.57 | 0.0091 | 127.338 | 0 | 0 | 0.0025 | 35.0214 |
| 5 | 0 | 0 | 0.0012 | 16.51 | 0.0065 | 90.62 | 0.0008 | 11.67 | 0.0139 | 195.45 | 0.0033 | 46.58 | 0.0086 | 120.349 | 0 | 0 | 0.0065 | 90.5605 |
| 6 | 0 | 0 | 0.0034 | 47.99 | 0.0063 | 88.19 | 0.0263 | 368.28 | 0.0213 | 299.45 | 0.0048 | 62.75 | 0.0091 | 126.798 | 0 | 0 | 0.0064 | 89.3619 |
| 7 | 0 | 0 | 0.0045 | 63.24 | 0.0459 | 643.54 | 0.0694 | 971.62 | 0.0152 | 213.21 | 0.0059 | 82.25 | 0.0083 | 116.102 | 0 | 0 | 0.0022 | 30.5276 |
| 8 | 0 | 0 | 0.0023 | 32.38 | 0.0491 | 687.01 | 0.0457 | 640.73 | 0.0041 | 57.09 | 0.0017 | 23.84 | 0.0087 | 121.977 | 0 | 0 | 0.0048 | 66.8175 |
| 9 | 0 | 0 | 0.0024 | 33.05 | 0.0404 | 565.65 | 0.0289 | 405.72 | 0.0045 | 62.33 | 0.0494 | 691.21 | 0.0084 | 118.157 | 0 | 0 | 0.0056 | 78.2742 |
| 10 | 0 | 0 | 0.0011 | 15.83 | 0.0094 | 131.15 | 0.0214 | 299.95 | 0.0084 | 117.88 | 0.0022 | 30.50 | 0.0093 | 129.688 | 0 | 0 | 0.0042 | 59.105 |
| 11 | 0 | 0 | 0.0025 | 31.45 | 0.0139 | 194.83 | 0.0137 | 191.80 | 0.0045 | 63.29 | 0.0045 | 6.96 | 0.0082 | 114.375 | 0.0096 | 134.20 | 0.0028 | 38.9543 |
| 12 | 0 | 0 | 0.0017 | 23.32 | 0.0097 | 136.09 | 0.0289 | 405.53 | 0.0054 | 76.24 | 0.0128 | 179.87 | 0 | 0 | 0.0081 | 113.340 | 0.0063 | 87.5886 |
| 13 | 0 | 0 | 0.0009 | 12.35 | 0.0027 | 38.34 | 0.0107 | 149.54 | 0.0088 | 123.33 | 0.0081 | 113.92 | 0 | 0 | 0.0067 | 93.81 | 0.0008 | 11.4491 |
| 14 | 0 | 0 | 0.0010 | 14.59 | 0.0030 | 42.30 | 0.0077 | 107.82 | 0.0101 | 142.38 | 0.0065 | 91.25 | 0 | 0 | 0.0050 | 70.1844 | 0.0283 | 395.638 |
| 15 | 0 | 0 | 0.0023 | 31.85 | 0.0017 | 23.56 | 0.0092 | 128.53 | 0.0203 | 283.90 | 0.0190 | 266.25 | 0 | 0 | 0.0061 | 84.8061 | 0.0190 | 266.527 |
| 16 | 0 | 0 | 0.0023 | 32.27 | 0.0046 | 63.98 | 0.0403 | 564.57 | 0.0121 | 169.09 | 0.0143 | 199.78 | 0 | 0 | 0.0067 | 93.2095 | 0.0083 | 116.769 |
| 17 | 0 | 0 | 0.0024 | 34.03 | 0.0024 | 33.80 | 0.0414 | 580.13 | 0.0162 | 226.68 | 0.0079 | 111.88 | 0 | 0 | 0.0021 | 29.9649 | 0.0097 | 135.874 |
| 18 | 0 | 0 | 0.0017 | 24.48 | 0.0022 | 30.99 | 0.0077 | 108.16 | 0.0023 | 32.61 | 0.0087 | 121.99 | 0 | 0 | 0.0046 | 64.1069 | 0.0092 | 128.584 |
| 19 | 0 | 0 | 0.0024 | 33.97 | 0.0172 | 240.83 | 0.0086 | 120.62 | 0.0010 | 14.12 | 0.0121 | 169.58 | 0 | 0 | 0.0108 | 151.072 | 0.0202 | 282.824 |
| 20 | 0 | 0 | 0.0444 | 621.87 | 0.0232 | 325.17 | 0.0183 | 256.68 | 0.0047 | 65.70 | 0.0118 | 165.82 | 0 | 0 | 0.0119 | 166.463 | 0.0214 | 299.798 |
| 21 | 0 | 0 | 0.0034 | 47.79 | 0.0115 | 160.77 | 0.0637 | 892.35 | 0.0018 | 25.45 | 0.0136 | 190.05 | 0 | 0 | 0.0215 | 301.679 | 0.0229 | 321.211 |
| 22 | 0 | 0 | 0.0102 | 142.41 | 0.0536 | 751.23 | 0.0220 | 308.41 | 0.0219 | 306.19 | 0.0069 | 97.22 | 0 | 0 | 0.0123 | 171.941 | 0.0326 | 456.171 |
| 23 | 0 | 0 | 0.0018 | 25.61 | 0.0873 | 1221.69 | 0.0127 | 178.54 | 0.0141 | 196.93 | 0.0111 | 155.68 | 0 | 0 | 0.0094 | 131.801 | 0.0245 | 343.597 |
| 24 | 0 | 0 | 0.0576 | 806.28 | 0.0184 | 257.10 | 0.0172 | 240.67 | 0.0191 | 267.06 | 0.0145 | 203.27 | 0 | 0 | 0.0049 | 69.119 | 0.0158 | 220.849 |
| 25 | 0 | 0 | 0.0155 | 216.50 | 0.0149 | 208.13 | 0.0057 | 79.24 | 0.0065 | 91.56 | 0.0191 | 267.98 | 0 | 0 | 0.0113 | 158.657 | 0.0183 | 256.532 |
| 26 | 0 | 0 | 0.0413 | 578.76 | 0.0115 | 160.92 | 0.0011 | 14.85 | 0.0044 | 61.57 | 0.0074 | 103.98 | 0 | 0 | 0.0109 | 152.435 | 0.0178 | 249.143 |
| 27 | 0 | 0 | 0.0308 | 430.68 | 0.0299 | 419.33 | 0.0013 | 17.57 | 0.0131 | 183.32 | 0.0082 | 114.74 | 0 | 0 | 0.0120 | 167.512 | 0.0190 | 265.767 |
| 28 | 0 | 0 | 0.0442 | 618.85 | 0.0244 | 341.47 | 0.0013 | 18.70 | 0.0120 | 168.65 | 0.0089 | 124.71 | 0 | 0 | 0.0476 | 666.133 | 0.0202 | 282.568 |
| 29 | 0.0091 | 127.88 | 0.0052 | 73.45 | 0.0642 | 899.48 | 0.0016 | 21.98 | 0.02 | 252.27 | 0.0078 | 109.82 | 0 | 0 | 0.029 | 406.592 | 0.0261 | 365.418 |
| 30 | 0.0079 | 111.44 | 0.0222 | 311.21 | 0.0349 | 489.13 | 0.0010 | 13.84 | 0.01 | 134.29 | 0.0057 | 80.04 | 0 | 0 | 0.0067 | 94.4102 | 0.0216 | 302.887 |
| 31 | | | 0.0062 | 86.90 | 0.02 | 342.25 | | | 0.01 | 179.93 | | | 0 | 0 | | | 0.027 | 377.534 |
| Total | 0.0170 | 239.33 | 0.3459 | 4840.63 | 0.6909 | 9675.23 | 0.5334 | 7470.74 | 0.3901 | 5465.17 | 0.3292 | 4555.72 | 0.0896 | 1252.92 | 0.2372 | 3321.44 | 0.4182 | 5853.56 |

The monthly rainfall, run-off, and sediment yield are given in Table 3.6 and the relationship between run-off and sediment yield is shown in Fig.3.2. The minimum sediment yield of 239.326 tonnes (0.0170ha.m) was recorded in June due to the lower stream flow (44.844 mm/month).

The month of August accounts for the highest sediment yield of 9675.229 tonnes/months (0.6909 ha. m /month) followed by September (7470.739 tonnes/ 0.5334 ha. m), though the run-off was the maximum during October. This increased rate of sediment yield during August and September is due to the large quantity of soil movement together with surface flow at the time of inter-cultural operations in the cultivable lands. The sediment yield was found to have decreased during October and November as the intensity and duration of rainfall decreased.

**Water resources**

***Surface water***

The major sources of surface water in the watershed are: (i) stream flowing through the watershed, (ii) ponds [both public and private], and (iii) irrigation canal.

**Stream flow**

The volume of water as runoff through the stream was computed (Table 3.2). The existing water storage structures in the streams include one check dam and 15 vented crossbars. The check dam was located near the origin of the main stream, Bharathamala. Though there were 15 vented cross bars in the stream, they were not properly working due to poor maintenance. The flow can be regulated by putting thick wooden planks in the crossbar during the end of the monsoon period and taking them off after the commencement of the next rainy season.

The main problem in the functioning of this system is the lack of conscientious people for the maintenance of wooden planks and hence the chance of their theft. Some of the crossbars identified in the watershed themselves are in great disrepair; wooden planks were found only at one crossbar out of 15. Details of the vented crossbars are furnished in Table 3.7.

The major advantages of arresting the flow of the stream by providing crossbars are:

(i) Crossbars are less costly and are good water storage devices; the stored water could be used for irrigation in large areas surrounding their location.

(ii) By storing water, the ground water table in the surrounding wells can be maintained thus ensuring the availability of water during summer, for domestic as well as for irrigation purposes.

**Table 3.6 Monthly rainfall run-off and sediment yield recorded from the watershed**

| Year | Month | Rainfall (mm/day) | Run-off (mm/day) | Sediment yield (t/d) |
|---|---|---|---|---|
| *1997* | January | 0 | 0 | 0 |
| | February | 0 | 0 | 0 |
| | March | 0 | 0 | 0 |
| | April | 8.70 | 0 | 0 |
| | May | 66.50 | 0 | 0 |
| | June | 725.50 | 44.84 | 259.32 |
| | July | 940.75 | 306.53 | 4840.63 |
| | August | 564.07 | 400.34 | 9675.23 |
| | September | 252.00 | 353.47 | 7470.74 |
| | October | 375.45 | 595.44 | 5465.66 |
| | November | 200.00 | 462.73 | 4555.69 |
| | December | 214.00 | 172.91 | 1252.92 |
| *1998* | January | 0 | 0 | 0 |
| | February | 0 | 0 | 0 |
| | March | 14.00 | 0 | 0 |
| | April | 66.80 | 0 | 0 |
| | May | 147.05 | 0 | 0 |
| | June | 852.30 | 306.55 | 3321.45 |
| | July | 842.10 | 359.53 | 5853.57 |

**Figure 3.2 Relationship between run-off and sediment yield**

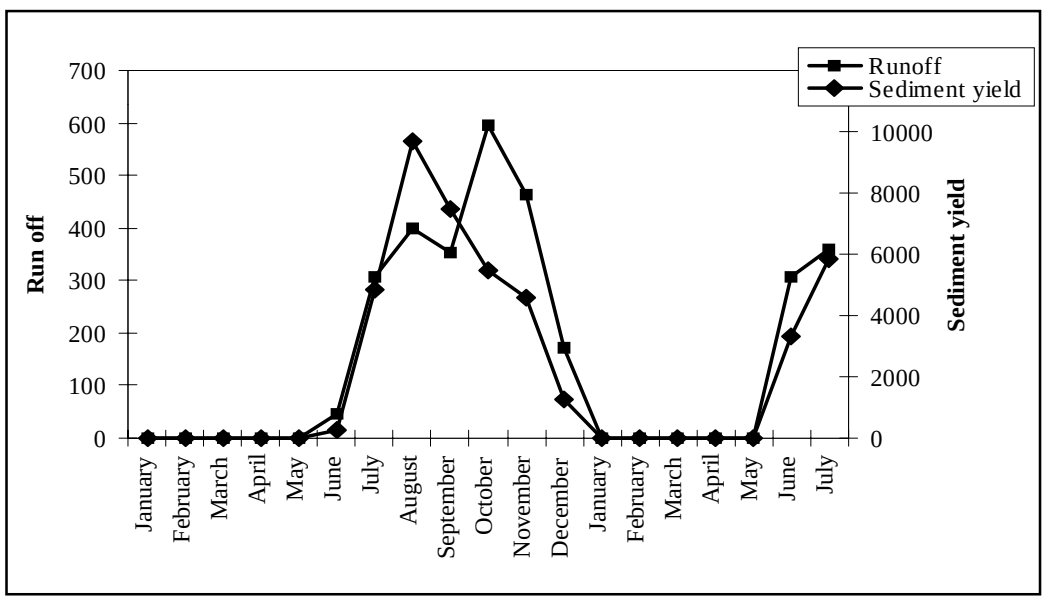


**Table 3.7 Details of vented crossbars in the watershed**

| Sl.No. | Location | Remarks |
|---|---|---|
| 1. | Near Sakthi Devi Temple | Not working |
| 2. | Kayyalappady | Not working |
| 3. | Near Vennattuparamb | Not working |
| 4. | Near Cheerampath house | Not working |
| 5. | Near Cherru's house | Not working |
| 6. | Kavallur | Partially working |
| 7. | Vattanathra | Partially working |
| 8. | Tottiparambu thazham | Not working |
| 9. | Kovath thazham | Partially working |
| 10. | Maliyekkaparambu | Partially working |
| 11. | Near Thekkanath | Not working |
| 12. | Payyakkara | Not working |
| 13. | Vattakkottai | Partially working |
| 14. | Vellanikkode | Partially working |
| 15. | Ayyamkode | Partially working |

**Ponds**

In earlier periods, well-maintained farm ponds used to be kept by individual landholders. These farm ponds served as good natural storage for surface water and supplied water for irrigation and even for domestic purposes. Ponds helped to maintain the water table of the area within safe limits. But nowadays, the majority of these ponds have disappeared; some of them, which have become dysfunctional due to silting and clotting by waste materials. In places in which ponds existed, there now stand buildings; or they have become agricultural plots.

The watershed consisted of a large number of ponds, used as good reservoirs of surface water. There are now 10 public ponds in the watershed, having an area of about 16,0000$m^2$. If, these public ponds are properly maintained, a large quantity of water can be stored to recharge the area, which in turn would increase water availability during the summer season. The details of public ponds with their local names are furnished in Table 3.8.

**Irrigation canals**

A branch canal of the Peechi Irrigation Project follows through this watershed for a total length of 11 km. Canal committees were formed at different locations of the watershed to ensure efficient functioning and timely operations of the canal. Most of these committees have, however, become defunct.

This canal seldom supplied water to the area due to lack of adequate water in the main canal during the summer months. If sufficient quantity of water were diverted through this branch canal, the watershed could be irrigated and its agricultural output increased substantially. Another important advantage of having irrigation water in canals is the maintenance of water

**Table 3.8. Details of public ponds in the watershed**

| Sl.No | Local Name | Area ($m^2$) | Present Status |
|---|---|---|---|
| 1. | Makkalakulam Chira | 3200 | Not maintained properly |
| 2. | Pappu Nair Chira | 1000 | 4m deep; can be deepened up to 8m |
| 3. | Ayyamkulam | 3000 | The boundary is lined with rubbles; but cracks exist now in the lining. |
| 4. | Rathrikkulam | 2000 | 2m deep |
| 5. | Palkkarakulam | 600 | Poorly maintaining |
| 6. | Aryakkarakulam | 3000 | Maintenance work was done during 1995-96 |
| 7. | Chungamkulam | 600 | Sides protected |
| 8. | Choorakkulam (Pechampully) | 2000 | Poorly maintaining |
| 9. | Kavalloorkulam | 1000 | Sides were protected with dry rubbles. |
| 10. | Ponnikkkulam | 600 | Sides protected |

table in the surrounding wells at fairly high levels thus alleviating the problem of scarcity of drinking water particularly during summer months. In fact, the canal water from Peechi had not reached the watershed for the past four years.

**Ground water**

The availability of ground water is determined by the rainfall in the region. The main source of extraction of ground water is open dug wells. Tube wells are also in use in some places of the watershed. Due to water level fluctuations between the pre- and the post-monsoon periods, most of the wells in the area are dried up for two to three months during summer. The quality of the ground water is good for domestic, agricultural, and industrial use.

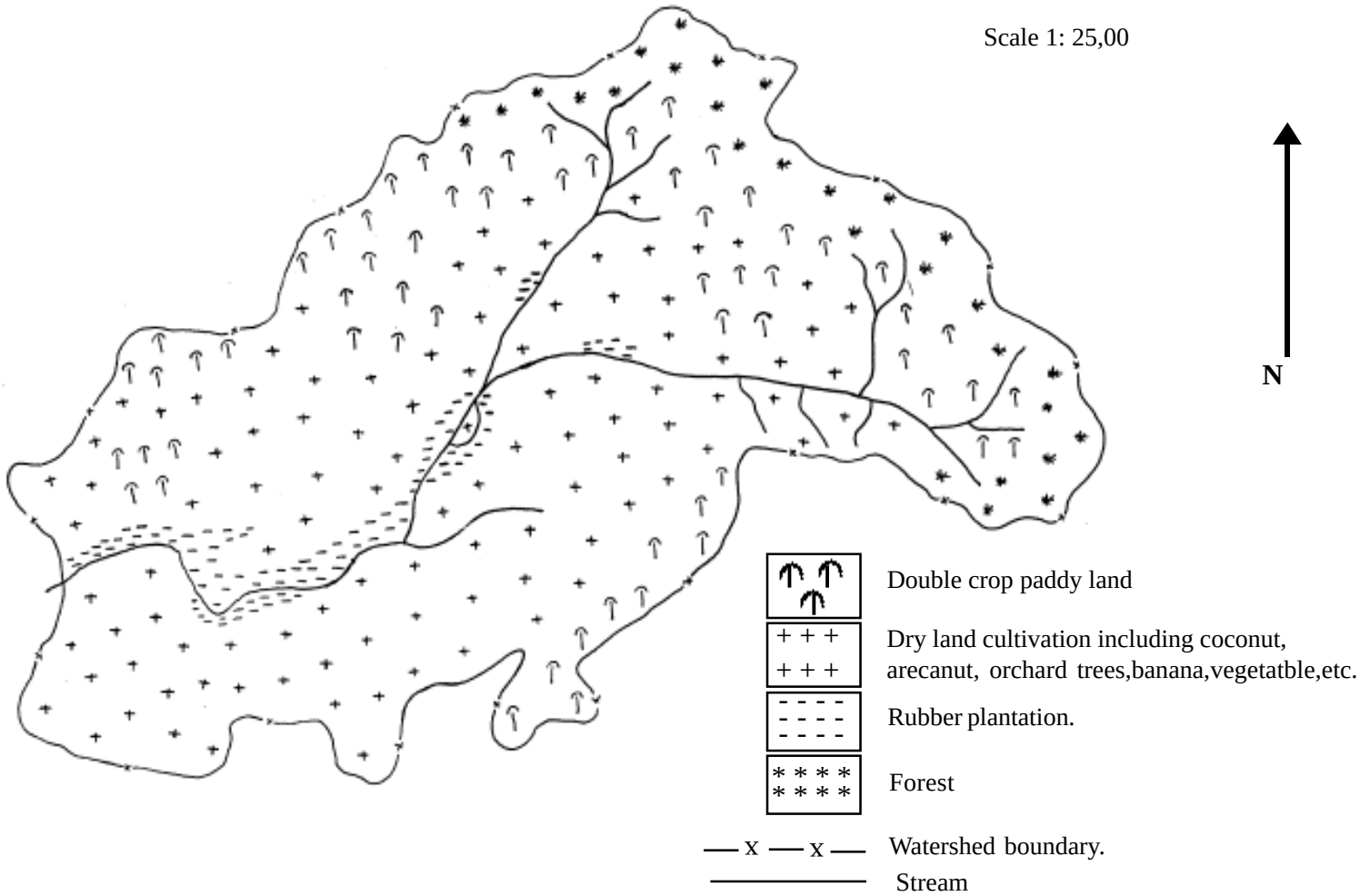
Almost all the beneficiaries in the watershed depend on open wells for drinking water. There exist 22 open public wells in this watershed serving about 200 households. The depth of open wells in the watershed ranges from 8 to 12 m. In summer, the majority of the open wells get dried up due to the draw-down of ground water level. The draw-down of water level can be minimised by adopting proper soil and water conservation practices, by every household in the region. Water received during the rainy seasons should be conserved by each household.

There are 58 tube wells, including four dysfunctional wells, located in the watershed, out of which 10 are in the public sector. These 10 public tube wells serve nearly 100 families in the region. The depth of tube wells ranges from 200-350 feet. However, tube wells should not be promoted if the valuable natural groundwater sources are to be conserved.

**Land use pattern**

The major categories of land use identified and mapped are, (i) agricultural land [both wet and dry lands], and (ii) forests (Map No.4).

**Map No.4 Present landuse/ land cover pattern of Bharathamala-Vattakkotta watedshed**



***Agricultural land***

**a. Wetland**

The wetlands are under rice cultivation and lie scattered in an area of 195 ha having 0-2 percent slope and constituting about 9.68 percent of the total area. As in the other regions of Thrissur district, except in Kole lands, there are two cropping seasons for rice: the autumn season (*Virippu*), from April-May to September-October, and the winter season (*Mundakan*), from September-October to December-January. Both local and high-yielding varieties like *Pattambi-27*, *Pavizham*, *Triveni*, and *Masoori* have found a place in cultivation of rice in this area. The average yield of rice in the watershed was 3865 kg/ ha. Though a network of irrigation canals exists in the Peechi Irrigation Project, it hardly meets the irrigation needs of rice cultivation in the watershed. So, the major source of irrigation water for rice is the North-East monsoon. The stream flowing through the watershed also serves as a source of irrigation water for rice.

Group farming, a scientifically and technologically proved cultural practice, was adopted by the farmers for rice cultivation. The three main *padasekharams* in the watershed were Vellanikkode, Pookkode-Vattanathra, and Payyakkara. The extent of adoption of improved farm implements / machinery was limited in this area. A self-propelled harvester is owned by the Pookkode-Vattanathra *Padasekharam*, the only modern equipment used for rice cultivation in the area. This machine can harvest 0.3 hectares per hour and its cost is Rs 45,000. The farmers in this *Padasekharam* are of the view that rice cultivation can be done with minimum manpower and in time if mechanisation were introduced.

During the third season (December-January to March-April), the paddy lands were mainly used for cultivation of pulses and vegetables. The major vegetables raised were bitter gourd, ladies finger, brinjal, snake gourd, cowpea, and cucumber. Thrikkur and Alagappa Nagar *panchayats* of the watershed contributed the major portion of vegetables marketed in Thrissur market. The limiting factor for vegetable cultivation was lack of irrigation facilities. Production could be enhanced two-fold, if proper water sources were available for irrigation. In some places, vegetables were cultivated on a joint basis, a practice that helps farmers to develop or maintain common irrigation sources. Moreover, land preparation, seeding/ planting, manuring, and pesticide application are done with minimum cost and in time. In paddy fields, labourers cultivated banana and vegetables on oral lease basis; they do not get loans or assistance from financial institutions due to non-availability of collateral in the form of land or jewellery.

The dangerous phenomenon seen in the watershed was the conversion of paddy lands for other purposes, as is the case with other parts of the State also. The conversion of paddy land is mainly due to (i) low profit from rice cultivation, (ii) drudgery of labour, (iii) high labour cost, (iv) non-availability of irrigation facilities, and (v) non-availability of improved implements/machinery. It is now realised that rice cultivation cannot be sustained without the introduction of appropriate farm machines. Mechanisation not only increases profit, but generates additional employment opportunities as well for the educated youth.

**Dry land**

The study area comprised 1510 ha of dry land under cultivation, which comes to about 74.94 percent of the area of the watershed. The dry land has plantations and orchards. Orchards occupied the major portion and consisted mainly of homesteads. Seasonal and perennial crops are grown under mixed cropping in the dry lands.

Rubber occupied an area of 420 ha (20.84 percent) of the watershed. The major hybrid varieties of rubber cultivated in the area are RRI-105 and GTI No.311. Rubber was cultivated mainly on the side slopes and hilltops of the watershed having a slope ranging from 10 to 25 percent.

Coconut was cultivated in an area of 840 ha, (41.69 percent) of the study area. Though improved varieties such as WCT and DXT were used for cultivation, the yield was meagre due to various factors. Coconut trees in the lower area were closely spaced (5 m on an average between trees); the upper area suffers moisture stress except in the homesteads. Dry lands with very deep soils lying near wetlands were mainly cultivated with coconut, banana, arecanut, pepper, betel vine, and vegetables. These crops were cultivated in a multi-tier cropping system at slopes ranging from 2-10 percent. Both seasonal and perennial crops were grown in combination. Banana and vegetables occupied 110 ha (5.46 percent) and 60 ha (2.98 percent) respectively; they were also cultivated in paddy lands depending on the availability of water. The major varieties of banana were *Nenthran*, *Robusta*, and *Palayankodan*.

The common vegetables cultivated were bitter gourd, snake gourd, cowpea, amaranths, green chilly, ladies finger, ash gourd, and yam. Banana and vegetables were cultivated in leased lands also. Other crops cultivated in the watershed were arecanut, betel vine, nutmeg, ginger, and turmeric. Arecanut occupied an area of 35 ha (1.74 percent) of the watershed. The common varieties were *Kasaragodan*, *Mangala*, and *Sumangala*. The area under pepper and betel vine cultivation came to about 20 and 25 ha respectively. Arecanut was cultivated under the multi-tier cropping system with banana, betel vine, pepper, nutmeg, ginger, and turmeric as inter-crops.

**Forest**

The most critical sector of a watershed, and also probably the most damaged, is the forest. Its importance lies not only in its own values and contributions to the economy and well-being of the rural population, but in the fact that it is also essential for maintaining ecological balance and water regime, preventing flood, drought, erosion, and sedimentation.

Bharathamala-Vattakkotta watershed occupied an area of 310 ha of forest, which comes to about 15.38 percent of the total area. This forest cover was located mainly in the East and the Northeastern part of the Thrikkur *panchayat* and spreads over wards VI, VII, and VIII. Owing to the high population pressure in the low and midlands, the forest area is encroached upon extensively and converted into agricultural land. Large areas of the forestland were converted into rubber plantation in recent years. Deforestation is leading to severe soil erosion, run-off, sedimentation, and floods and draughts in the watershed. Even in the area of forest,

which has survived the onslaughts, the plant density was found low. Another interference in the forest that takes place is in the form of grazing cattle and cutting of trees. Gap-filling is urgently needed to restore this dense forest ecosystem.

**Relationship between rainfall and evapo-transpiration**

The relationship between rainfall and evapo-transpiration was analysed for estimating surplus and deficit of water in the watershed.

The rainfall data during the period of study was recorded by installing a rain gauge station at a representative area of the watershed, namely Pachalippuram. The rainfall received in the watershed was 3346.97 mm during 1997 and 1922.25 mm during 1998 up to 31st July (Table 3.1).

The monthly evapo-transpiration of different crops in the study area for the past 14 years was calculated (Table 3.9). The water balance of the watershed was estimated by plotting the rainfall and evapo-transpiration for the past 14 years as shown in Fig.3.3. It was found that there was water surplus in seven consecutive months (May to November) and water deficit for the rest five months (December to April). On an average, the water surplus amounts to 2982.6 mm, which is equivalent to 60.10 X 106$m^3$. The water deficit was of the order of 546.6 mm amounting to 11.01 X 106 $m^3$ of water.

**Table 3.9 Average monthly rainfall and evapo-transpiration**

| Month | Rainfall (mm) | Evapo-transpiration (mm) |
|---|---|---|
| Jan | 0.00 | 147.88 |
| Feb | 0.00 | 125.15 |
| Mar | 0.00 | 137.19 |
| Apr | 8.70 | 115.84 |
| May | 66.50 | 102.17 |
| Jun | 725.50 | 60.52 |
| Jul | 940.75 | 57.00 |
| Aug | 564.25 | 65.71 |
| Sep | 252.10 | 69.75 |
| Oct | 375.50 | 66.97 |
| Nov | 200.00 | 75.76 |
| Dec | 56.50 | 119.10 |

**Land capability classification of the watershed**

Land capability classification is an interpretative grouping of soils to show their suitability for different kinds of uses together with risk of land degradation and their response to management based on limitations imposed on the sustained use of soils by their inherent soil characteristics, in combination with external land features and environmental characteristics.

The land capability classification of the watershed is shown in Table 3.10 (See Map No.5).

**Figure 3.3 Relationship between rainfall and evapo-transpiration**

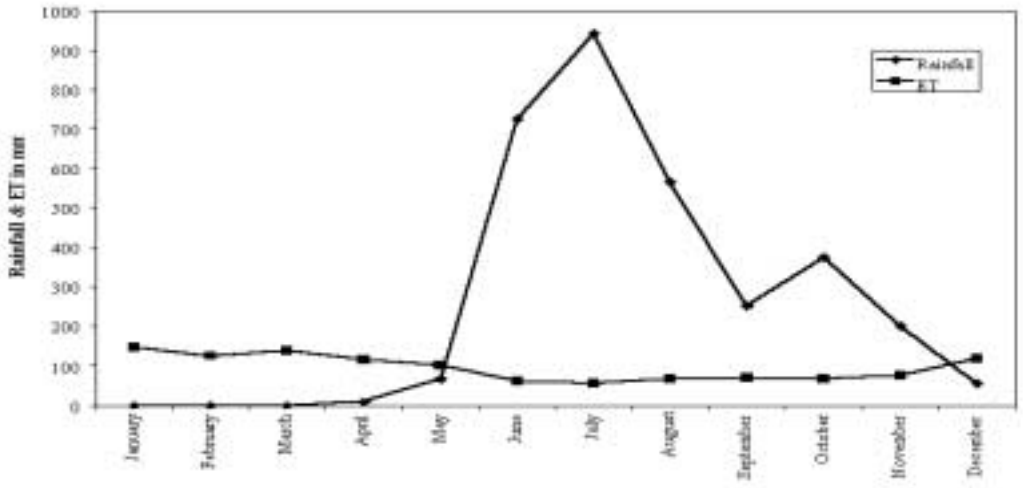
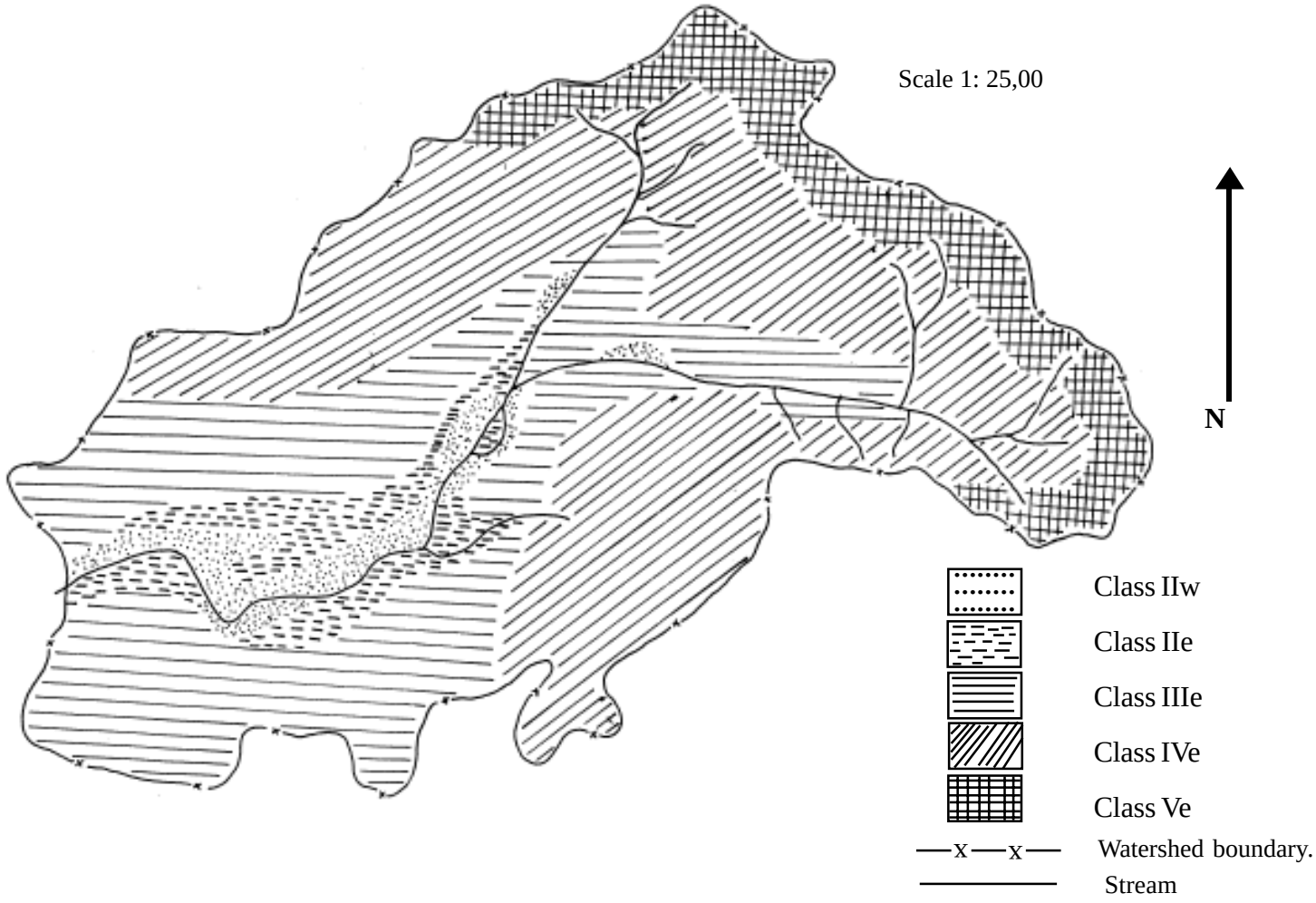



**Table 3.10 Land capability classification of the watershed**

| Sl. No | Capability subclass | Characteristics and limitations | Slope per cent | Area ha | Percentage to total area |
|---|---|---|---|---|---|
| 1. | IIw | Soils are very deep with clay loam to silty clay loam texture. The limiting factor is water logging during monsoon. | 0-2 | 195 | 9.7 |
| 2. | IIe | Soils are deep to very deep, with gravelly clay loam to clay loam texture. | 1-3 | 250 | 12.4 |
| 3. | IIIe | Soils are deep to very deep, gravelly clay loam to clay loam structure. Soil erosion is the major limiting factor | 5-10 | 620 | 30.7 |
| 4. | IVe | Soils are deep to very deep and must be protected with rubble- pitched contour bunds. Soil erosion is the maj or problem | 10-25 | 640 | 31.8 |
| 5. | VIe | The depth of soil ranges from deep to very deep with gravelly clay loam to gravelly clay texture. Crops, which require frequent intercultural operations, are not recommended. | > 25 | 310 | 15.4 |
| | | **Total** | | **2015** | **100.0** |

**Map No. 5 Land Capability Classification of Bharathamala-Vattakkottai watershed**



***Class IIw***

This class spreads over an area of 195 ha. These soils were found to be very deep with clay loam to silty clay loam texture. The area was cultivated mainly with rice. The limiting factor is excess water during monsoons, a factor which generally affects the choice of crops.

The serious problem encountered by this class of land was its shifting from rice to other crops like coconut, arecanut, and banana due to low profitability of rice, drudgery of labour involved, higher wage rate, low price of the produce, and lack of improved machinery or implements in rice cultivation. This trend is dangerous because the problem with class IIw land is water-logging. The garden crops are likely to be affected adversely in the coming years due to decay of roots. Another disadvantage of the transformation of paddy lands is excessive draining of water during the surplus period (monsoon). Since the garden crops are planted in a water-logged area, canals or drainage works will be carried out in it to drain out the floodwater. The excessive drainage that follows will cause early draw-down of ground water creating severe drought situation during the deficit period (summer). Thus the conversion of paddy lands will create both excessive floods and excessive draughts during the monsoon and the summer seasons respectively.

***Class IIe***

Class IIe was spread over an area of 250 ha in the watershed. The soils were very deep with gravelly clay loam to clay loam texture. The average slope of land under this class was one to three percent. The area was cultivated mainly with coconut, arecanut, banana, and vegetables.

Small earthen bunds or farm bunds, pits, and trenches can be constructed in the area under the class IIe. Agronomic practices such as planting vegetative cover like glyrecidia, subabool, and *adalodakam* may be adopted over these earthen bunds. Thus the limiting factor, erosion, can be reduced up to the permissible level. Organic mulching materials such as green manures may be produced and recycled to get high profits to farmers.

***Class IIIe***

Class IIIe spreads over an area of 620 ha. The slope of this area was found to be 5-10 percent, which causes erosion as a major limiting factor of the area. Soils were deep to very deep, gravelly clay loam to clay loam. Effective soil conservation measures are to be recommended as a pre-requisite to bring this type of land under regular cropping system. It can be used for regular cultivation of coconut, arecanut, pepper, and rubber with appropriate soil conservation measures.

Various water conservation measures like pits, trenches, levelling and shaping, check basins, bunds, terracing, stone-pitched contour walls, and gully-plugging can be undertaken in the area under class IIIe. Besides being used for cultivation, by providing the above treatments, the flood in the low lands like paddy field can be reduced and water availability during dry period can be increased to a great extent.

***Class IVe***

About 640 ha of land comes under this class. Soil erosion is the major problem of these areas. These soils occur in an area having 10-25 percent slope. They are deep to very deep. These soils must be protected with rubble-pitched contour bunds.

Water conservation measures like digging pits and trenches, construction of laterite bunds, levelling, shaping, terracing, and gully-plugging have to be adopted in these areas also. Deep-rooted biomass-recycling trees (subabool and glyrecidia) are suitable for the area. Fibrous-rooted trees like coconut and arecanut are not suitable except under homestead farming system. The area is occupied mainly by rubber plantations.

***Class VIe***

An area of 310 ha comes under this class. Since these soils occurred in area having > 33 percent slope, they need extra care. The depth of soil ranges from deep to very deep with gravely clay loam to gravelly clay texture. Normally, crops that require frequent inter-cultural operations are not recommended/ suitable for this area.

The area under this class is covered by forest. Trees like jackfruit, mango, and cashew having tap-root system, and are of the tall and hardy type could be grown in this area. Plant density is to be maximised using companion crops, so that a multi-tier cropping pattern may be developed, which will be similar to a forest ecosystem.

## 4. Socio-economic Conditions

The socio-economic condition of the watershed community is discussed in the following sections (Table 4.1).

### Human resources

The population of the watershed, which is spread out among eight wards of the two *panchayats* viz., Alagappa Nagar and Thrikkur, was found to be 14200. The population density of the watershed was 833 per sq. km, higher than that of the State of 819 per sq.km. The sex ratio of the region was 1026 females per 1000 males, which is lower than the State figures of 1058 females per 1000 males. The Scheduled Castes and the Scheduled Tribes in the watershed formed 1.41 percent and 0.25 percent of the total population respectively.

### Details of households

The total number of households in the watershed was 2905; 74 percent of the houses had tiles as roof and 20.8 percent had concrete roof. More than 50 percent of the Scheduled Castes and Scheduled Tribes lived in colonies viz., Bharatha and IHDP Colony, Athur in Thrikkur *panchayat*; another 37 percent lived outside the colonies. About 19 percent of the population in the watershed reported that they lack toilet facilities and 15 percent said they faced shortage of latrines.

### Energy

Nearly four-fifths of the houses had electricity connection: kerosene was used as fuel for lighting by the rest. For cooking, 85.6 percent of the population used firewood, 1.2 percent used biogas, 3.7 percent each used kerosene and LPG and 2 percent used smokeless *choolah*. The firewood for cooking was collected from the household premises (69.4 percent), and forest (2.3 percent), or was purchased (28.3 percent). About 25 households in the watershed owned biogas plant.

### Education

The percentage of literates in the watershed was found to be 90, among which 23.2 percent had Lower Primary level, 43 percent had Upper Primary level, or High School level education; 12. 4 percent had studied up to the higher secondary level; 6.2 percent had passed the Higher Secondary level, and 5.1 percent were graduates. About 8.3 percent of the population were technically qualified in various disciplines (Diploma and Degree holders in Engineering, Medicine, etc). There were three L.P Schools, two U.P Schools, and 10 *Anganwadis* in which the Government ran five *Anganwadis*. The reputed educational institution, Alagappa Nagar Polytechnic, is situated very near to the watershed.

### Employment

About 50 percent of the population in the watershed were engaged in jobs related to agriculture

**Table 4.1 Socio-economic data**

**1. Population (Percentage)**

| Male | Female | SC | ST | > 15 years | 15-40 years | 40-60 years | Above 60 years |
|---|---|---|---|---|---|---|---|
| 49.36 | 50.64 | 1.41 | 0.25 | 14.76 | 52.54 | 23.16 | 9.54 |

**2. Types of Houses**

***i) Roof***

| Grass/ leaves | Tiles | Concrete |
|---|---|---|
| 4.6 % | 74 % | 20.8 % |

***ii) Walls***

| Bricks & Clay | Bricks & Cement |
|---|---|
| 24.3 % | 75.1 % |

***iii) Flooring***

| Clay | Cement | Mosaic | Marble |
|---|---|---|---|
| 21.5 % | 69.8 % | 6.4 % | 1.7 % |

***iv) Area (Sq.ft)***

| >2000 | 200-500 | 500-1000 | 1000-1500 |
|---|---|---|---|
| 9.9 % | 30.2 % | 44.8 % | 15.1 % |

***v. Age of houses (Years)***

| 0-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-40 | 40-50 | Above 50 |
|---|---|---|---|---|---|---|---|---|
| 12.43 | 13.02 | 13.61 | 10.65 | 16.57 | 10.06 | 18.34 | 3.54 | 1.78 |

**3. Ownership of land holdings (Percentage)**

| Below 25 cents | 25-50 cents | 50-75 cents | 75-100 cents | 100-150 cents | 150-200 cents | 200-300 cents | Above 300 cents |
|---|---|---|---|---|---|---|---|
| 24.38 | 17.5 | 11.87 | 10.0 | 10.62 | 8.75 | 9.38 | 7.5 |

**4. Availability of water**

***(i) Drinking water***

| Pipe water | Own well | Public well | Tube well | Pond | Stream | Other (neighobouring well) |
|---|---|---|---|---|---|---|
| 2.9 % | 84.3 % | 6.4 % | 2.3 % | 0.6 % | 0.6 % | 2.9 % |

***(ii) Other purpose***

| Pipe water | Own well | Public well | Tube well | Pond | Stream | Other (neighobouring well) |
|---|---|---|---|---|---|---|
| 2.9 % | 83.7 % | 5.8 % | 2.3 % | 1.7 % | 0.6 % | 2.9 % |

***(iii) Scarcity of drinking water***

| Up to 3 months | Up to 6 months | More than 6 months Marble |
|---|---|---|
| 33.5 % | 8.1 % | 3.7 % |

**5. Annual income (Rs.)**

| > 5000 | 5000-10000 | 10000-20000 | 20000-30000 | 30000-50000 | 50000-75000 | > 75000 |
|---|---|---|---|---|---|---|
| 42.45 % | 15.09 % | 12.26 % | 7.55 % | 15.09 % | 4.72 % | 2.83 % |

**6. Fuel supplies for cooking (Percentage)**

| Firewood | Bio gas | Kerosene | LPG | Smokeless *choolah* |
|---|---|---|---|---|
| 85.6 | 1.2 | 3.7 | 3.7 | 2 |

**7. Availability of firewood (Percentage)**

| From premises | Forest | Market |
|---|---|---|
| 69.4 | 2.3 | 28.3 |

**8. Educational status (Percentage)**

| Illiterate | Literate | L.P | UP & High School | Pre degree | Higher secondary | Graduate | Professional |
|---|---|---|---|---|---|---|---|
| 90 | 10 | 23.2 | 43 | 12.4 | 6.2 | 5.1 | 8.3 |

**9. Employment (Percentage)**

| Labourers | Farmers | Staff employed | Government employee | Private employee | Unemployed |
|---|---|---|---|---|---|
| 36.15 | 24.9 | 9.4 | 7.1 | 4.1 | 8.7 |

**10. Educational Institutions**

| Balavady | LP School | UP School |
|---|---|---|
| 10 | 3 | 2 |

**11. Health care facilities**

| PHC sub-centre | Ayurvedic hospital |
|---|---|
| 4 | 1 |

**12. Industries**

| Tile factory | Rice mill | Oil mill | Ceramic company | Furniture industry |
|---|---|---|---|---|
| 5 | 10 | 4 | 3 | 2 |

**13. Other institutions**

| Post office | ICDP centre | Co-operative bank | Co-operative society | Rubber marketing society | Milk society | Library | Club |
|---|---|---|---|---|---|---|---|
| 2 | 1 | 1 | 1 | 2 | 1 | 6 | 6 |

**14. Agricultural machinery**

| Tractor | Power tiller | Reaper | Thresher |
|---|---|---|---|
| 7 | 2 | 1 | 1 |

**15. Water resources**

| Open well (public) | Tube well (public) | Tube well (private) | Ponds (public) | VCBs | Check dam |
|---|---|---|---|---|---|
| 22 | 10 | 44 | 10 | 15 | 1 |

and allied activities; under-employment problem was chronic. Agricultural labourers constituted 36.2 percent, farmers 24.9 percent, self-employed 9.4 percent, government employees 7.1 percent, and persons employed in private companies 4.1 percent. About 8.7 percent of the educated youth were registered in the various employment exchanges. The proportion of the unemployed comes close to the State average.

**Operational holdings**

As elsewhere in the State, operational holdings comprised tiny plots in the watershed also. Marginal holdings of one hectare or less constituted about 92.5 percent of the total holdings in the area. About 24.4 percent of the land holdings were of less than 25 cents; 17.5 percent were of 25 to 50 cents; 11.9 percent had areas between 50 and 75 cents; 10 percent came under the category of 75 to 100 cents; 10.6 percent were in the range of 100 and 150 cents; and 25.7 percent were above 150 cents. The major crops cultivated in this area are coconut, rubber, arecanut, pepper, betel vine, vegetables, banana, nutmeg, cashew, and tapioca.

**Animal husbandry**

The livestock population in the watershed was about 4005, out of which 59.5 percent were cattle, both local breed (59 percent) and hybrid (41 percent). Buffaloe and goat came to about 3 percent and 38 percent respectively.

The total poultry population in the watershed was about 16,500 including fowls and ducks. The ratio of fowls and ducks was found to be 196: 1. Both local and hybrid varieties of fowls were seen in the area.

**Healthcare facilities**

There were no major hospitals in the watershed. The only dependable health care centres situated in the study area were the four Primary Health Sub-centres, located in Muttithadi, Vellanikkode, Pookkode, and Pachalippuram. Besides these sub-centres, one Ayurveda hospital also functioned in the area, in Alengadu of Thrikkur *panchayat*.

**Industry**

Five tile factories, two wood industries, and three ceramic companies exist in the watershed. There were also 10 flourmills and 4 oil mills. Rolled gold works were common in the project area especially in Alagappa Nagar *panchayat*.

**Irrigation and soil and water conservation practices**

Irrigation facilities were available for only 35.4 percent of the landowners. The major irrigation methods adopted were furrow irrigation, irrigation through pipes, and drip irrigation. Though water sources were available for 35.4 percent of landowners, availability of irrigation water was restricted to 27.5 percent of the farmers. Water-logging was experienced by 14.4 percent of the population and about 40.4 percent practised drainage methods.

More than 72 percent of the households did not practise any soil and water conservation methods. Forty-seven percent of the population was not even aware of conservation practices. The conservation measures implemented in the project area were mulching, construction of check basins around trees, construction of earthen bunds, digging trenches, pits and contour furrows, and terracing. About 12.7 percent of the people in the watershed had attended various training classes in soil and water conservation.

**Mechanisation in rice cultivation**

The extent of adoption of improved farm implements/ machinery was very limited in rice cultivation in the watershed. The agricultural machinery, currently in use in the watershed included seven tractors, two power tillers, one rice harvesting machine (reaper), and one paddy thresher. In most of the paddy-fields ploughing, spraying, and irrigation were carried out with the help of machinery. Mould-board plough, disc-plough, cultivator, cage-wheel leveller, trailer, etc., were the tractor-mounded implements used in the paddy fields of the watershed.

The data obtained from the field study showed that severe water deficit was experienced in the watershed from December to May. Water storage may be minimised using the following strategies:

(i) Discourage fibrous-rooted crops like coconut in lands of Class III and above. Instead, deep-rooted plants may be encouraged for tapping soil moisture from deeper layers.
(ii) Put a stop to the burning of organic waste; mulching may be promoted for improving the water-holding capacity of the soil by reducing surface evaporation.
(iii) Develop multi-tier cropping pattern, except for paddy lands, for increasing organic recycling.

The relationship between rainfall and run-off (Fig.3.1) showed very small lag period of discharge. This lag period of discharge should be increased by a multidisciplinary approach of water management programmes such as the following:

(i) Development of a multi-tiered cropping pattern using companion crops for intercepting the high-intensity rainfall to increase the time of concentration and thereby increasing the lag period.
(ii) Promotion of organic recycling and soil aggregation for increasing the infiltration rate from ridge to valley.
(iii) Construction of pits, trenches, and bunds for reducing the surface flow and increasing the sub-surface flow.
(iv) Development and proper maintenance of ponds and vented cross bars (VCBs) for holding floodwater.

Thus, a combination of suitable mechanical and agronomic conservation practices is recommended for increasing the lag period of discharge and overcoming drought.

## 5. Resource Management

### Land-use planning

In selecting crop groups according to land suitability, it has to be recognised that some crops are widely adaptable while others are more specific in their requirements for satisfactory growth and yields.

The suggested land use plan for the watershed is given in Table 5.1 and its spatial distribution is shown in Map No.6. The Table shows that an area of 1010 ha (50.13 percent of the total area) is ideal for agro-horticultural crops, and homestead cultivation practices. Combination of crops should be on the principles of companion corps. Mixed cropping may be practised with deep-rooted trees and shallow-rooted shrubs which are light-demanding with shade-bearing. That is, coconut trees should not stand under shade and the required spacing is to be maintained.

The cropping technique should be in tune with the land capability considerations. For example, shallow-rooted coconut, arecanut, etc., should not be planted in hilltops and slopes where moisture stress is affected immediately after the cessation of rainfall. Coconut and other light-demanding crops should not be planted under-shade; shade should be removed if it affects such plants. Coconut should be planted at the required spacing and inter-cropping in such areas should be done without shade affecting such crops. In grown-up coconut gardens, inter-cropping may be promoted with tap-rooted and dwarf crops. Attention should be given to provide organic mulching to coconut trees with the biomass produced in each garden using green manure plants/trees and with products of mixed farming. Green manure plants shall be cultivated in paddy fields as third crop and in dry lands as inter-crop, without causing shade to light-demanding crops or without causing competition to main or inter-crops.

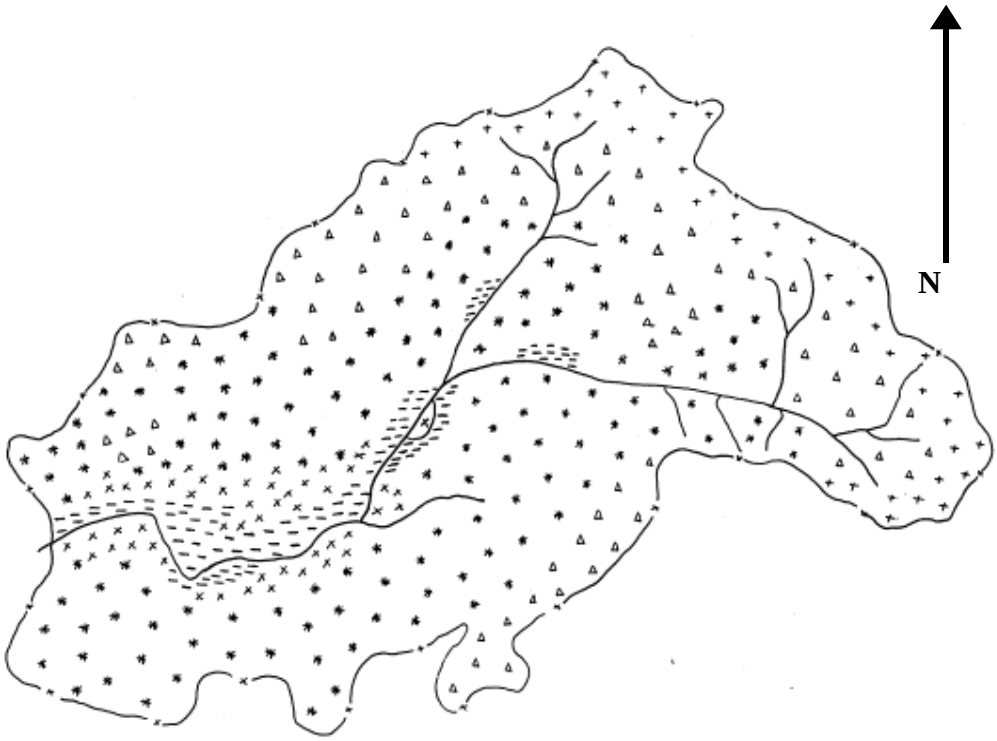
Burning of organic matter (leaf litter, house waste, and weeds) is to be discouraged; it may be used for mulching. Organic recycling is stressed to improve infiltration rate, water-holding capacity, aeration, tilth and micro, and secondary nutrient availability.

Considering the fact that agricultural production is the mainstay of the people of the area, emphasis should be laid on sustainable agricultural practices including cultivation of seasonal crops such as rice, pulses, vegetables, pineapple, and banana and of perennial crops such as arecanut, coconut, rubber, and mango.

From the watershed, about 195 ha covering the low land has been demarcated for rice cultivation. In this area, it is proposed to have double-crop rice followed by a third crop of pulses or vegetables depending on soil condition and water availability.

The first crop (*Virippu*) is to be cultivated during April-May to September-October and the second crop (*Mundakan*) during September-October to December-January. Selection of the third crop has to be decided from time to time and from field to field. The third crop may

**Map No. 6 Proposed land use pattern of Bharathamala- Vattakkottai.**




Legend

Double crop paddy followed by pulses, vegetables, and green manure crop.

Arecanut plantation with - multitier cropping system with coccoa,nutmeg, clove, banana,betelvine, pepper, tuber crops, and green manure crops.

Agro-horticulture including homestead cultivation with intercrops such as a mango, jack tree, cashew, tamarind, gooseberry, tuber crops, medicinal plants, banana, clove, betelvine, pepper, nutmeg, and green manure plants.

Rubber plantation with kalpagonium as cover crops.

Forest - gap filling by seeding fringe planting with hedge plants

Watershed boundary

Stream

**Table 5.1 Suggested land use plan for Bharathamala-Vattakkotta watershed**

| Sl. No | Suggested land use | Area (ha) | Slope (per cent) | Percentage to total area |
|---|---|---|---|---|
| 1a | Double crop rice followed by pulses, vegetables, green manure crops, etc. | 195 | 0-2 | 9.68 |
| 1b | Banana as pure crops in paddy fields | | | |
| 2 | Arecanut plantation with multi-tier cropping system with cocoa, nutmeg, clove, banana, betel vine, pepper, tuber crops, green manure crops etc., and contour cultivation. | 80 | 2-5 | 3.97 |
| 3 | Agro-horticulture including homestead cultivation with intercrops such as mango, jack tree, cashew, tamarind, goose berry, tapioca, yam, colocasia, medicinal plants, banana, clove, betel vine, pepper, nutmeg, and green manure plants; contour cultivation is recommended. | 1010 | 2-8 | 50.13 |
| 4 | Rubber plantation with kalpagonium as cover crop | 420 | 5-18 | 20.84 |
| 5 | Forest – gap-filling by seeding, fringe planting with hedge plants like Agava-Americana, fire belts, social fencing, etc. | 310 | >18 | 15.38 |

include pulses, and vegetables such as cowpea, bitter-gourd, snake-gourd, green chilly, amaranths, ladies finger, and ash gourd. The third crop is proposed to be raised on a joint basis wherever possible. In addition to the increase in the benefit-cost ratio of the farming operation, it enables the farmers to maintain a common cultural practice.

The area under rice cultivation is being reduced drastically due to the conversion of paddy fields to other crops, as rice cultivation is not profitable. This trend is dangerous because, this land (IIw) is susceptibile to water-logging and will affect adversely the newly planted garden crops. After a decade or so, these perennial crops will be heavily damaged due to root decay caused by water-logging. However, to have the maximum possible intensity of crops in this water-logged area, proper drainage systems are to be constructed to maintain the water level from falling. Excessive drainage would result in early draw-down of ground water thus creating a drought situation. Conversion of paddy lands will not only lead to flood during monsoons but draught in summer as well. This trend could be stopped by adopting suitable socio-economic interventions and raising rice annually in two crop seasons, by introducing selective farm mechanisation.

An area of 80 ha (3.97 percent) of the watershed demarcated for arecanut plantation is mainly on the stream bank levees and foothills adjacent to paddy fields. Arecanut plantations are recommended as part of the multi-tier cropping system with banana, betel vine, nutmeg,

clove, vegetables, ginger, yam, and colocasia as inter-crop. The selection of suitable inter-corps may be decided based on soil and site conditions, type and age of the main corps, and water availability, it may vary from field to field, and may be decided at the time of implementation.

More than 50 percent of the project area is found to be ideal for agro-horticulture with homestead cultivation practices. These areas lie on the side slopes, foot slopes, and upper and middle reaches of the watershed. In this system, both seasonal and perennial crops are recommended to be grown in combination. Selection of appropriate crop is very important in this area. The land capability classifications in these areas are IIe, IIIe, and IVe with slopes 0-2 percent, 2-10 percent, and 10-25 percent respectively. The area under IIe subclass (130 ha) is proposed to have multi-tier cropping system with coconut as the main crop and nutmeg, clove, cocoa, banana, betel vine, and pineapple as the inter-crops. Green manure crops such as glyricedia are suitable to be grown at the boundaries and side slopes.

The land shall be divided into blocks for conserving surface flow. The area under IIIe and IVe sub classes is proposed for cultivation of coconut as the main crop with inter-crops such as banana, pepper, nutmeg, and vegetables depending on the soil condition and availability of water. Horticultural tap-rooted perennial crops like jackfruit tree, tamarind, mango, and gooseberry are the best suited in these types of area.

In the watershed, about 420 ha are cultivated with rubber. This comes to about 20.84 percent of the total area of the watershed and spreads over the upper reach of the project area. Kalpagonium may be grown as a cover crop in the plantation at the early stages, and it is best suited for conserving moisture and soil. Pits, trenches, and gully-plugging are necessary in this area.

**Forest**

The establishment of a well-managed forest cover is the most effective soil and water conservation component. The forest found in the watershed has lost most of its productive capacity due to misuse causing severe erosion. The area has some potential for the establishment of a protective forest of trees and bushes with low canopy.

Forest covers an area of 310 ha (15.38 percent) of the watershed. Afforestation is recommended where the existing cover of the forestland needs to be increased by complementary planting. Gap-filling is necessary by seeding common forest species. In order to protect the forest from cattle, live hedge-planting with Agava Americana and other thorny plants in the boundary may be promoted.

Agri-silviculture practices with forage crops like napier, guinea, glyricedia, subabool, adathoda, and vasikka may be produced together with forest trees. However, permission should be given only for harvesting of forage crops; feeding should be done outside the area. The removal of litter for burning or composting must be prevented to increase the moisture-conserving capacity of the soil. Establishment of a fire belt around the forest boundary is essential. Awareness campaigns for the preservation of forest should be extended to the

neighbouring population also, in order to kindle an interest in them to protect the forest. This method of social fencing will help the preservation of the forestland.

**Soil and water conservation**

Small check dams of 100 cm in height, 110 cm in base width, and 45 cm in top width may be constructed by using dry rubbles, so that a large quantity of water could be retained in the stream itself. These are proposed to be constructed at 25 m interval in the upland region and 100m interval in the midland region. The sketch of gully plugging structure is shown in Appendix III.

It would be unwise to start soil and water conservation activities on the low lands without having them done on the high lands. The conservation practices should be started in the uplands of the watershed. Pits, trenches, contour bunding, and terracing are recommended in the upper and middle reaches of the project area. Pits are more suitable in places where mixed cropping system is followed, since they cause the minimum disturbance to existing crops. These are dug with overall dimensions of 1.00 x 1.00 x 0.70 m and the total volume of earthwork amounts to 300$m^3$ per hectare. Trenches with dimensions of 2 x 1 x 0.7 m are to be constructed along the contour line. The volume of earthwork recommended for trenches is 300$m^3$/ha, but may vary depending on the intensity of rainfall received in the watershed.

Earthen bunds are suitable for areas having slope up to 10 percent. They protect the land effectively from severe soil erosion during high rainfall. Bunds may be constructed across the slopes through areas having equal height.

Contour terracing is recommended in areas having a slope of more than 10 percent. An easy and economical procedure to develop contour terracing is Puertoriccan type terracing with vegetative barrier. In this method, land is ploughed along the contour and the soil is allowed to move downhill against a barrier of stiff-stemmed grasses until the slope has been reduced to a non-erosive gradient. The grass barrier is first planted along the contour at the recommended vertical intervals for various slopes. Then the land between grass barriers is used in the normal manner, but care is taken to plough towards the barrier line while ploughing the land each time.

The slope of the bench will change during each ploughing and after about seven or eight ploughing, a satisfactory bench will usually be formed. With this method, land would be in use at all times. The recommended vertical interval for the terracing is 1 m for 20-25 percent slope, 1.2 m for 30 percent slope, and 1.5 m for 30-33 percent slope; the slope of the ricer will be 1: 0.5 when grass is planted. For small slopes, a bund can be formed along the contour with grass cover on it so as to divert the run-off to drain through the land and hence prevent the flow of water through the grass, which otherwise causes the uprooting of grasses.

Various methods of soil and water conservation such as bench terrace, orchard terrace, basins for individual plants and natural terrace are shown in Appendix III (FAO, 1985).

**Land treatment (Mechanical measures)**

***Treatments for forestland***

Gully control structures
(i) Check dams
(ii) Water-harvesting structures

**Part I - On-farm treatments**

***(A) Treatments for upper lands (Class IV and IIIe)***

(i) Construction of earthen/stone-pitched contour bunds,
(ii) Puertoriccan type terracing,
(iii) Pits
(iv) Trenches

***(B) Treatments for dry low land (Class IIe)***

(i) Farm bunds/ collar bunds
(ii) Terracing
(iii) Pits
(iv) Trenches

**Part II - Drainage line treatments**

(i) Gully plugging
(ii) Renovation of public ponds and other water-harvesting structures
(iii) Maintenance of vented crossbars
(iv) Removal of drainage congestion caused by desilting and removing thick and thorny plants.
(v) Strengthening of bunds by planting *padanna*/ reeds/ cane, etc.
(vi) Construction of retaining walls.

**Animal husbandry**

Employment opportunities may be generated extensively by means of domestic cattle farming. Cattle farming is an important source of organic manure for the crops. Though the milk production in the area is not sufficient to meet the requirement, cattle-farming as a main or even a subsidiary occupation is not practised due mainly to non-availability of cattle feeds, fodder crops, etc. More emphasis should be given to produce fodder crops and cattle feeds so that they will be available to the farmers at affordable prices and at all times. Fodder crops, besides serving as a feeding material, act also as a good cover crop to prevent soil erosion.

Poultry farming may be encouraged to increase production of eggs at least to meet subsistence requirements. Programmes should be implemented for the production and distribution of

both hybrid and local breeds of poultry for increasing supply of meat as well as eggs. But the prime importance should be given to increase of the stock of local breeds.

**Industries**

Small-scale units are recommended in the following activities:

(i) Bee-keeping;
(ii) Vermi-composting;
(iii) Horticulture, particularly cultivation of orchids and other ornamental plants; and
(iv) Food-processing.

***Food-processing units***

Seasonal fruits and vegetables such as pappaya, mango, jackfruit, bitter gourd, tomato, tapioca, and sweet potato are available in plenty in the area; food-processing units may be installed incorporating in them suitable processing techniques. These units may be used also for preparation of masala powder, sweets, pappad, and chips during the off-season.

The following products may be prepared from local fruits, vegetables, cereals, and eggs and meat by using simple processing techniques:

| | **Materials** | | **Products** |
|---|---|---|---|
| (i) | Fruits | : | jam, jelly, candy, squash, sauce. |
| (ii) | Vegetables | : | pickles, chips, *pappad*, dry fruits |
| (iii) | Cereals & tuber crops | : | *rava*, chips, noodles, sweets, *pappad*, bakery products |
| (iv) | Oil seeds | : | sweets, nectar, candy, cream, tender coconut, coconut powder, vinegar |
| (v) | Mushroom | : | pickles, chips, *pappad* |
| (vi) | Dairy products | : | sweets, candy, ice cream, butter, ghee, *khoa*, and bakery items |
| (vii) | Fish/meet/egg | : | pickles, bakery products, dry products |
| (viii) | Spices | : | pickles, masala powder, confectionery |

## 6. Watershed Development Programme: A blueprint

The various improvement activities need to be co-ordinated between the local people and the government departments owing to the multi-disciplinary nature of watershed development projects. The success of such projects depends much on the degree of co-ordination and co-operation between local people and various administrative units concerned.

Since the watershed development programme in a region is dependent heavily on the co-operation and active involvement of the local people in that region, they should be thoroughly aware of the relevance and importance of each project included in the development plan. This may be achieved by organising training programmes, discussions, and seminars on the social, administrative, and technical aspects involved in the multi-disciplinary approach of watershed development programme. The implementation of the development plan may be co-ordinated by a 'watershed development committee' constituted for this purpose which should include the *panchayat* members of the concerned wards, representatives of local people, farmers, social and political organisations, experts from various departments such as Soil Conservation, Agriculture, Irrigation, and Animal Husbandry.

All the development projects may be implemented through the People's Planning Programme, which ensures the participation of the local people in that area. The District *Panchayat*, Block *Panchayat*, and *Grama Panchayat* should give the necessary financial support for implementing the projects. For this, the watershed development committee should prepare on a priority basis the individual projects required for the concerned *panchayats* and present them before the *Grama sabhas* of each ward included in the watershed. The necessary financial support for the implementing the projects may be availed of from the local bodies.

The detailed estimation for the development plan of Bharathamala-Vattakkottai watershed is given in Appendix IV.

An outline of a tentative watershed development programme with project costs, sources of finance, and organisational structure is given.

(i) Gap-filling by tree-planting and agrostology

| | | | |
|---|---|---|---|
| a. | Project cost | : | Rs 24,80,000 |
| b. | Financing | : | *Grama panchayat* on subsidy base |
| c. | Organisational structure | : | Through watershed development committee/ beneficiaries committee |

(ii) Pits and trenches

| | | | |
|---|---|---|---|
| a. | Project cost | : | Rs 1,48,80,000 |
| b. | Financing | : | *Grama Panchayat* on subsidy base |
| c. | Organisational structure | : | Through watershed development committee/ beneficiaries committee |

(iii) Terracing

| | | | |
|---|---|---|---|
| a. | Project cost | : | Rs 28,80000 |
| b. | Financing | : | Block *Panchayat* on subsidy base |

c. Organisational structure : Through watershed development committee/ beneficiaries committee

(iv) Desilting of stream

a. Project cost : Rs 1,50,000.00
b. Financing : Block *Panchayat*
c. Organisational structure : Through watershed development committee/ beneficiaries committee

(v) Forest management

a. Project cost : Rs 2,00,000
b. Financing : Block *Panchayat*
c. Organisational structure : Through watershed development committee/ beneficiaries committee

(vi) Promotion of animal husbandry

a. Project cost : Rs 5,00,000
b. Financing : Block *Panchayat* on subsidy base
c. Organisational structure : Through watershed development committee/ beneficiaries committee

(vii) Training programme

a. Project cost : Rs 1,50,000
b. Financing : Block *Panchayat*
c. Organisational structure : Through watershed development committee/ beneficiaries committee

(viii) Repair and maintenance of Vibes/ cheeps

a. Project cost : Rs 5,62,500
b. Financing : District *Panchayat*
c. Organisational structure : Through watershed development committee/ beneficiaries committee

(ix) Gully plugging

a. Project cost : Rs 2,76,000
b. Financing : District *Panchayat*
c. Organisational structure : Through watershed development committee/ beneficiaries committee

(x) Renovation of public ponds

a. Project cost : Rs 20,00,000
b. Financing : District *Panchayat*
c. Organistional structure : Through watershed development committee/ beneficiaries committee

(xi) Small-scale industrial units

a. Project cost : Rs 10,00,000
b. Financing : District *Panchayat* on subsidy base
c. Organisational structure : Through watershed development committee/ beneficiaries committee

## Appendix- I Climatological data, 1983-1996

**Table 1.1 Monthly rainfall data (mm) for the past 14 years**

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983 | 0.0 | 0.0 | 0.0 | 0.0 | 37.4 | 387.2 | 580.6 | 754.7 | 494.6 | 149.8 | 60.2 | 24.4 | 2488.9 |
| 1984 | 0.0 | 27.0 | 18.9 | 109.3 | 39.4 | 853.1 | 730.4 | 260.2 | 158.6 | 323.7 | 7.8 | 16.4 | 2544.8 |
| 1985 | 14.7 | 0.0 | 2.0 | 20.3 | 216.4 | 947.1 | 532.3 | 374.6 | 59.3 | 377.1 | 14.4 | 58.8 | 2617.0 |
| 1986 | 1.2 | 1.9 | 8.4 | 23.2 | 118.6 | 669.9 | 381.4 | 358.7 | 296.3 | 421.3 | 176.2 | 10.8 | 2467.9 |
| 1987 | 0.0 | 0.0 | 0.0 | 13.3 | 95.0 | 837.7 | 336.5 | 388.4 | 174.0 | 280.4 | 224.4 | 64.6 | 2414.3 |
| 1988 | 0.0 | 7.8 | 37.9 | 145.4 | 242.6 | 632.1 | 545.0 | 507.8 | 700.0 | 116.6 | 11.0 | 14.9 | 2961.1 |
| 1989 | 0.0 | 0.0 | 31.3 | 52.6 | 115.8 | 784.6 | 562.0 | 319.9 | 180.1 | 551.3 | 8.1 | 0.0 | 2605.7 |
| 1990 | 3.5 | 0.0 | 4.4 | 38.8 | 583.9 | 477.3 | 759.3 | 356.4 | 87.5 | 313.3 | 69.8 | 1.8 | 2696.0 |
| 1991 | 3.9 | 0.0 | 1.8 | 83.8 | 56.1 | 993.1 | 975.6 | 533.3 | 61.5 | 281.7 | 191.2 | 0.2 | 3182.2 |
| 1992 | 0.0 | 0.0 | 0.0 | 48.6 | 90.6 | 979.8 | 874.5 | 562.9 | 302.1 | 386.7 | 376.7 | 2.0 | 3623.9 |
| 1993 | 0.0 | 6.6 | 0.0 | 32.1 | 131.1 | 700.3 | 651.6 | 286.7 | 85.3 | 519.0 | 74.6 | 18.0 | 2505.3 |
| 1994 | 19.4 | 1.7 | 21.0 | 155.2 | 124.2 | 955.1 | 1002. | 1509.2 | 240.5 | 358.2 | 125.3 | 0.0 | 3511.9 |
| 1995 | 0.0 | 0.5 | 2.8 | 118.7 | 370.5 | 500.4 | 884.7 | 448.7 | 282.5 | 110.4 | 88.4 | 0.0 | 2807.6 |
| 1996 | 0.0 | 0.0 | 0.0 | 152.6 | 95.4 | 400.3 | 588.7 | 310.0 | 391.6 | 219.3 | 22.1 | 60.4 | 2240.4 |

Source: Meteorological Station, Kerala Agricultural University, Vellanikkara, Thrissur.

**Table I.2 Monthly Maximum Temperature (°C)**

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983 | 33.3 | 34.5 | 36.2 | 36.2 | 35.1 | 31.9 | 29.7 | 29.1 | 29.5 | 31.2 | 31.8 | 31.2 |
| 1984 | 32.4 | 34.3 | 35.2 | 34.5 | 34.5 | 29.0 | 28.6 | 29.3 | 30.4 | 29.9 | 32.6 | 31.9 |
| 1985 | 32.6 | 34.7 | 36.1 | 35.5 | 34.1 | 28.3 | 28.5 | 28.8 | 30.5 | 31.1 | 31.8 | 32.2 |
| 1986 | 32.5 | 34.2 | 36.2 | 36.0 | 34.2 | 30.0 | 29.5 | 29.4 | 30.5 | 31.8 | 31.2 | 32.5 |
| 1987 | 33.2 | 35.0 | 36.4 | 36.2 | 36.1 | 30.7 | 30.3 | 29.6 | 31.5 | 31.9 | 31.6 | 31.6 |
| 1988 | 32.4 | 35.8 | 35.7 | 35.1 | 33.7 | 30.0 | 29.0 | 29.2 | 29.9 | 31.7 | 32.6 | 32.6 |
| 1989 | 33.4 | 36.3 | 36.5 | 35.3 | 33.7 | 29.4 | 29.1 | 29.5 | 29.9 | 31.0 | 32.5 | 32.7 |
| 1990 | 33.5 | 34.9 | 36.0 | 35.8 | 31.5 | 29.7 | 28.4 | 29.0 | 30.7 | 31.9 | 31.2 | 32.3 |
| 1991 | 33.6 | 35.9 | 36.4 | 35.6 | 35.1 | 29.7 | 29.1 | 29.0 | 31.5 | 30.9 | 31.5 | 31.9 |
| 1992 | 32.6 | 34.5 | 36.9 | 36.3 | 33.8 | 30.1 | 28.8 | 28.9 | 30.1 | 30.7 | 31.0 | 31.1 |
| 1993 | 32.6 | 34.1 | 35.4 | 34.5 | 34.4 | 30.1 | 28.5 | 29.6 | 30.6 | 30.7 | 31.5 | 31.6 |
| 1994 | 32.9 | 34.8 | 36.2 | 34.9 | 33.6 | 28.9 | 28.6 | 30.0 | 31.8 | 32.3 | 31.8 | 32.2 |
| 1995 | 32.9 | 35.4 | 37.6 | 36.6 | 33.5 | 31.6 | 29.9 | 30.6 | 30.1 | 33.2 | 31.3 | 32.5 |
| 1996 | 33.1 | 34.7 | 36.4 | 34.6 | 32.8 | 30.5 | 28.8 | 29.1 | 29.2 | 30.1 | 31.5 | 30.5 |

Source: Meteorological Station, Kerala Agricultural University, Vellanikkara, Thrissur

**Table I. 3 Monthly Minimum Temperature (°C)**

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983 | 21.6 | 22.7 | 23.8 | 25.8 | 25.5 | 24.5 | 23.7 | 23.8 | 23.4 | 23.1 | 22.3 | 23.9 |
| 1984 | 23.3 | 24.2 | 24.3 | 24.9 | 25.8 | 22.7 | 22.9 | 22.2 | 23.2 | 22.1 | 23.1 | 20.8 |
| 1985 | 22.6 | 22.8 | 24.6 | 25.1 | 25.3 | 22.8 | 22.7 | 22.7 | 23.0 | 22.5 | 22.3 | 22.9 |
| 1986 | 22.4 | 22.1 | 24.3 | 25.2 | 24.7 | 23.1 | 23.2 | 22.7 | 22.7 | 22.9 | 22.0 | 23.5 |
| 1987 | 22.7 | 22.4 | 22.2 | 25.3 | 24.3 | 23.7 | 23.5 | 23.5 | 23.9 | 23.9 | 22.8 | 23.3 |
| 1988 | 22.0 | 23.1 | 24.4 | 24.3 | 25.4 | 23.7 | 23.2 | 24.3 | 23.2 | 23.3 | 22.9 | 22.3 |
| 1989 | 22.2 | 21.2 | 23.3 | 25.1 | 24.5 | 22.7 | 23.3 | 23.1 | 23.1 | 23.0 | 22.7 | 23.2 |
| 1990 | 20.6 | 21.9 | 23.8 | 25.4 | 24.1 | 23.3 | 22.5 | 23.0 | 23.4 | 23.2 | 22.6 | 23.1 |
| 1991 | 22.2 | 21.7 | 24.9 | 24.5 | 25.5 | 23.8 | 22.6 | 22.7 | 23.6 | 23.2 | 23.0 | 21.7 |
| 1992 | 20.9 | 21.6 | 22.8 | 24.4 | 24.8 | 23.7 | 22.7 | 23.3 | 23.1 | 22.9 | 23.1 | 22.3 |
| 1993 | 20.7 | 22.0 | 23.7 | 25.0 | 24.8 | 23.9 | 22.9 | 23.4 | 23.1 | 23.4 | 23.6 | 23.1 |
| 1994 | 22.6 | 23.1 | 23.7 | 24.4 | 24.7 | 22.9 | 22.4 | 22.6 | 23.2 | 22.7 | 23.3 | 22.2 |
| 1995 | 22.4 | 23.4 | 23.8 | 24.9 | 23.9 | 23.1 | 23.2 | 23.7 | 23.5 | 23.2 | 22.5 | 21.3 |
| 1996 | 22.4 | 23.4 | 24.3 | 25.0 | 25.2 | 23.8 | 23.1 | 23.6 | 23.7 | 22.9 | 23.6 | 21.8 |

Source: Meteorological Station, Kerala Agricultural University, Vellanikkara, Thrissur

**Table I.4 Monthly average relative humidity (mm)**

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983 | 51.1 | 64.0 | 65.0 | 66.0 | 69.0 | 79.0 | 87.0 | 87.0 | 84.0 | 77.0 | 71.0 | 63.0 |
| 1984 | 56.0 | 56.0 | 67.0 | 73.0 | 71.0 | 87.1 | 87.0 | 86.0 | 80.0 | 79.0 | 67.0 | 58.0 |
| 1985 | 67.0 | 58.1 | 63.3 | 67.0 | 73.0 | 89.0 | 86.0 | 86.0 | 80.0 | 77.0 | 70.0 | 62.0 |
| 1986 | 58.0 | 58.0 | 60.0 | 67.0 | 72.0 | 84.0 | 84.0 | 83.0 | 81.0 | 80.0 | 71.0 | 60.0 |
| 1987 | 57.0 | 52.0 | 55.0 | 64.0 | 66.0 | 83.0 | 84.0 | 87.0 | 79.0 | 79.0 | 77.0 | 70.0 |
| 1988 | 56.0 | 56.0 | 67.2 | 70.0 | 76.0 | 86.0 | 88.0 | 86.0 | 85.0 | 78.0 | 68.0 | 57.0 |
| 1989 | 54.0 | 45.0 | 58.0 | 69.0 | 74.0 | 86.0 | 86.0 | 83.0 | 82.0 | 80.0 | 63.0 | 60.0 |
| 1990 | 50.0 | 58.0 | 64.0 | 68.0 | 82.0 | 85.0 | 88.0 | 85.0 | 79.0 | 80.0 | 74.0 | 59.0 |
| 1991 | 57.0 | 51.0 | 66.0 | 68.0 | 70.0 | 88.0 | 86.0 | 87.0 | 78.0 | 82.0 | 75.0 | 64.0 |
| 1992 | 53.0 | 65.0 | 61.0 | 65.0 | 73.0 | 84.0 | 87.0 | 88.0 | 82.0 | 82.0 | 77.0 | 61.0 |
| 1993 | 53.0 | 62.0 | 63.0 | 69.0 | 74.0 | 86.0 | 87.0 | 87.0 | 81.0 | 83.0 | 63.0 | 66.0 |
| 1994 | 56.0 | 59.0 | 59.0 | 74.0 | 75.0 | 90.0 | 91.0 | 85.0 | 78.0 | 80.0 | 78.0 | 58.0 |
| 1995 | 59.0 | 60.0 | 60.0 | 71.0 | 78.0 | 86.0 | 89.0 | 86.0 | 82.0 | 78.0 | 80.0 | 57.0 |
| 1996 | 53.0 | 53.0 | 60.0 | 73.0 | 77.0 | 85.0 | 90.0 | 87.0 | 84.0 | 82.0 | 72.0 | 68.0 |

Source: Meteorological Station, Kerala Agricultural Station, Vellanikkara, Thrissur

**Table I.5 Monthly mean bright sunshine hours (Hours)**

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983 | 9.2 | 9.5 | 9.8 | 7.8 | 9.0 | 3.8 | 2.9 | 2.0 | 3.6 | 7.0 | 8.2 | 6.9 |
| 1984 | 8.2 | 8.2 | 7.7 | 8.0 | 7.3 | 1.4 | 2.5 | 5.0 | 6.5 | 6.0 | 7.3 | 9.0 |
| 1985 | 9.0 | 8.9 | 7.0 | 6.8 | 8.2 | 2.2 | 2.7 | 2.9 | 5.7 | 6.5 | 7.1 | 9.0 |
| 1986 | 7.7 | 8.9 | 8.5 | 6.7 | 8.4 | 3.7 | 4.8 | 5.5 | 5.7 | 6.4 | 7.4 | 9.3 |
| 1987 | 9.6 | 10.1 | 10.2 | 9.0 | 7.8 | 4.2 | 5.7 | 3.7 | 7.4 | 6.2 | 6.7 | 2.1 |
| 1988 | 10.4 | 10.0 | 9.1 | 6.2 | 8.8 | 4.2 | 3.0 | 3.7 | 5.1 | 7.1 | 7.9 | 9.0 |
| 1989 | 8.1 | 9.8 | 9.5 | 7.0 | 8.3 | 2.2 | 4.2 | 5.4 | 5.5 | 6.2 | 8.5 | 9.5 |
| 1990 | 9.0 | 10.0 | 9.7 | 4.5 | 8.3 | 2.4 | 2.5 | 3.5 | 6.2 | 6.5 | 6.0 | 10.2 |
| 1991 | 8.9 | 10.1 | 8.7 | 7.5 | 8.9 | 4.8 | 2.5 | 2.8 | 7.3 | 4.3 | 7.1 | 8.6 |
| 1992 | 9.0 | 9.2 | 9.2 | 7.5 | 8.8 | 3.3 | 2.1 | 2.7 | 4.1 | 4.6 | 5.5 | 8.9 |
| 1993 | 8.1 | 9.4 | 9.0 | 6.5 | 9.1 | 3.3 | 2.4 | 4.8 | 6.4 | 4.8 | 5.8 | 7.5 |
| 1994 | 9.1 | 8.7 | 9.3 | 8.0 | 8.0 | 2.1 | 1.4 | 3.0 | 7.3 | 6.7 | 8.1 | 10.6 |
| 1995 | 9.6 | 10.0 | 9.3 | 6.5 | 9.1 | 3.7 | 2.1 | 3.7 | 6.1 | 8.3 | 6.5 | 10.3 |
| 1996 | 9.4 | 9.9 | 9.3 | 7.7 | 8.3 | 4.7 | 2.7 | 3.7 | 4.3 | 6.0 | 7.1 | 6.8 |

Source: Meteorological Station, Kerala Agricultural Station, Vellanikkara, Thrissur

**Table I.6 Monthly mean wind speed (km/h)**

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1983 | 10.1 | 4.4 | 4.5 | 1.4 | 4.6 | 4.5 | 1.9 | 2.3 | 2.3 | 5.4 | 5.4 | 3.1 |
| 1984 | 11.7 | 11.2 | 7.3 | 1.7 | 6.0 | 5.0 | 5.3 | 5.5 | 4.7 | 4.7 | 6.7 | 8.4 |
| 1985 | 12.3 | 6.8 | 6.4 | 1.7 | 5.5 | 4.6 | 4.4 | 4.5 | 4.0 | 3.8 | 6.2 | 9.2 |
| 1986 | 12.0 | 8.3 | 7.6 | 1.7 | 5.8 | 5.6 | 5.3 | 3.7 | 4.8 | 3.8 | 6.8 | 13.6 |
| 1987 | 13.6 | 9.3 | 6.8 | 1.3 | 5.4 | 4.8 | 4.1 | 3.7 | 3.9 | 4.1 | 4.1 | 8.6 |
| 1988 | 11.3 | 6.5 | 4.9 | 1.0 | 4.6 | 5.0 | 3.9 | 3.9 | 4.0 | 3.3 | 5.7 | 9.6 |
| 1989 | 10.5 | 6.8 | 5.6 | 1.3 | 5.0 | 4.4 | 5.2 | 4.6 | 3.9 | 3.6 | 7.4 | 11.2 |
| 1990 | 9.8 | 8.2 | 5.2 | 1.2 | 4.4 | 4.2 | 3.7 | 3.7 | 2.8 | 2.3 | 4.0 | 9.4 |
| 1991 | 4.2 | 4.1 | 4.7 | 1.6 | 4.4 | 4.6 | 4.4 | 3.4 | 4.0 | 3.6 | 5.9 | 9.7 |
| 1992 | 11.6 | 4.8 | 5.0 | 1.8 | 4.4 | 5.3 | 4.3 | 4.3 | 3.6 | 3.1 | 5.8 | 13.7 |
| 1993 | 10.7 | 3.3 | 5.3 | 1.6 | 4.7 | 3.8 | 6.9 | 5.4 | 3.4 | 6.9 | 13.0 | 13.0 |
| 1994 | 3.8 | 7.1 | 3.3 | 1.7 | 6.2 | 3.8 | 4.4 | 2.9 | 2.9 | 2.9 | 2.5 | 6.2 |
| 1995 | 10.4 | 12.7 | 2.9 | 1.7 | 3.5 | 3.7 | 2.1 | 2.6 | 4.2 | 1.3 | 0.6 | 3.9 |
| 1996 | 3.3 | 6.1 | 5.5 | 1.8 | 2.3 | 2.0 | 2.3 | 4.7 | 3.7 | 3.3 | 1.6 | 4.0 |

Source: Meteorological Station, Kerala Agricultural University, Vellanikkara, Thrissur

**Table I.7 Monthly Evaporation data (mm)**

| Year | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 219.3 | 210.6 | 199.1 | 159.5 | 214.9 | 85.0 | 90.3 | 125.2 | 137.7 | 118.9 | 160.2 | 201.7 |
| 1985 | 241.8 | 178.9 | 224.3 | 196.2 | 177.3 | 83.1 | 95.2 | 91.8 | 114.3 | 103.9 | 125.0 | 216.9 |
| 1986 | 230.8 | 191.5 | 226.0 | 211.0 | 167.0 | 101.6 | 104.8 | 128.5 | 118.2 | 120.6 | 141.8 | 223.4 |
| 1987 | 266.8 | 230.0 | 257.6 | 214.9 | 218.6 | 106.5 | 117.4 | 100.0 | 120.0 | 118.2 | 103.8 | 143.3 |
| 1988 | 217.4 | 191.2 | 202.5 | 172.9 | 144.9 | 86.3 | 78.7 | 97.6 | 87.5 | 113.7 | 116.7 | 206.3 |
| 1989 | 253.8 | 227.7 | 218.6 | 179.2 | 152.0 | 83.0 | 98.1 | 110.2 | 97.8 | 112.4 | 114.3 | 204.7 |
| 1990 | 222.0 | 210.6 | 213.7 | 189.8 | 109.5 | 84.3 | 79.1 | 90.4 | 101.0 | 109.9 | 101.7 | 184.5 |
| 1991 | 198.6 | 211.7 | 195.6 | 170.6 | 149.3 | 66.8 | 74.9 | 78.2 | 110.2 | 78.7 | 120.7 | 190.1 |
| 1992 | 229.6 | 150.4 | 206.7 | 174.1 | 160.1 | 88.6 | 68.7 | 83.4 | 93.8 | 80.6 | 98.9 | 206.3 |
| 1993 | 216.0 | 197.5 | 213.3 | 180.3 | 158.1 | 104.5 | 90.5 | 117.9 | 110.1 | 89.6 | 122.0 | 164.0 |
| 1994 | 222.2 | 169.2 | 209.2 | 144.7 | 137.0 | 84.2 | 66.1 | 91.4 | 113.9 | 97.1 | 137.9 | 169.6 |
| 1995 | 178.5 | 172.2 | 190.2 | 164.3 | 129.3 | 103.7 | 88.5 | 96.4 | 97.7 | 113.8 | 89.1 | 195.9 |
| 1996 | 208.6 | 206.9 | 219.2 | 157.1 | 135.0 | 103.4 | 88.9 | 100.9 | 94.9 | 92.8 | 119.0 | 134.4 |

Source: Meteorological Station, Kerala Agricultural University, Vellanikkara, Thrissur

## Appendix-II Typical profile and major constituents of soil type of the watershed

**Table II. 1 Typical profile of Koottala soil series**

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-18(18) | Very dark grayish - brown (10YR 3/2) clay loam moderate medium, sub-angular blocky and slightly plastic, medium abundant roots, moderate permeability, clear smooth boundary (pH 6.6). |
| B2 | 18-40 (22) | Reddish brown (5YR 4/4) moist, clay, moderate medium sub-angular blocky structure, moist friable sticky and plastic, medium common roots, moderately slow permeability, clear wavy boundary (pH 6.2). |
| Bc | 40-92 (52) | Yellowish red (5YR 4/6) silty loam, weak fine sub-angular blocky structure, moist friable non-sticky and non-plastic, many fine roots, moderately rapid permeability (pH 5.9). |

**Table II. 2 Major constituents of Koottala soil series**

| Horizon | Depth (cm) | Gravel % | Course sand % | Fine sand % | Silt % | Clay % | Organic carbon % | pH |
|---|---|---|---|---|---|---|---|---|
| Ap | 0-18 | 15 | 40.75 | 10-15 | 16.25 | 30.00 | 1.57 | 6.6 |
| $B_2$ | 18-40 | Nil | 24.40 | 11-10 | 1.25 | 51.25 | 1.27 | 6.2 |
| Bc | 40-92 | Nil | 24.20 | 20-85 | 8.00 | 45.00 | 0.80 | 5.9 |

**Table. II.3 Typical profile of Kozhukkully soil series**

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-20 | Dark brown (7.5 YR 3/2) moist, gravelly clay loam, moderate medium sub-angular blocky structure, moist-friable, sticky and slightly plastic, many fine pores, few gravels and stones, abundant medium coarse roots, clear smooth boundary. |
| $B_1$ | 20-25 | Dark reddish brown ( 5YR 3/4) moist clay loam, moderate medium sub-angular blocky structure, moist firm sticky and slightly plastic, many fine pores and stones, few gravels and clear wavy boundary. |
| $B_2$ | 55-110 | Yellowish red (5YR 5/6) moist clay, moderate medium sub-angular blocky structure, moist firm, sticky and plastic quartz, gravels and stones, micaflakes and weathered rock. |

**Table II. 4 Major constituents of Kozhukkully soil series**

| Horizon | Depth (cm) | Gravel % | Course sand % | Fine sand % | Silt % | Clay % | Organic carbon % | pH |
|---|---|---|---|---|---|---|---|---|
| Ap | 0 –20 | 28.09 | 36.22 | 29.31 | 8.42 | 24.19 | 0.42 | 6.0 |
| $B_1$ | 20-55 | 11.9 | 32.84 | 27.61 | 8.15 | 28.47 | 0.20 | 6.8 |
| $B_2$ | 55-110 | 11.9 | 19.87 | 18.87 | 17.95 | 40.52 | 0.17 | 6.3 |

**Table II.5 Typical profile of Painkulam soil series**

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-37 | Dark brown (7.5 YR 3/2) sandy clay, moderate medium sub-angular blocky structure, moist friable, slightly sticky and slightly plastic, few quartz granules, abundant, fine roots, clear smooth boundary (thickness 37 cm). |
| $B_1$ | 37-74 | Reddish brown (5 YR 4/4) moist gravelly clay, sticky and plastic, moist firm, moderate medium sub-angular blocky, many fine pores, few fine medium roots, moderately slow permeability, clear wavy boundary. |
| $B_{21}$ | 74-106 | Reddish brown (5YR 4/4) moist gravelly clay loam, sticky and slightly plastic, moist friable, weak fine sub-angular blocky, many fine pores, very fine few quartz particles, moderately slow permeability. |

**Table II.6 Major constituents of Painkulam soil series**

| Horizon | Depth (cm) | Gravel % | Course sand % | Fine sand % | Silt % | Clay % | Organic carbon % | pH |
|---|---|---|---|---|---|---|---|---|
| Ap | 0-37 | 13.21 | 32.90 | 31.30 | 12.00 | 20.00 | 0.51 | 6.2 |
| $B_1$ | 37-74 | 25.00 | 20.00 | 23.20 | 20.25 | 33.50 | 0.25 | 6.0 |
| $B_{21}$ | 74-106 | 20.56 | 17.00 | 19.40 | 19.25 | 41.25 | 0.37 | 6.0 |

**Table II.7 Typical profile of Mariakkal soil series**

| Horizon | Depth(cm) | Description |
|---|---|---|
| Ap | 0-27 | Very dark grayish brown (10 YR 3/2) loam, moderate medium sub-angular blocky structure, moist firm, sticky and plastic, abundant fine roots, few gravels, moderately slow permeability, clear wavy boundary, pH 6.2. |
| $B_1$ | 27-94 | Reddish brown ( 5YR 4/3) gravelly clay loam, moderate medium sub-angular blocky structure, moist firm sticky and plastic, few stones, moderately slow permeability, gradual irregular boundary, pH 6.0. |
| $B_2$ | 94-146 | Dark reddish brown (2.5 YR 3/4) gravelly clay, strong, medium sub-angular blocky, moist firm, very sticky and plastic, slow permeability, pH 6.0. |

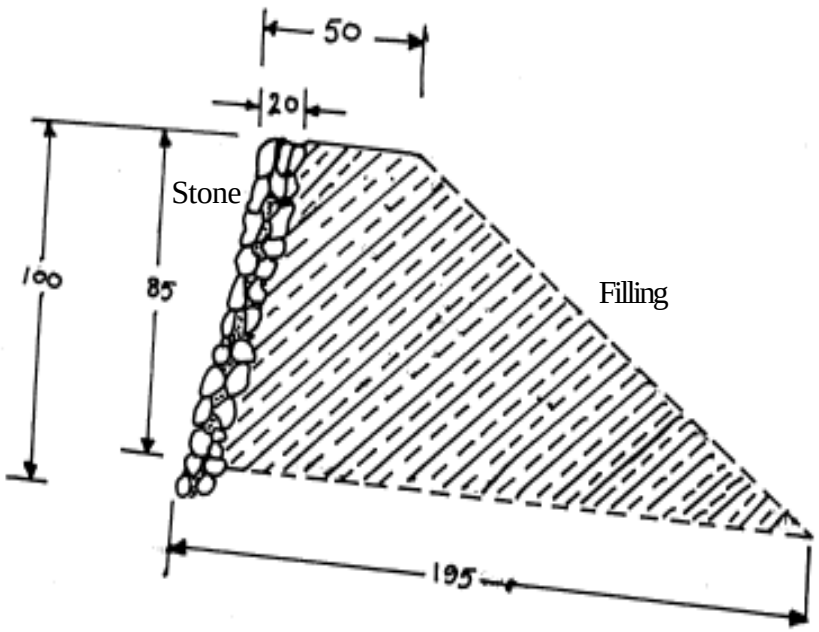
**Table II. 8 Major constituents of Mariakkal soil series**.

| Horizon | Depth (cm) | Gravel % | Course sand % | Fine sand % | Silt % | Clay % | Organic carbon % | pH |
|---|---|---|---|---|---|---|---|---|
| Ap | 0 - 27 | 11.00 | 34.35 | 29.90 | 4.50 | 31.10 | 1.103 | 5.4 |
| $B_1$ | 27-94 | 29.70 | 33.80 | 12.87 | 10.80 | 38.40 | 0.700 | 5.7 |
| $B_2$ | 94-146 | 44.17 | 43.42 | 6.95 | 20.00 | 30.00 | 0.615 | 5.0 |

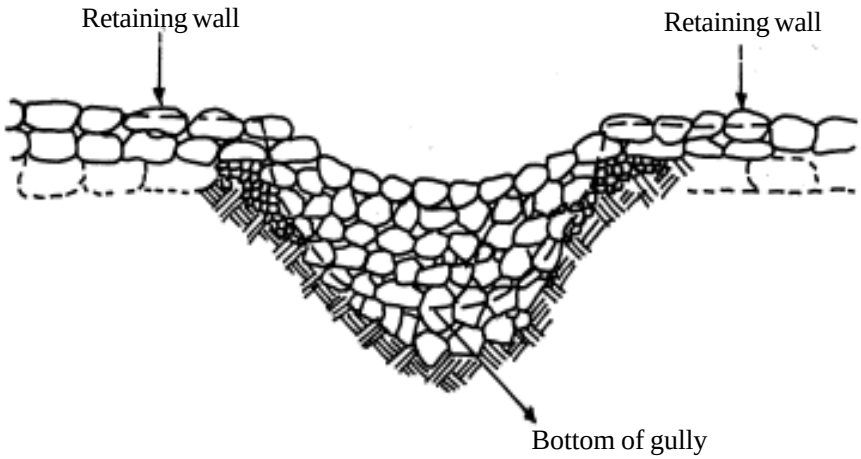
## Appendix -III Soil and Water Conservation Measures

**Sketch of Earthern Bund**

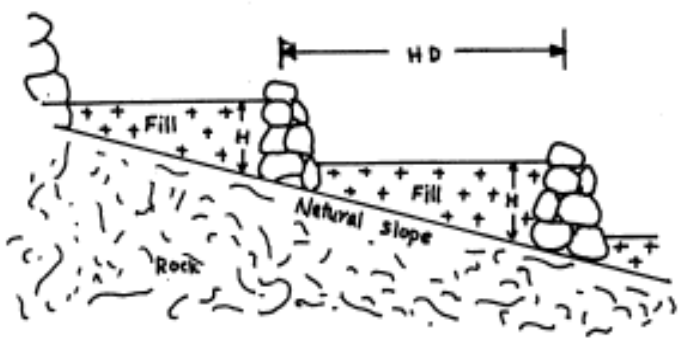
**Cross-section of Stone-pitched Bund**



**Sketch of Gully Plugging Structure**



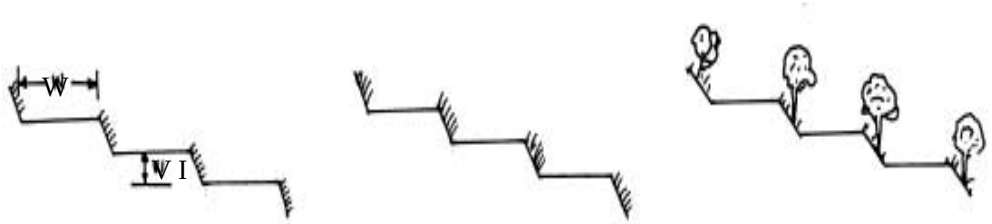

**Sketch of Bench Terracing Constructed by Filling**



**Sketch of Pueritoriccan Type Terracing**

At the time of Planning

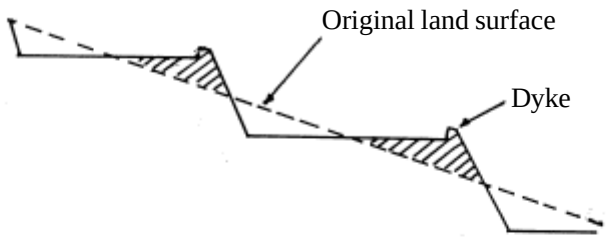

As Fully developed



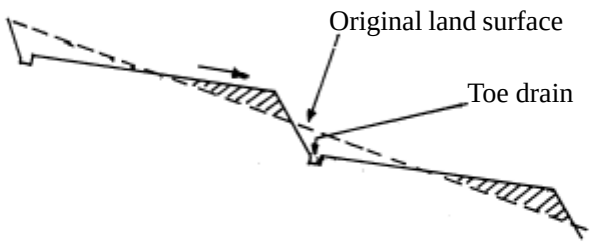

H I- Horizontal Interval
V I- Vertical Interval
W - Width of terrace

## Type of Bench Terraces

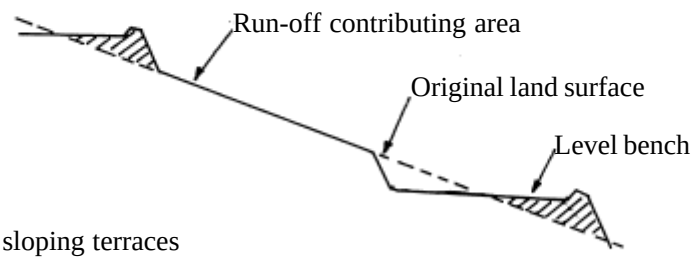
1. Level bench terraces



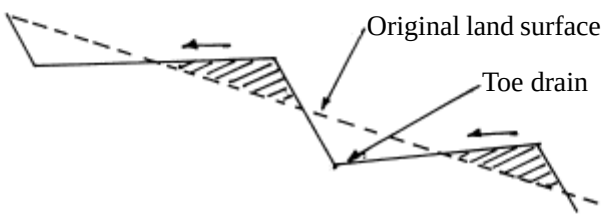

2. Outward sloping terraces



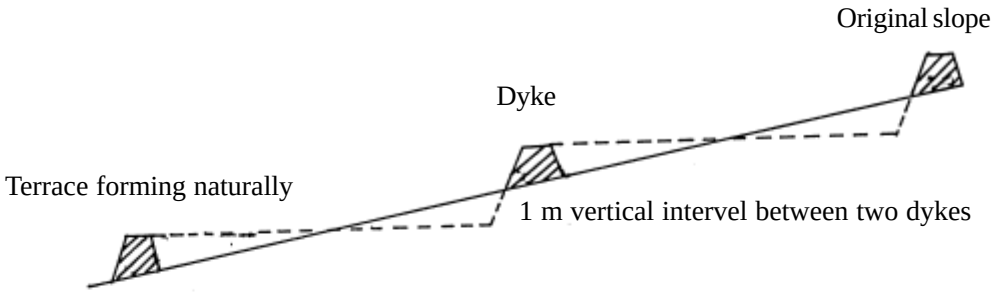

3. Conservation bench terraces



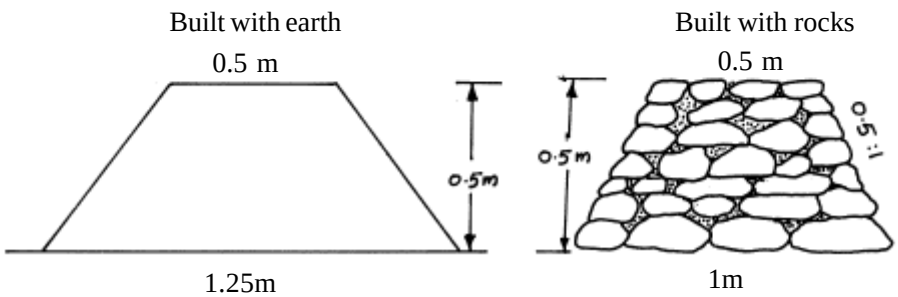

4. Reverse sloping terraces



## Field Arrangement




## Natural Terrace Design and Cross-section




( On light soil, the size slope is 1:1)

**Cross-sectional View of Orchard Terracing**

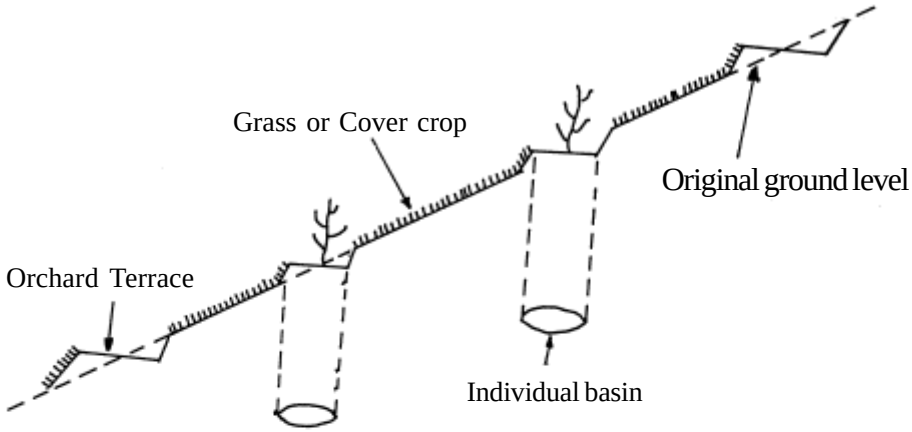
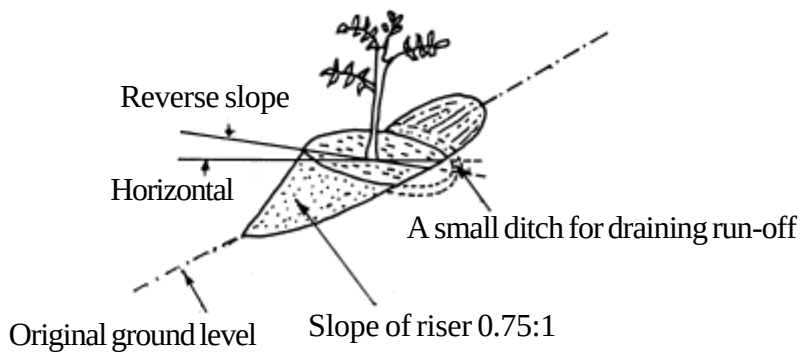



**Diagram of Individual Basin for Trees**



## Appendix- IV Cost estimates for the development programme

***(I) Gap filling by tree planting:***

| | | |
|---|---|---|
| Area to be planted | : | 1000 ha |
| Average plants /ha | : | 100 |
| Cost of planting/ha @Rs. 20.00 | : | Rs.2000.00 |
| Total cost of planting | : | Rs.20,00,000.00 |

***(II) Agrostology:***

| | | |
|---|---|---|
| Area to be planted | : | 200 ha |
| Average length of planting/ha | : | 800 m |
| Cost of planting/ ha @ Rs. 3.00/m | : | Rs.2400.00 |
| Total cost of planting | : | Rs.4,80,000.00 |

***(III)Pits:***

| | | |
|---|---|---|
| Area recommended for pits | : | 500 ha |
| Size of pits | : | 1.00 x 1.00 x 0.7m |
| Earth work required/pit | : | 0.7 3 |
| Earth work/ha | : | 300 3 |
| Cost of earth work/ha @ Rs. 62.00 /m3 | : | Rs.18,600.00 |
| Total cost of pits | : | Rs.93,00,000.00 |

***(IV) Trenches***

| | | |
|---|---|---|
| Area recommended for trenches | : | 300 ha |
| Size of trench | : | 2 x 1 x 0.7 m |
| Earth work required/trench | : | 1.4m 3 |
| Earth work/ha | : | 300 m3 |
| Cost of earth /ha @ Rs.62.00/ m 3 | : | 18,600.00 |
| Total cost of trenching | : | Rs.55,80,000.00 |

***(V) Puretoriccan type terracing:***

| | | |
|---|---|---|
| Area recommended for terracing | : | 100 ha |
| Length terracing / ha | : | 800 m |
| Cost of terracing/ ha @ Rs.36.00 m2 | : | Rs. 28,800.00 |
| Total cost of terracing | : | Rs.28,80,000.00 |

***(VI) Repair and maintenance cost of existing vented cross bar (VCB):***

| | | |
|---|---|---|
| Number of VCBs | : | 15 |

| | | |
|---|---|---|
| Average size of VCB | : | 5 x 4m |
| Thickness of wooden planks (*Thampakam*) | : | 7.5 cm |
| Quantity of wooden planks required/VCB | : | 1.5m 3 |
| Cost of timber/VCB @ Rs 25,000.00 /m3 | : | Rs 37,500.00 |
| Total cost of timber for the 15 VCBs | : | Rs 5,62,500.00 |

***(VII) Gully-plugging:***

| | | |
|---|---|---|
| Materials used | : | Dry rubbles |
| Average length of each gully | : | 5 m |
| Volume of each gully-plugging | : | 4 m3 |
| Cost/gully @ Rs. 300.00/ m3 | : | Rs.1200.00 |
| Approximate length of stream | : | 8000 m |
| Number of gully-pluggings in the upland region @ 25 m interval | : | 200 |
| Number of gully-pluggings in the midland region @ 100 m interval | : | 30 |
| Total cost of gully-plugging | : | Rs 2,76,000.00 |

| | | |
|---|---|---|
| ***(VIII) Cost for renovation of the 10 public ponds*** | : | Rs.20,00,000.00 |
| ***(IX) Cost for desilting the stream*** | : | Rs 1,50,000.00 |
| ***(X) Expense for forest management*** | : | Rs.2,00,000.00 |
| ***(XI). Expense for implementing small scale industrial units*** | : | Rs 10,00,000.00 |
| ***(XII) Promotion of animal husbandry*** | : | Rs 5,00,000.00 |
| ***(XIII) Training programmes*** | : | Rs.1,50,000.00 |
| **Total cost for the development programme** | **:** | **Rs 2,50,78,500.00** |

(Rupees Two Crores Fifty Lakhs Seventy Eight Thousand and Five Hundred)

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