

ABSTRACT

MICRO WATERSHED MANAGEMENT STUDY OF TUIRINI RIVER, MIZORAM, INDIA



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INTRODUCTION

India has diverse soil and agro-climatic resources. The production potential of different eco-regions varies widely. Without wise and sustainable use of soil and water resources, the development of farming will not be possible. The optional use of land requires that the land resources be well characterised, their spatial relations delineated and their capacities for all likely uses, at various levels of management, be determined and implemented.

Watershed is a geohydrological unit or a piece of land that drains at a common point. This natural unit has evolved through interaction of rain water with land mass and typically comprises arable lands, non-arable lands and natural drainage lines in rainfed areas. Therefore, for scientific utilization of the natural resources, particularly of land and water, the ideal geographical unit would be the watershed. For microlevel planning and implementation, a much smaller area, in comparison to a 'watershed', is selected which is termed as micro-watershed. Proper management plan on long term basis for a watershed or micro-watershed has to be evolved. The data generated on geophysical, biophysical and socio-economic conditions of a micro-watershed helps in evolving management strategies for the sustainable utilisation of natural resource base of land and water *vis-a-vis* sustainable production of biomass and maintainance ecological balance.

SCOPE AND OBJECTIVES OF THE PRESENT STUDY

Need for the management of natural resource on the watershed basis is felt. Nevertheless, no effort has been made in Mizoram to study in detail the geophysical, biophysical and socio-economical attributes of Tuirini River on micro-watershed basis in order to evolve a comprehensive watershed management plan. Therefore, the present study was designed to study, in depth, the various attributes of Tuirini River with the following objectives :

- * Study of the geophysical, biophysical and socio-economic attributes of Tuirini watershed in order to evolve a comprehensive micro- watershed management plan.

- * Framing the strategies for conserving soil and water *vis-a-vis* sustainable utilisation of natural resources, and
- * Screening of the farming system developed in the North Eastern India or in other parts of country which would be able to tackle biophysical problems of the land and socio-economic problems of the farmers of Tuirini watershed.

REVIEW OF LITERATURE

About 200 research papers, reports and books have been reviewed and consulted during the course of this study.

STUDY AREA

Tuirini is a tributary of Tuirial river and drains water from mid-north of the state in the Aizawl district. Tuirial river in turn joins Barak river in Cachar (Assam). The coordinates $23^{\circ} 28' 35''$ - $23^{\circ} 53' 02''$ N and $92^{\circ} 49' 03''$ - $92^{\circ} 58' 27''$ E delimit the Tuirini watershed. This watershed is confined to the valley between two N-S trending hill ranges. It flows in northerly direction and joins Tuirial river north-west of Seling. The entire watershed is hilly terrain. The elevation at the origin point is 1060 m and at the outlet is 80 m. The maximum elevation in the watershed is 1900 m whereas the minimum is 80m. The watershed is highly elongated in shape and covers a geographical area of about 398.69 sq. km. Several perennial and non-perennial streams originate from the eastern and western slopes of the two hill ranges. Twenty five well defined micro-watersheds have been delineated in the Tuirini watershed and are numbered 1 - 25.

Forest occupy a major portion of the watershed and belong to tropical semi-evergreen type. Jhuming is extensively practised all over the watershed (about 80 % of population is involved in jhuming) on hill slopes whereas permanent cultivation is done in the valley plains. The rocks of the watershed belong to Surma group of Lower Miocene epoch (Tertiary period of Kainozoic era).

METHODOLOGY

The methodology adopted to study and to collect data related to geophysical (slope, soil, climate and physiography), biophysical (resource inventory of forest types, economic species, existing cropping pattern and land use etc.) and socio-economic (population, education etc.) parameters is mentioned here briefly.

Geophysical

Slope

The slope map of the area has been prepared using the method suggested by Wentworth (1930) which is a simple and most widely accepted one due to its lucid approach. It forms the most convenient technique of average slope determination for preparation of slope map. However, it has been modified to suit the metric system of measurement.

Soil

The soil survey report of Govt. of Mizoram and Soil Survey manual form the basis of the present study. The soil survey has been conducted in the following manner:

- * A reconnaissance soil survey mapping of the micro watershed by using 1:50,000 scale Survey of India Toposheets as base.
- * Selection of samples of major physiographic units of the micro-watersheds to conduct survey in order to establish co-relation between physiography and soil.
- * Collection of soil samples from representative units by making fresh cutting and digging to study soil profile.
- * Preparation of soil map after confirmation or cross-checking.

Climate

The data related to temperature, rainfall and humidity are collected from the meteorological stations as well as from the study site. The seasonal variation in temperature, rain fall (average, monthly rainfall, intensity of rainfall), maximum, minimum and average etc., have been computed.

Physiography

Various watershed shape, drainage, and topographic factors have been evaluated based on the methods suggested by Horton 1932 1945, Chorley 1957, Eyles 1965, Linsley

et al., 1975, Melton 1964, Miller 1964, Morisawa 1958, Schumm 1956 and Strahler 1954, 1957 & 1964). Finally, run-off and sediment production rate has been estimated based on the method suggested by Jose and Das (1982) which is as follows:

$$\begin{aligned} \text{Log } Q &= 2238.43 + 22.12 \text{ Log } (100+R_f) \\ &\quad - 608.28 \text{ Log } (100+C_r) \\ &\quad - 530.02 \text{ Log } (100+C_c) \end{aligned}$$

where, Q = runoff in sq km - cm/sq km,

R_f = Rotundity factor $(L_b^2 / 4A)$

C_r = Circulatory ratio $(4\pi A / L_p^2)$

C_c = Compactness coefficient $(0.282 L_p / A^{0.5})$

$$\begin{aligned} \text{Log } \text{SPR} &= 4919.80 + 48.64 \text{ Log } (100+R_f) \\ &\quad - 1337.77 \text{ Log } (100+C_r) \\ &\quad - 1165.64 \text{ Log } (100+C_c) \end{aligned}$$

Where, SPR= Sediment Production Rate in Ha-m/100sq km/year,

R_f =Rotundity factor,

C_r = Circulatory ratio and

C_c =Compactness coefficient.

Prioritization of micro-watersheds has been done based on the sediment production rate.

Biophysical

Survey to prepare resource inventory of forest species (dominant, dominated and suppressed) and economic species

- * Collection of information from papers, reports, extension materials published by the concerned deptt.
- * Collection of information about the economic plant species growing in the watershed.
- * Collection and processing of plant samples
- * Pre-planned field trip and field work
- * Plant Processing
- * Identification

Exiting cropping systems in the watershed

- Survey of all major representative sites to identify major farming systems and other diversified land use practices in the watershed.
- Collection of productivity data of important cropping systems to identify best land use practices.

Socio-economic

Data regarding population, population-composition, literacy, occupation and other economic activities (*viz.* domestic animals, poultry, fisheries, piggeries, rearing etc.) have been recorded through secondary sources and after conducting actual survey to collect the information which is not available in the Govt. depts. and also to cross-check the authenticity of the data of the secondary sources.

RESULT

Geophysical

Slope

The slope map of Tuirini watershed has been prepared on 1:50,000 scale. It shows that the slope values in the watershed range from 4° to 34°. This range has been divided into five classes starting from below 15° and ending with above 30° with an interval of 5°. Accordingly, five slope categories, namely, gentle, moderate, moderately steep, steep and very steep, have been worked out. These represent varying nature of surface inclination. Area-slope distribution and spatial distribution of average slope categories has been worked out. It indicates that the five slope categories occupy 0.64 per cent, 11.27 per cent, 40.24 per cent, 41.29 per cent and 6.56 per cent of the area respectively.

Soil

Soil map of Tuirini watershed has been prepared on 1:50,000 scale. The soils of the Tuirini watershed belong to Entisol, Inceptisols and Ultisols orders. The soils found in the area at great group levels are Hapludults, Dystrachrepts and Udorthents. The typifying pedons found in the watershed are comprised of mixed mineralogy and belong to hyperthermic temperature class. The pedons are: Loamy Skeletal Umbric Dystrachrept, Loamy Skeletal Typic Dystrachrept, Loamy Skeletal Typic Hapludult, Loamy Skeletal Typic Udorthent, Loamy Skeletal Lithic Udorthent, Coarse Loamy Umbric Dystrachrept,

Fine Loamy Humic Hapludult, Fine Loamy Typic Udorthent, Fine Loamy Umbric Dystrochrept, Fine Loamy Typic Dystrochrept and Fine Loamy Typic Hapludult. The physiography and soil association has been deciphered. Land capability classification for the Tuirini watershed has also been worked out. It shows that the land capability classes II to IV and VI to VII are found in the Tuirini watershed. The land belonging to capability classes V and VIII are not found in the watershed.

Climate

Climatic conditions of the Tuirini watershed have been studied considering the weather in an year. These are: winter season (December to February), summer season (March - May), monsoon season (June - September), and retreating monsoon season (October - November). The mean annual maximum and minimum temperature for the last 10 years in the watershed are (1991-2000) are 25.89°C and 17.25°C respectively. The mean annual rainfall is 231.27cm and average annual rainy days are 165. The average annual humidity is 77.85 per cent.

Physiography

About 17 morphometric attributes of independent nature have been computed for all the 25 micro-watersheds of Tuirini watershed. From these, morphometric factors of micro-watersheds, namely, shape factors (shape index, form factor, compactness coefficient, elongation ratio, circulatory ratio and rotundity factor), drainage pattern factors (stream order, bifurcation ratio, drainage density, stream frequency, stream grade, length of overland flow, and time of concentration) and topographic factors (total watershed relief, relief ratio, relative relief, ruggedness number and channel maintainance factor) have been estimated. Based on these run-off and sediment production rate has been estimated for each of the micro-watersheds of Tuirini watershed.

Biophysical

Resourse inventory of forest species

Ethnomedicinal plants

Ten most important ethnomedicinal plants found in the watershed are *Adina cardifolia*, *Alstonia scholaris*, *Aprosa octandra*, *Berginia ciliata*, *Blumea laciniata*, *Cassia alata*, *Chikrassia tabularis*, *Cinnamomum bejolghota*, *Ficus benjamina* and

Oroxylum indicum. The important bamboo species recorded in the area are *Bambusa oliveriana*, *Bambusa tulda*, *Bambusa polymorpha*, *Bambusa vulgaris*, *Dendrocalamus giganteus*, *Dendrocalamus hamiltonii*, *Dendrocalamus longispathus*, *Dendrocalamus sikkimensis*, *Dendrocalamus strictus* and *Melocanna baccifera*. Important tree species growing in the natural forest or in plantation in the watershed are *Gmelina arborea*, *Phoebe attenuate*, *Phoebe hainesiana*, *Sapium baccatum*, *Albizia chinensis*, *Albizia procera*, *Schima wallichii*, *Pterospermum acerifolium*, *Castanopsis tribuloides*, *Cassia javanica*, *Chisocheton paniculatus*, *Carallia brachiata*, *Mesua ferrea*, *Dillenia pentagyna*, *Eurya cerasifolia*, *Firmiana colorata* and *Persea peteolari*.

Cropping system

Jhuming is extensively practiced in the watershed. Village wise data under different cropping systems, viz., wet and hill rice, maize, sugarcane, tobacco, cotton and potato cultivation has been collected along with their production. Like wise, village wise data on the livestock population, viz., bovine, caprine, porcine, sheep, buffalo, mithun, poultry fowls and ducks has been collected. Details regarding the horticultural practices in the watershed has also been collected.

Socio-economic

Village wise population statistics (male and female) for all the 25 villages of the watershed has been worked out as on 1.4.1999. Villages have been grouped into three categories based on the population. Distance of the village from the block headquarters has been determined. Projection of the population has been made for the years 2004, 2009 and 2010. Similarly, educational facilities available in the watershed have been documented and in depth analysis of male and female students in the primary, middle, high and higher secondary schools and college has been made. Number of students (male and female) has also been projected for the years 2004, 2009 and 2010. The available facilities pertaining to health, communication, transportation, recreation, water supply and industries have also been documented.

DISCUSSION AND CONCLUSION

Suggested land use based on average slope

More than 88 per cent of the area of the watershed has slope more than 20° and only about 12 per cent area has slope <20°. During the course of field study, it has been noticed that in many a place the gradient of jhum land appears as steep as 70°. The result is heavy run-off and soil erosion. Land with gradient upto 25° is recommended for cultivation keeping in view the prevailing practices of cultivation in the state. The land use types proposed for the Tuirini watershed based on the average slope is shown in the following table.

Table 1: Proposed land use type for Tuirini watershed based on average slope

Sl. No.	Slope Class	Slope Angle	Suggested landuse	Area sq.km.
1.	Gentle Slope	< 15°	Suitable for wet land cultivation of puddy mustard etc.	2.55
2.	Moderate Slope	15°- 20°	Suitable for upland crops like, Paddy, Maize, beans, chillies, pulses, potato, ginger, sugarcane, topioca, turmeric oil seeds, sweet potato etc.	44.95
3.	Moderately Steep Slope	21°- 25°	Suitable for plantation crops like, banana, citrus fruits, pineapples, papaya etc.	160.44
4.	Steep Slope	26°- 30°	Suitable for forestry & fodder like timber and fuel trees, fodder species etc.	164.62
5.	Very Steep Slope	> 30°	Suitable for social forestry.	26.13
Total				398.69

Land evaluation for its suitability under different cropping systems

The soils of the Tuirini watershed have been evaluated for their suitability for different land use types. The study indicates that the following land utilisation types are suitable for the Tuirini watershed:

1. **Upland crops:** Paddy, maize, beans, chillies, pulses, potato, ginger, sugarcane, tapioca, turmeric, oilseeds, sweet potato etc.
2. **Forestry and fodder:** Timber and fuel trees, fodder species etc.
3. **Plantation crops:** Banana, citrus fruits, pine apples etc.
4. **Wet land cultivation:** Paddy, mustard etc.

These LUTs may help in maintaining the ecological balance in the study area and may also be useful in reducing the miseries of the shifting cultivation. Relative suitability classes under different land use types have been worked out and shown in Table 2.

Table 2: Relative suitability classes under different Land Use Types (LUTs)

Sl. No.	Physiographic units	Forestry crops	Plantation crops	Upland crops	Upland paddy	Area sq. km.	Suggested landuse
1.	A, G, M	S3	S3	S3	S3	23.874	Forestry
2.	B, H, N	S3	S3	S3	N	143.577	Forestry
3.	C, I, O	S3	S3	S3	S3	117.829	Plantation crops
4.	D, J, P	S2	S2	S2	S3	39.562	Plantation crops
5.	E, K, Q	S2	S2	S2	S3	40.203	Upland crops
6.	F, L, R	S2	S2	S2	S3	20.510	Upland crops
7.	S	S2	S2	S2	S2	13.054	Upland paddy

Climate

The distribution of rain fall in the watershed is uneven. The rain fall is mainly concentrated during the pre-monsoon (55.54cm) and monsoon(147.20cm) seasons. Therefore, these seasons are favourable for the growth of crops and other plants. The retreating monsoon and winter season receive 22.83cm and 5.70cm rainfall respectively. Due to this, dry or semidry conditions prevail for more than a half of the year (retreating and winter seasons) and the soil retains less moisture content in these seasons. As a result, cultivation is not possible in these seasons. Effort should be made for the irrigational facilities through check dams etc. in order to enhance the production of food grains.

Prioritization of micro-watersheds

Priority and grading of micro-watersheds within the watershed under very high, high, medium, low and very low are fixed according to their sediment yield index, jhuming intensity value and run-off etc. In the present study, Sediment Production Rate (SPR) has been taken as the basis for prioritising micro-watersheds of Tuirini watershed as has been recommended by the Soil Conservation, Ministry of Agriculture, Govt. of India. Priority classes have been finalised by arranging SPR in the descending order (Table 3).

Table 3: Mean annual run-off, sediment production rate and priority classes of the micro-watersheds of Tuirini watershed, Mizoram.

Watershed No.	Mean Annual Run-off	Sediment Production Rate	Priority Classes
1.	50.5015	4.5994	VHP
2.	35.3400	2.0679	LP
3.	48.5447	4.1562	HP
4.	56.7390	5.8689	VHP
5.	55.6832	5.6205	VHP
6.	44.8281	3.6205	HP
7.	42.4997	2.0799	LP
8.	59.4694	6.4949	VHP
9.	44.4484	3.4238	HP
10.	58.7327	6.3196	VHP
11.	50.2093	4.5025	VHP
12.	57.5119	6.0349	VHP
13.	38.8011	2.5397	HP
14.	51.8833	4.8110	VHP
15.	53.3332	5.1121	VHP
16.	56.1054	5.7147	VHP
17.	40.5881	2.8040	HP
18.	39.1093	2.5842	HP
19.	44.8040	3.4844	HP
20.	39.1671	2.5924	HP
21.	51.3910	4.7338	VHP
22.	51.2510	4.6837	VHP
23.	51.2324	4.6797	VHP
24.	76.6876	11.3613	VHP
25.	60.8084	6.8203	VHP

LP= Low Priority HP= High Priority VHP=Very High Priority

The Table 4 shows that about 55 per cent (219.0360 sq km area in 15 micro-watersheds) of the Tuirini watershed is considered as belonging to very high priority class and needs immediate attention for conservational measures. Besides, about 40 per cent of the area (162.4710 sq km area in 8 micro-watersheds) belongs to high priority class. Thus, high and very high priority classes constitute about 95 per cent of the area of Tuirini catchment. Engineering measures of soil and water conservation are essential and should be given top priority to avoid further degradation of the valuable natural resources from the Tuirini watershed. This can be achieved by evolving suitable watershed management plans.

Table 4: Details of the priority classes of Tuirini watershed

Priority Class	No. of micro-watersheds	Area in sq.km.	Area in per cent
Low Priority	2	17.1830	4.3099
High Priority	8	162.4710	40.7512
Very High Priority	15	219.0360	54.9389
	Total 25	398.6900	100.0000

Biophysical

It is found that the watershed abounds in many commercially and medically valuable plants. The most preferred tree species, bamboo species and medicinal plants have been listed along with their description.

Although climatic conditions are suitable for agriculture, the area is lagging behind in food crop production due to undulating topography. Jhuming is extensively practiced in the watershed and the production under jhuming is low. The production is further decreasing due to the shortening of the jhum cycle and the erosion of top soil. As a result, the gap between production and consumption is increasing. The present production of paddy (3,230.09 tonnes) from 10.751 sq km of area is enough only for 83 days in an year for the total population of the watershed *i. e.* 39, 360 and the people face shortage of rice for the remaining 282 days. Maize is also cultivated in 2.6 sq km of the area with the

annual production of 977.5 tonnes. Production of cash-crops has negligible effect on the economy of rural poor as, at present, only 1.017 sq km of the area in the watershed is under such crops. The topography, climate and soil of the watershed are highly suitable for practicing horticulture. However, this sector has not yet been fully exploited. The orange, banana and pine-apples grow very well in the area and there is a need to plant them in a large scale. The data shows that the piggeries and poultry farming are flourishing in the watershed and contribute significantly towards the income of the rural poor.

Socio-economic

The population is fastly increasing in the watershed. The total population at present is 39,360 (1999) which is projected to be 46,528 (in 2004; 118 per cent increase), 54,993 (in 2009; 140 per cent increase) and 56,867 (in 2010; 144 per cent increase). Long - term strategies have to be evolved to provide quality education to the people of the watershed. Existing health facilities have to be improved and new health centers may be opened. Water supply facilities in the villages need to be enhanced and means of communication be strengthened. Small scale industries have to be set up for generating employment and for boosting economy.

Watershed management plan

Several design and models have been suggested to solve the problems of shifting cultivation or hill farming system. The three tier system was suggested by ICAR, Shillong *i. e.*, cultivation of trees at the hill tops, horticulture crops in the middle portion of the hill slopes and forming terraces at the lower portions of the hill slopes for cultivation of crops. This model may not be suitable for the farmers having small land holdings in the Tuirini watershed.

The Directorate of Agriculture, Govt. of Mizoram, Aizawl introduced Contour Trench Farming system. There are many drawbacks in this model, *viz*, depth, width and length of contour trenches at different slope per cents and spacing between the two contour trenches do not have any scientific basis. Continuous contour trenches may cause land slip due to steepness of hill slopes. The rate of soil erosion is high in the Tuirini watershed. The contour trench may trap silt load carried along with the run-off up to two

years and may be filled thereafter. A farmer will need additional labour for the maintenance of trenches.

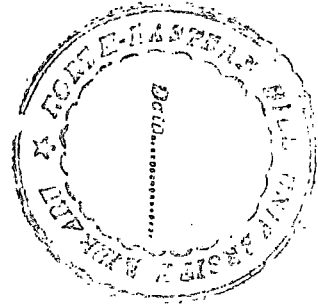
We need a technology which would be able to tackle socio-economic, geophysical and biophysical problems in the Tuirini watershed. Therefore, before introduction of modern technology, one should study in depth, the psycho-socio-cultural profiles of the farmers, particularly the social organisation, social behaviour and social cognition associated with shifting cultivation and permanent settlement pattern. This study would provide empirical foundation to formulate strategies for cognitive and behavioural modification of individuals to facilitate permanent settlement patterns relating to agriculture, forestry and animal husbandry. The jhum control should be need-based and location-oriented. The model tested elsewhere may not be suitable in the Tuirini watershed and it needs to be modified by studying the existing agricultural practices, biophysical and geophysical problems and the need of the farmers.

Jha (2000) has introduced TGhCFS and CTTGCFS models as an alternative to shifting cultivation. These models may be introduced after modification in hill farming system in the watershed. These models exert control over the biophysical, geophysical and socio-economic problems associated with shifting cultivation or hill farming system. These are capable of providing four basic things, namely, food, fodder, timber and fuel wood on a sustainable basis and will have control over soil erosion, nutrient and moisture losses and would generate year round employment.

These two models have been suggested for the Tuirini watershed keeping in view its biophysical, socioeconomic and geophysical characteristics. However, there may be a need to modify these depending on the local variations in these characteristics.

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**MICRO WATERSHED MANAGEMENT STUDY OF
TUIRINI RIVER, MIZORAM, INDIA**



**By
Nalini Kanta Sinha
Department of Forestry**

**Submitted
in partial fulfilment of the requirement of the
Degree of Doctor of Philosophy in Forestry of
North-Eastern Hill University, Shillong**

NORTH -EASTERN HILL UNIVERSITY
FEBRUARY, 2001

I, Nalini Kanta Sinha, hereby declare that the subject matter of this thesis is original work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to any body else, and that this thesis has not been submitted by me for any research degree in any other University/Institute.

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CHAPTER 1: INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Population, crop production and environment

At the time of the commencement of the Planning Commission in 1950, the general assumption that the country's population would be more than double in less than 10 years time was thought to be exaggerated and misplaced. The challenge to feed the burgeoning population had been accepted by India and necessary investment on the self sufficiency in food had been made along with agricultural research and extension to the fields. The stupendous task of achieving our own food to feed the hungry mouths had been attained by 1972-73. This feat of self sufficiency in food production is one of the great achievements of Indian agriculture.

The benefits of the 'Green Revolution' have not come without environmental costs. Agricultural resources in several areas have been severely degraded. Signs of agroecosystem stress, and even of its break down, are abundant (Virmani 1991). In India 90 million hectares of land suffers from water erosion, 50 million hectares from wind erosion, seven million hectares is affected by salinity and alkalinity, and 20 million hectares is prone to flooding (Singh 1994).

Thus, 167 million hectares or 51 per cent of the total land surface in India suffers from soil degradation. In addition, about 20 million hectares of canal irrigated area (the mainstay of the Green Revolution) run the risk of becoming degraded. According to Dhruvanarayana and Sastri (1985), nearly 175 million hectares of the country's land area (including 140 million hectares cultivable land) is under some form of degradation. The above findings give us an idea of the gravity and the magnitude of the problem. It is apparent that the sustainability of agriculture across the country is threatened by further increase in population. In India, about 70 per cent of the 144 million hectares are arable land which depend entirely on rainfall for crop production.

India has diverse soil and agro-climatic resources. The production potential of different eco-regions varies widely. Without wise and sustainable use of soil and water resource, the development of farming areas will not be possible. The optional use of

land requires that the land resources be well characterised, their spatial relations delineated and their capacities for all likely uses, at various level of management, be determined and implemented (Virmani 1991).

Virmani (1997) has mentioned that annual cycle of weather events poses a challenge to policy makers to innovate technical options and construct a comprehensive 'package of practices' to sustain rainfed crop production for different eco-regions. The technologies have to be 'area based' rather than individual 'farm based' and their fine-tuning be in accordance with available natural resources.

Rainfed agriculture research and development has been dominated by the concept of high yields for decades. It arose from the scientific principles developed for the 'Green Revolution' high-input, high-output technologies. Fatigue and cracks are now developing in the green revolution areas. For rainfed agriculture, an area-based development through watershed management provides an excellent framework for sustained yield. Also the landscape watershed units focus on the maintenance of biodiversity through diversified cropping systems (Jasmin 1984, Lim Suan 1991 and Wagley 1997).

1.2 Watershed and catchment concept

Initially, a watershed was described as a mass of land that drains at a common point on a natural drainage system. However, in the due course of time, the term has evolved to cover even those areas where distinguishable drainage lines do not exist. According to Sinha (1997), the watershed, in Indian situation, would include the following:

***Watershed with well defined drainage lines**

A piece of land or a geographical unit which drains at a common point on the natural drainage line and is the product of inter-play of rainfall and land mass.

***Watershed with not distinguishable drainage lines**

The low rainfall and desert areas

In such an eco-system, the watershed means an index catchment, but supports, large underground aquifers or groups of small aquifers.

Drainage congestion areas of the Himalayan foot-hills

Such eco-systems are found in the drainage congestion areas of the Himalayan Foot Hills. In this ecosystem, the area that drains into a common depression (Chaur)/ or a cluster of depressions is taken up as the watershed for planning and action.

***Coastal Saline areas**

Under these eco-systems, the area bounded by creeks are taken for survey, planning and implementation of project activities. In coastal watersheds, excess of water poses limitations on bio-mass production.

In other words, watershed is a geohydrological unit or a piece of land that drains at a common point. The natural unit has evolved through interaction of rain water with land mass and typically comprises of arable lands, non-arable lands and natural drainage lines in rainfed area. Sustainable production depends on health, vitality and purity of production and environment of which land and water are important constituents. Therefore, for scientific utilization of the natural resources, particularly of land and water, the ideal geographical unit would be the product of interaction of rain with land *i.e.* the watershed (Anon. 1991, Zijestra 1989 and Nalampoon 1995). According to Mohsin (1989), the total area contributing water, which flows through the outlet, is the watershed of that outlet. The outlet may be small natural drain, a rivulet, a stream or even a river.

For very specific and proper utilisation of land and water resources and for enabling actual microlevel planning and implementation, a much smaller area, in comparison to a 'catchment', is selected which is termed as 'watershed'. A catchment may be demarcated into a sub-catchment, a watershed, a sub-watershed, a Mini-watershed and Micro-watershed on the basis of various drainage size (Mohsin 1989).

Catchment

A primary river is a long river having a drainage area of more than one lakh hectares with a number of tributaries of first, second, third, fourth, fifth or even higher orders. The primary river generally discharges load to the sea. The drainage area of such a river is called a catchment.

Sub-Catchment

A secondary river is a tributary of a primary river having a drainage area of more than forty thousand hectares. The drainage area of such a river is called sub-catchment.

Watershed

A tertiary stream or river is a tributary of a secondary river having a drainage area of 4 to 40 thousand hectares. The drainage area of such a stream or river is called watershed.

Sub-Watershed

A quaternary stream is a tributary of a tertiary having a drainage area between 2 to 4 thousand hectares. Such a drainage area is called a Sub-Watershed.

Mini-Watershed

A pentad streamlet is a tributary of a quaternary having a drainage area between 400 - 2000 hectares. Such a drainage area is called a mini-watershed.

Micro-Watershed

A hexad streamlet is a tributary to a pentad having a drainage area of less than 400 hectares. Such a drainage area is called a micro-watershed.

1.3 Objectives of the watershed management plan

The conservation strategies in the watershed area are based upon ecological balance and production on sustained basis for the future of our civilization. According to NWDPPRA guidelines, the objectives of watershed management are as follows:

- * Conservation, upgradation and utilisation of natural endowments like land, water, plant, animal and human resources in a harmonious and integrated manner. This will aim at perpetual availability of food, fodder, fuel, fibre, timber and biomass for rural and cottage industries to meet the growing demands of human and livestock population through diversified land use.
- * Improvement of production, environment and restoration of ecological balance through scientific management of land and rain water. In the process, in-situ moisture conservation, introduction of scientific production system, net-work of run-off management structures and devices for recharge of ground water will ensure enhanced availability of water for human and livestock drinking purposes, domestic consumption, lift irrigation and raising of appropriate cash-crop according to agroclimatic potentials.
- * Reduction of inequalities between irrigated and rainfed areas. Ultimately, stable production and processing of biomass would contribute towards better life in rural areas. This will reduce large scale migration from rural areas to cities.
- * In addition to food, fuel and fodder the project would endeavour to enhance cash flow to the rainfed farmers and landless agricultural labourers through increased casual employment, marketable surplus of agricultural and dairy produce, growing of cash crops like vegetables, etc. in suitable areas.

1.4 Management of watershed

Management of watershed involves judicious use of land and maintenance of tree, bush or grass so as to conserve soil and water for immediate and long term gains along with assured productivity of the land and regular employment to the inhabitants

of watershed areas. In the past, the problem of watershed area were managed through soil and water conservation means and improved crop husbandry practices were tried on individual basis only. This approach did not solve the problems of a watershed. In the last decade, new technologies were introduced in the watershed area. Thus, management of watershed has become an important area of planning and development in the agriculture sector (Jha 1995).

1.4.1 Historical perspective and the evolution of Watershed management programme in India (Sinha 1997)

1.4.1.1 Colonial times

In pursuance of the recommendations of Royal Commission on Agriculture to develop dryland farming on a sustained basis, four research stations were started in the early 1920's at Rohtak, Sholapur, Hyderabad and Bellari. The dry farming system developed included field bunding, deep ploughing, fallowing of land and cropping in alternate years, use of bulky organic manure and moisture conserving methods and cultural practices. The systems were popularised in late 1930's and during 1940's in dry farming areas. The package of practices minimised total crop failure and induced an element of stability in food production, but, there was no appreciable increase in the overall productivity. Moreover, attention was limited only to crop lands. The treatment of non-arable lands and development of animal husbandry, which is an integral part of the dry farming system, was not included. As a result, the technology achieved a limited success.

1.4.1.2 Post - Independence soil conservation research

During the 1950's research attention was focused on developing soil conservation measures to stabilise the catchment areas of the dams, to prevent the siltation of reservoirs. The research centre conducted valuable research on rainfed analysis and soil loss and brought out ecological potential and problems of their region, but the production system was not given due attention.

1.4.1.3 Post green revolution dryland watershed management

After achievement of the national goal of self-sufficiency in the matter of food grains, through the development of irrigated agriculture in the early 1970's, an all India Coordinated Research Project was launched at 23 participatory research centres in the country. In the vicinity of these centres, pilot projects of integrated watershed development were launched to test, adopt and refine the research findings. The results brought out good potential crop varieties, moisture conservation measures and input oriented cropping system. Because of the inherent uncertainties in the amount and intensity and distribution of rainfall and the consequent risk in the dry areas, coupled with resource poor conditions of dryland farmers, the technology, could not be adopted in a big way.

Therefore, in the early 1980's, during the period of the Sixth Five Year Plan, the Department of Agriculture and Cooperation launched a pilot project for propagation of water conservation / harvesting technology in rainfed areas, in 19 watershed located in 15 states, representing major agro-climatic regions of the country. The Department of Rural Development also adopted this scheme in 23 watershed areas. Thus, a total number of 42 model watersheds were developed. The central point was water conservation and water harvesting. Good results were obtained and the need for bringing vegetative conservation measures and promoting a simple and low cost water management technology was highlighted.

On the basis of accumulated experience, the National Watershed Development Programme for Rainfed Agriculture was launched during the seventh plan in 99 selected watersheds of the country. These watersheds demonstrated models for successful crop production. As per project design, non-arable lands were to be developed by funds provided from other schemes. Later on, the National Watershed Development Project for Rainfed Areas (NWDPR) was re-structured and launched during 1990 - 91.

During the process of delineation of watersheds, diagnosis of problems, development of solutions and their application in the field, major attention was paid to programme content, technical specifications of different conservation measures and the attendant costs, project implementation, supervision, monitoring

etc., in the delineated watersheds. Somehow the relationship of the watershed area with the total problem was neglected (Grandstaff and Grandstaff 1987, Halls 1987, Anon. 1989 and Anon.1992).

One of the major shortcomings of watershed development approach has been the lack of people's participation in the programme. The only way to accelerate the pace of watershed development programme is to invoke willing participation of the people in the programme (Sinha 1997).

1.5 Why do we need watershed management ?

- * The neglect of the upland had effected the low land.
- * The deforestation in the hilly terrain resulted in floods and soil erosion. Land became degraded with poor nutrient and moisture.
- * Large scale migration of farmer in the urban areas in search of job because farming became subsistence farming.

1.6 Need to collect data on various attributes to prepare a sound watershed management scheme

In each watershed area, lands may be classified into various categories on the basis of land-use capability. The capability class does not indicate what the best use of land is. It only indicates the range of use to which each group is put. Soil and water conservation and increase in productivity in watershed area is only possible by applying mechanical as well as biological methods. Biological and mechanical measures are supplementary to each other (Klingebiel and Montgomery 1961, Brooks *et al.* 1986, Stepler and Nair 1987 and Jha 1995).

1.7 Mountain ecosystem : Low yields in North Eastern region and need for management of land resource on watershed basis:

The Eastern Himalayan Region of India (Zone II) under Agro-climatic Planning, as classified by the Planning Commission, comprises seven states of the North-East (Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya and Tripura), Sikkim, as well as the district of Darjeeling, Coochbehar and Jalpaiguri of West Bengal. The region as a whole is an interesting amalgam of mountains and lush green valleys,

with a geographical area of 27.5 million ha. which constitute 8.36 per cent of the Indian sub-continent. It stretches from 22°N to 29.3°N latitudes and 88.05°E to 93.24° E longitude. The altitude ranges from 97 meters in the plains to as high as 5,000 meters above mean sea level in the hills. The climate ranges from alpine to sub-alpine in the high altitude regions, mild sub-tropical in the plains of Assam and mild tropical in Tripura. The unique feature of this region is the high rainfall ranging from 3,000 mm to 12,000 mm. In addition, there are wide regional variation. For example, in Sikkim, the annual rainfall varies from 300 mm to 2,800 mm, in Darjeeling, from 900 mm to 2,700 mm and in Arunachal Pradesh, it is 4,000 mm (Bora 1991).

The diversification of crops and high intensity cropping programmes is full of risk due to high variability in the date of commencement and distribution of rainfall in the north eastern India. Indiscriminate felling of trees for age old shifting cultivation with shorter cycle resulted degradation of land, heavy soil loss during the rainy season. The soil is acidic in reaction due to leaching of bases as a result of heavy rainfall. In general, the yield level of crops are low and unable to meet the basic requirements of the population (Sinha *et al.* 2000).

1.7.1 Sustained productivity through watershed based management approach

The age -old cropping practices of the region have been evolved as a result of the interaction of geo-climatic and socio-economic factors which are in harmony with nature. The existing farming systems in different agro-ecological situations need to be grouped into homogenous units to facilitate the application of tested technologies for production of crops as well as for improving livestock quality. Environmental suitability, social acceptability and economic viability should be taken into consideration in such attempts. It is, therefore, necessary to identify the appropriate farming system based on physical, biological and socioeconomic settings of different ecological zones in the region (Anon. 1992).

Interdisciplinary and integrated efforts on a priority basis are needed to manage and develop watershed both in the hilly and valley lands of the entire region to restore the ecological base of the region. Watershed development should be the strategy for soil and water conservation, river valley projects and flood control. This will help in reducing the annual loss of natural resources due to high rainfall. At the

same time watershed based management approach in the hilly areas will give opportunity to the shifting cultivators to adopt ecologically sound settled cultivation. Scientific land use planning and identification of an ecologically and economically sound farming system for each agro-ecological situation on a watershed basis, through extensive research are the strategies required to achieve the objectives *i. e.* increase in productivity on sustained basis without disturbing the ecology of the hilly terrain of North Eastern states. (Bora 1991, Tiwari & Jha 1997 and Sinha *et al.* 2000).

1.7.2 Watershed management in Mizoram

The approach and strategy for rainfed areas are now based on the integrated watershed development concept, including production of individual holdings, regeneration of common property resources and promotion of household production system. Based on these, watershed programmes are being implemented under the National Watershed Development Programme for Rainfed Areas (NWDPA) in Mizoram (Sinha 1995 and Sinha *et al.* 2000). But in real sense these projects lack:

- * Proper management plan on long term basis for a watershed or micro-watershed. The watershed management plan has been finalised without recording various geographical, biophysical and socio-economic attributes.
- * The data generated on geographical, biophysical and socioeconomic condition of a micro-watershed helps in evolving management strategies pertaining to the sustainable utilisation of natural resources base of land and water *vis-à-vis* sustainable production of biomass and maintains ecological balance.
- * Emphasis on mobilizing people's active participation and making use of every resource available to the optimum level by understanding the relationship of various elements and its effect on one another. The package of practices can minimise total crop failure, but, there may not be appreciable increase in the overall productivity. Moreover, attention was limited only to crop lands.

The state of Mizoram receives little attention so far as the literature on the watershed studies is concerned. In status report on "Dhaleswari" and "Tuivai" catchment of Mizoram, the components like - runoff, soil loss, soil types, vegetation, rainfall etc., were studied (Anon. 1989). Rao *et al.* (1994) and Tiwari and Jha (1994)

have studied soil erosion and land degradation problems in Mizoram. They also studied rainfall, soil types, runoff, soil loss and land use etc. on watershed basis.

For a detailed and comprehensive watershed management study, the physical behaviour of watershed is to be ascertained through the analysis of various factors like - geophysical, biophysical and socio-economic. The physical factors include - slope, soil types, rainfall, runoff, soil loss (sediment yield); biophysical include vegetative resources, cropping pattern, live stock and animal husbandry while socio-economic factors include human resources, their literacy, economic and social status.

Although, various Government Departments like Forest & Environment, Soil and Water Conservation and Agriculture etc, are engaged in the study of watershed for the purpose of their management, a detail work on closer domain is yet to be carried out.

1.8 Scope and objective of the present study

Need for the management of natural resource on the watershed basis is felt. Nevertheless, no effort has been made in Mizoram to study in detail the geophysical, biophysical and socio-economical attributes of Tuirini River Watershed, in order to evolve a comprehensive watershed management plan. Therefore, the present study was designed to study in depth various attributes of Tuirini River with the following objectives :

- * Study of the geophysical, biophysical and socio-economic attributes of Tuirini watershed in order to evolve a comprehensive micro- watershed management plan.
- * Framing the strategies for conserving soil and water *vis-a-vis* sustainable utilisation of natural resource, and
- * Screening of the farming system developed in the North Eastern India or in other parts of country which would be able to tackle biophysical problems of the land and socio-economic problems of the farmers of Tuirini watershed.

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CHAPTER 2: REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE



2.0 An overview

Following the Earth Summit, the United Nations Development Programme (UNDP) led a regional initiative to develop an Asian agricultural resource management programme based on the concept of sustainable human development, as summarised by Speth (1994) : ‘Development will bring food security only if it is people-centered, it is environmentally sound, if it is participatory, and if it builds local and national capacity for self reliance.’ A recent issue of the United States Agency for International Development (USAID) Evaluation News has identified three basic elements for successful agricultural development. These are agricultural technology - applicable to particular soil, water and climatic conditions; economic policy and land tenure framework-conducive to agricultural growth by encouraging investments in land and other agricultural assets; an easy access to credit and related rural infrastructure and agricultural services. Virmani (1997) has opined that in order to operationalise these elements for the development of rainfed agriculture, the watershed model conceptually provides an envelope through which many of the steps for sustaining agriculture can be implemented.

Systematic study conducted by various workers in abroad and India in regard to the various parameters like geophysical, biophysical and socio-economic characteristics of a watershed to operationalise various elements for development of rainfed agriculture on sustained basis are reviewed here.

2.1 Geo and Biophysical

2.1.1 Geomorphic

Most geomorphological parameters are inter-related to varying degree (Gray 1961). Slope analysis, stream length, basin relief, drainage density and other topographic factors of the watershed control the physical behaviour of the watershed (Sinha *et al.* 2000) and study on these aspects help in estimation of runoff volume and

sediment production rate and helps in delineating the priority areas for the soil conservation treatment of a watershed, (Ebismiju 1979, Chaudhury and Sharma 1998, and Sinha *et al.* 2000). Henry and Raisz (1937), Calef and Newcomb (1953), Miller and Charles (1960), and Bhan (1988) used slope unit for delineating erosion risk categories. Bucko and Mazurova (1958) used drainage density for assessing erosion categories. Morgan (1980) and Sahi *et al.* (1977) have suggested the technique of erosion risk evaluation as a specialised form of land resource assessment. Jose and Das (1982) gave the model for empirical estimation of run-off and sediment production rate for Mayurakshi catchment. Chaudhury and Sharma (1998) have studied the different sub-catchments of the Giri basin to assess their potential hazard based upon physiographic, morphometric and drainage characteristics. The parameters used were relief ratio, drainage density, drainage texture and bifurcation ratio, for delineating sub-catchments for their treatment on priority. The toposheet obtained from Survey of India were used to derive these parameters. Sharma and Singh (1991) reported drainage density of 3 km per sq km in Kinnaur and Spiti areas in the high Himalayas. A figure of 4.5 km per sq km of drainage density was reported for Kumaon Himalayas (Jalal 1986). Mikhailov (1972) also placed the mountainous regions of Johar, Palau, Langkavi and Lumpur in Bulgaria under high erosion category on the basis of high drainage texture value. The average relief ratio of entire Giri catchment was calculated 0.10 (\pm 0.04) indicating high potential energy for down slope movement of water and sediment. The sub-catchments having compound parameter value <10 were classed under I, 10 to 15 under II and >15 under III priority (Chaudhury and Sharma 1998). The same procedure was adopted by Goal and Sharma (1996) for prioritisation of Satluj river catchment in Himachal Pradesh. Other noted contributors are Horton (1932 and 1945), Morisawa (1958), and Strahler (1952 and 57). Pathak (1985) analysed morphology of selected watershed of upper Damodar valley. Biswas *et al.* (1999) considered parameters like bifurcation ratio, drainage density, stream frequency, texture ratio, form factor, circulatory ratio and elongation ratio as erosion risk assessment parameters and used these for prioritising sub-watersheds of Murli river in Midnapur district of West Bengal.

The geomorphic characteristics of Dhaleswari and Tuivai catchments of Mizoram have been studied in detail (Anon. 1989). This study also deals with the estimation of run off and sediment production rate. The study shows that more than 50 per cent area in both the catchments is under severe erosion and need quick conservation measures. Rao *et al.*(1994) delineated 22 well defined watersheds in Mizoram and estimated mean annual runoff (discharge) and sediment production rate for each of these. For the ease in the development of management plan, the watersheds of Mizoram have been classified into low, high and high priority classes. The analysis of data suggests that degree of soil erosion problem in 55 per cent of the watersheds of Mizoram is at an alarming rate and need quick conservation measures on priority basis to check it. Tiwari and Jha (1997) have evaluated different watershed parameters to know the morphological characteristics of the watersheds of Mizoram.

2.1.2 Soil and land capability classification

Soil is a thin upper layer of earth's crust which serves as a natural medium for the growth of plants. The physical properties of soil *e.g.* the water holding capacity, permeability to water, aeration and nutrient supplying ability, determine the manner in which it can be used. The survey of soil and its mapping gives information on how to evolve a rational land use plan in a given watershed. The land capability classification is an interpretative grouping of soil primarily meant for agricultural purposes (Murthy 1997 and Sinha 1997). Mathur (1984) opined soil status capability is the potential of the land for use in specified ways or with specified management. Jha (1995) categorised the land into different capability classes and suggested suitable cropping system. Solanki and Bisaria (2000) have reported broad ideas about the soil types, and land use system for some micro-watersheds. Land degradation due to soil erosion has been reported by many workers, Anon. 1979, Brown 1981, Dudal 1982, Dent 1984, Morgan, 1986 and Lal 1990 (a and b). Physical properties of soil in relation to its erodibility studied by Bhatia and Sarmah (1996) and Chibbar *et al.* (1961). Prasad *et al.* (1986) and Sharma and Agarwal (1980) have reported soil erosion hazards associated with land use practices in North- Eastern hill region. Productivity, soil fertility and hydrological behaviour of micro-watershed based system on a hill slope was studied by Singh and

Satpathy (1998). Soil erosion under different land use systems in North-Eastern states reported by various workers (Prasad *et al.* 1993, Jha 2000 and Singh 2000) gives alarming picture. Need is felt to introduce farming system (various models) which can conserve the soil, moisture and nutrients and increase productivity on sustained basis (Dhruva Narayan and Sastri, 1985). Young 1989, Wiersum 1991, Singh 1986, Singh 1994, Singh *et al.* 1996 a & b, Young 1997, Singh 1998, Singh and Satpathy, 1998, Pathak *et al.* 1999, Sharma and Kumar, 2000, Sharma *et al.* 2000, and Singh and Savant, 2000. Mandays requirement, cost, crop yield and biomass productivity under different system of slope and on terrace land studied by Singh (2000) is worth mentioning. Effect of runoff and soil loss under different cropping pattern and vegetative cover are reported by Singh *et al.* 1967, Bhola *et al.* 1975, Singh and Verma 1978, Sood and Chaudhury 1980, Gutal *et al.* 1988, Hadda and Sur 1989, Prasad *et al.* 1993 and Khara and Singh 1995.

2.2 Cropping system and species diversity

In Mizoram, main cropping systems may be grouped into wet rice cultivation, orange, potato, ginger and pine apple cultivation category. Jhum cultivation (Jhum fallow in TDA, *i.e.* dominated by trees and jhum fallow dominated by JBA *i. e.* dominated by bamboos. This work carried in these areas has been documented here.

Haines (1982) opined agriculture throughout the world is still man's single most important activity and is still the only reliable source of food and an important source of fibres and other products. Among many forms of farming system, shifting cultivation is one of the most common forms of agriculture throughout the world (Hauk 1974, Mishra and Ramakrishnan 1981 and Jha 1997 and 2000). Shifting cultivation, locally known as "Jhum", is the predominant form of agriculture used by the local tribes of North-Eastern hill region of India (Hmar *et al.* 2000). Structure and functioning of shifting cultivation in Meghalaya state of North-East India have been extensively studied with main focus on socio-economic aspects (Mishra and Ramakrishnan 1981 and 1983, Toky and Ramakrishnan 1981 and Gangwar and Ramakrishnan, 1987). In North-East India, there is a great confusion regarding the yields of crops from hill agro-ecosystem (Toky and Ramakrishnan, 1981). In Mizoram state, average yield from jhum land and

in other cropping systems are also studied by Upadhyaya and Jha (1997), Lalmuanpuia and Jha (1999) and Hmar *et al.* (2000). A comparative study of the energy budget on the jhum cultivation studied by Prakash (1980), Toky and Ramakrishnan (1982) and Hmar *et al.* (2000). Watson (1983), Andreas (1980), Boonkird *et al.* (1984), Ruthenberg (1971) and Akachu (1985) suggested horticultural plantation as an alternative shifting cultivation in the humid tropics. Horticultural crop plantations have also been suggested as an alternative to jhuming in North-Eastern India by Ramakrishnan (1985), Lalramnghinglova and Jha (1996), Jha (1999), and Hmar *et al.* (2000). Citrus, Pineapple and Banana constitute the major fruit crops of the eastern India (Ghosh 1978). These fruit crops have a considerable socio-economic importance in the North-East region of India (Maheswari 1988). Jha (1997) suggested horticultural crop can be a suitable alternative to jhum cultivation but need is to search an agroforestry model which would control biophysical problems of the land and socio-economic conditions of the farmers and increase the productivity on sustained basis. He also suggested to introduce Tree-Greenhedge-Crop Farming System as an alternative to jhum (Jha, 2000 a and b).

2.2.1 Wet rice cultivation

The rice can be cultivated in high altitude as well as in wetland. Wetland rice cultivation exhibit a monoculture of rice and is a settled form of agriculture. The energy budget of wet rice cultivation are reported by Toky and Ramakrishnan 1982 and Helen, 2000. Among the four ages of WRC, 1 -year old plot contributed the highest energy and money input (281.27 MD ha⁻¹ or 1527.85 MJ ha⁻¹ and 1378166 Rs ha⁻¹ respectively). The total input sharply declined in the 2 -years old field. There was no significant decline of total input from 2 -years old cultivation onwards (Helen *et al.* 2000 and Helen 2000). Helen *et al.* (2000) have reported that the monetary output : input ratio of 1-year old plot was 0.95 which indicates that 1-year old plot was not efficient in terms of money. From 2nd year old plot onwards, the system showed efficiently in terms of money. The monetary output : input ratio was 2.08, 2.32 and 2.75 in 2nd, 3rd and 4th years old plot respectively.

2.2.2 Horticulture practices

In humid tropics cultivation of horticultural crops have been suggested most remunerative and ecologically sustainable (Ruthenberg 1971, Andreas 1980, Watson 1983 and Boonkird *et al.* 1998). In North-Eastern states, horticulture crops *viz.*, orange, pine apple, banana and ginger cultivation have been established as an alternative and remunerative farming (Helen 2000).

2.2.2.1 Orange

Orange trees are originally native to China and Indo-China and the orange has been grown extensively throughout the Far East for many years (Osche *et al.* 1960). Orange can be grown on a wide range of soil types from heavy clays to very light sand with pH ranging from 6.0 to 8.0 (Randhawa 1997). However, orange tree grows and produces best on fertile, well drained sandy loams with irrigation during dry periods. The climate of North-Eastern states specially Mizoram is ideal for growing orange tree. The majority of orange plantations are situated in the western and middle parts of the state (Helen 2000).

2.2.2.2 Pineapple

Pineapple (*Ananas comosus*, L.Merr) is considered as one of the most wanted tropical fruits. There are large number of varieties of pineapple (Munro 1933). The important varieties grown in India are Kew, Queen and Mauritius. Kew and Giant Kew are the major varieties grown in North-Eastern region (Ghosh *et al.* 1981). In Mizoram the varieties of Kew and Queen are commonly grown with other indigenous types.

2.2.2.3 Banana plantation

Banana (*Musa balbisiana*, Colla) is one of the most important fruit in the world, second to grapes and citrus in production (Anon. 1977). It has been recorded as one of the most important fruits in the domestic market in India (Randhawa and Iyer 1978). The plant is a large perennial herb with rhizomatous stem and adventitious roots.

Banana is essentially a humid tropical plant, coming up well in regions with temperature ranging from 10° C to 40° C, and an average of 23° C. It is moisture and heat loving plant and cannot tolerate frost or arid condition (Randhawa 1997). The “*dwarf cavendish*” and “*robusta*” are common in North -Eastern states including Mizoram, though some local varieties are also cultivated. Banana plantation is one of the most common farmings practised by the cultivators as an alternative to the shifting cultivation in Mizoram (Helen 2000).

2.2.2.4 Ginger cultivation

Ginger (*Zingiber officinale*, Rose) is a herbaceous perennial with leafy shoots which attains height upto four feet. It has been cultivated in all tropical countries (Macmillan 1984). India remains the world’s largest producer and exporter of ginger (Kochhar 1981). Rao and Reddy (1990) reported that, in Garo hills, 87 per cent of the cash income of jhuming was derived from ginger alone while Saha (1990) reported the yield ranges 0.01 to 0.12 quintal per hectare of ginger from jhum in different parts of North-Eastern Hill region. The ginger varieties like Nadia, Thingpui, Thinglaimu, Thingria (Acharya 1999) are grown in Mizoram. The soil and climate of Mizoram is conducive and ideal for growing ginger (Helen 2000).

Besides above system, coffee, tea & sericulture plantations are in progress in Mizoram, though in small scale.

2.3 Socio-economic

The rural people including tribals living in forest areas are dependent upon the forests in several ways. Tribal life and the forest are so closely related that tribals cannot visualise a life without forests. Infact, this is symbolic in nature. Degradation of the forests, coupled with relatively slow rate of agriculture productivity per unit area presents a rather grim picture for the country. This has forced the rural people, to search the alternative ways of livelihood (Jha 1996). The work so far done in the field of socio-economic of rural areas are reviewed here which is essential to prepare sound, effective watershed management plant for successful implementation and adoption by the villages. Pandith (1964) had observed that the farmers of middle age groups (26 - 45)

were better adopted than younger or older. Singh (1983) was of opinion that age does not influence adoption of farm mechanization and new technology. Shaukarih and Singh (1967) had observed a positive correlation between education and adoption. This was confirmed by Kakoty (1975) who had recorded a significant association of educational level for adoption of animal husbandry practices. The fact that education (even non-formal) is an important factor in adoption of new and novel technologies (Singh 1982). No significant correlation was observed by Malik and Sohal (1980) between adoption of improved practices and family size. However, Srivastava (1982) had pointed out Munda farmers are more inclined to adopt a new technology due to small family size. Bapat and Brahmhbhatt (1976) in their study in Gujrat have observed that with a higher income and literacy rate, tribal farmers showed more initiative for participation in different social and developmental activities.

Tyagi and Sahal (1983) pointed out that the family education, occupation and media exposure were positively and significantly associated with understanding of respondents. A positive correlation between farm size and adoption of farm innovations was observed by Wilkening (1952). Larger number of contacts made with different extension methods and socio-economic status facilitate adoption of innovations (Kar *et al*, 1970). Phagot (1980) in his study on the role of the socio-economic characteristics, trends and attitudes of farmers of rural Haryana influencing the adoption of agricultural technologies had reported that land holding, and socio-economic status of so called farmers should also be taken into consideration. Data pertaining to the extent of awareness regarding information sources of the respondents from selected villages of Chotanagpur plateau was generated by Jha (1996). Mishra and Srivastava (1987) reported that in the beginning of the programme a lot of difficulties were faced in creating atmosphere conducive to win the goodwill and confidence of the farmers.

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CHAPTER 3: STUDY AREA AND METHODOLOGY

CHAPTER 3

STUDY AREA AND METHODOLOGY

3.1. Study area

3.1.1 Mizoram

3.1.1.1 Location and accessibility

Mizoram is one of the seven states in the north-east India. It falls between latitude 22° 00' - 24° 30' N and longitudes 92° 15' - 93° 25' E. It extends over an area of about 21,081 sq. km. It is flanked by the Chin Hills (Myanmar) to the east, Arakan Hill Tracts (Myanmar) to the south, Chittogong Hill Tracts (Bangladesh) to the west, Tripura to the north-west, Cachar (Assam) to the north and Manipur to the north-east (Fig.3. 1).

Mizoram is approachable through Assam by an all weather road (National Highway No. 54) which connects Silchar town in Assam with the Aizawl (180 km) and Lunglei (410 km) towns in Mizoram. Silchar is also the nearest rail head to the state. Besides, Aizawl, the capital town, is also connected by air with Calcutta (thrice a week *i. e.* Monday, Wednesday and Friday). Non-locals have to obtain inner line permit before entering the state which can be had from the Mizoram Houses at New Delhi, Calcutta, Guwahati and Silchar.

3.1.1.2 Climate

Mizoram comes under the tropical monsoon climatic zones of India. It has a pleasant climate, moderate both in summer and winter, the temperature generally ranges between 10°- 30°. It experiences rainfall from May to September (from South-West Monsoon) with an annual average of 250 cm. Winter is generally rain free and the blue sky together with wide sketches of morning fog in the valley present an enchanting view resembling a vast lake (Tiwari 1992)

3.1.1.3 Physiography

Mizoram forms a rugged hilly terrain. The hills in the state run North - South having maximum elevation in the central part and tendency to taper at both the ends. These tend to be higher towards the east with an average elevation 600 m. The highest peak is Phawngpui in Blue Mountain at the Myanmar border with an elevation of 2065

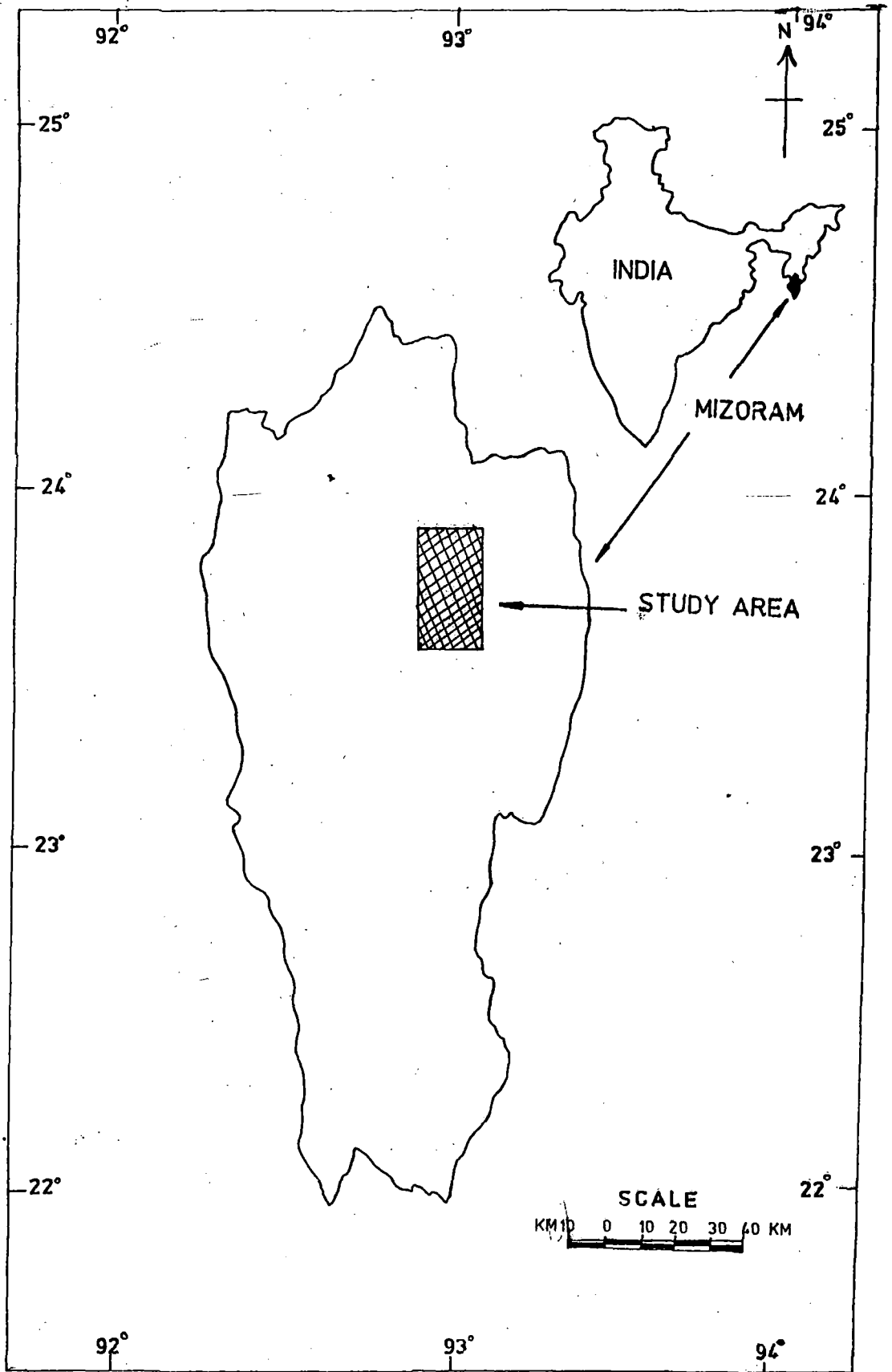


Fig. 3.1 LOCATION MAP

m. The hills are generally steep and are separated by river valleys flowing either to north or south forming deep gorges. The important northerly flowing rivers are Tlawng, Tuirial and Tuivawl which originate in the central part of the state and drain water in the Barak Valley in Assam. The rivers which flow to the south are Mat, Chhimtuipui and Karnaphuli. The first two drain water to Myanmar whereas the later to Bangladesh.

The Physiographic expression of the state is imported by approximately north-south trending, steep, mostly anticlinal, longitudinal, parallel to sub-parallel hill ranges and synclinal, narrow river valleys. These are intersected by transverse faults. The difference of elevation between valley floor and hill tops greatly varies from west to east, the range being 200 - 600 m (Anon. 1974, Tiwari 1992, Tiwari and Kumar 1997, Tiwari *et al.*, 1997).

3.1.1.4 General Geology

Mizoram is geologically a part of the Tripura-Mizoram miogeosyncline, which belongs to the Assam-Arakan geosynclinal basin. The Mizo Hills (=Lushai Hills) have been considered to be forming an integral part of the mobile belt constituted of very tight, elongated, asymmetrical, N-S trending anticlines, alternating or en-echelon with broad saucer shaped synclines showing a slightly arcuate and convex west ward submeridional trend (Srivastava *et al*, 1979). The hill ranges mainly comprise of compact and resistant older units, exposed in the anticlinal crests whereas the valleys are composed of younger and softer sediments exposed in the Synclinal troughs (Ganguli, 1975). The region is exposed mainly by geosynclinal mollasse sediments of Neogene age comprising of poorly fossiliferous succession of alternating shales, mudstones, siltstones and sandstones and their admixture in various proportions. The general strike of the rock formation is N-S with dip varying from 20°- 50° either towards east or west. A general increase in sedimentary thickness and in the argillaceous component is also apparent in the same direction (Tiwari and Kumar 1997).

The sedimentary succession in the state belongs to three stratigraphic, groups namely, Barail (Oligocene), Surma (Miocene) and Tipam (Pliocene) of Tertiary Period. Barail group rocks occur in eastern Mizoram around Champhai, Surma rocks in northern, central and southern Mizoram, and Tipam rocks in North-Western part of the

state. Surma group is further divisible into a lower, Bhuban and an upper Boka Bil units (Tiwari, 1992).

3.1.1.5 Soil

The soils of Mizoram have been derived from the Shales, Sandstones, Siltstones and Mudstones of the Tertiary Period. There are classified under three orders, namely, Entisols, Inceptisols and Ultisols. Soils of Entisols are weakly developed having no evidence of profile development. These do not have diagnostic surface horizon. These are found on steep slopes and ridges. This order is represented by Typic Udipsamments, Loamy skeletal lithic Udorthent, and Loamy Skeletal Typic Udorthent. Soils of Inceptisol order occur widely in sub-humid to humid regions. These have well developed horizon sequence and are mostly cultivated. Loamy Skeletal Typic Dystrochrept and Fine Loamy Typic Dystrochrept soil families of this order are found in the state. Ultisols are commonly found in mid-altitudes. These have well developed horizons which are rich in translocated silicate clays with intensive leaching in humid sub-tropical climate. The families of this order occurring in the state are Fine Loamy Typic Hapludults, Loamy Skeletal Typic Hapludults and Loamy Skeletal Typic Palendults (Anon. 1980, Rao *et al*, 1994).

3.1.1.6. Forest

About 76 per cent of the area (15,932 sq.km.) of Mizoram is covered with the Forest of one type or the other. The forests in the state are owned by the state Government or District Council or the Village Council. Forests in Mizoram are classified under three types (Anon. 1980 and Rao *et al*. 1994). These are :

- (1) Tropical Wet Evergreen Forest.
- (2) Tropical Semi-Evergreen Forest.
- (3) Montane Sub-tropical Pine Forest.

Tropical wet evergreen forest is the most important and is largely found in South and West side of the state. It has rich and valuable timber species in the top canopy. Bamboos occur abundantly in the middle and lower story. Canes are also found in this type of forest. The common timber species are, *Dipterocarpus turbinatus*, *Artocarpus chaplasha*, *Terminalia myriocarpa*, *Amoora wallichii*, *Michelia champaca*,

Mesua ferrea etc. The common bamboo species are, *Melocana bambusoides*, *Dendrocalamus strictus*, *Bambusa tulda*, *B. vulgaris*, *D. giganteus*, *D. hamiltoni* etc.

Tropical Semi-evergreen forest is mostly seen in the north-western and central parts of the state and covers major area of Mizoram. It is rich in timber species, bamboos and canes. The important species are, *Michelia champaca*, *Schima wallichii*, *Gmelina arborea*, *Toona ciliata*, *Chukrassia tabularis*, *Sterculia villosa*, *S. colarata*, *Podocarpus nerifolia*, *Adina cordifolia*, *Bombax ceiba*, *Dillenia* species etc.

Montane Sub-Tropical Pine Forest is found in the eastern fringes of the state bordering Chin Hills of Myanmar where elevation is higher, temperature is lower and annual precipitation is also lower. The common species in this type of forest are, *Pinus kesiya*, *Quercus incana*, *Q. serrata*, *Castanopsis* sp., *Rhododendron* sp., *Rubus* sp. etc.

3.1.1.7 Economy

Agriculture is the mainstay of people of Mizoram and the state represents agrarian economy. Jhuming or shifting cultivation is extensively practiced in the state. About 80 per cent of the population is involved in this occupation. People have now realised the futility of this type of agriculture but the practice still continues for the want of other modes of livelihood available to the villagers living in the distant localities. Livestock provides additional income to the farmer along with the horticulture produces (Anon. 1989).

3.1.1.8 Rivers of Mizoram

Numerous rivers originate mostly in the central part of the state and flow either to north or south and negotiate with tortuous gorges. These rivers are guided by hill ranges and it is very common to see parallel streams in the adjacent valleys flowing in opposite directions. The prominent rivers draining the southern part of Mizoram are Tiau, Chhintuipui, Tuichawng, Kawrpui, Karnaphuli and their tributaries. The rivers Langkaih, Teirei, Tut, Tlawng, Tuivawl, Tuivai and their tributaries drain the northern parts and ultimately join the Barak river in Cachar. In general, the drainage pattern is parallel to sub-parallel with angular, trellis and sub-dendritic pattern developed locally.

In Mizoram, 22 well defined watersheds have been delineated (Rao *et al.* 1994) based on physiography. These are, Langkaih, Teirei, Tut, Tlawng, Serlui, Tuichhuahen,

Tuirial including Tuirini, Tuivai including Tuivawl, Mat, Tuipui, Tuichang, Ngengpui, Tuilarpui, Sazuklui, Khawthlangtuipui, Kau + Deh, Tuichawng, Kawrpui, Chhimtuipui, Tiau, Sakeilui Salalui + Tinglo. The largest one is Chhimtuipui having an area of 2,74,055 ha. whereas the smallest one is Sazuklui with an area of 11,561 ha.

3.1.2 Tuirini watershed

3.1.2.1 Location and Accessibility

Tuirini is a tributary of Tuirial river and drains water from mid-north of the state of Aizawl district (Fig. 3.1A). Tuirial inturn joins Barak river in Cachar (Assam). The adjoining area of Tuirini watershed in the west is drained by Tuivai river, in the south by Tuichang river, in the east by Tuirial river. The coordinates $23^{\circ} 28' 35'' - 23^{\circ} 53' 02''$ N and $92^{\circ} 49' 03'' - 92^{\circ} 58' 27''$ E delimit the Tuirini watershed. It is about 55 km from Aizawl, the capital of the state. The river can be approached by NH 54 which runs along the western boundary of the watershed. Besides, Aizawl - Champhai road runs for about the distance of 35 Km within this watershed in the E -W direction. between Seling and Keifang.

3.1.2.2 Brief geographical account of Tuirini watershed

Tuirini watershed is confined to the valley between two N-S trending hill ranges. It flows in northerly direction and joins Tuirial river north-west of Seling. The entire watershed is hilly terrain. Many low lying hills and spurs can be seen in the area.

It originates south of the village Hmawngkawn, runs towards north for about 54.50 km and finally joins Tuirial river. The elevation at the origin point is 1060 m and at the outlet (confluence with Tuirial) is 80 m. The maximum elevation in the watershed is 1900 m (close to Sihfa village) whereas the minimum is 80m at its confluence with the Tuirial river (Photograph 1 and 2).

The watershed is highly elongated in shape (Fig. 3.1A) and covers a geographical area of about 398.47 sq. km. Several perennial and non-perennial streams originate from the eastern and western slopes of the two hill ranges. Most of the streams run nearly parallel to each other in the E-W direction and meet the main stream at angles ranging from 20° - 80° .

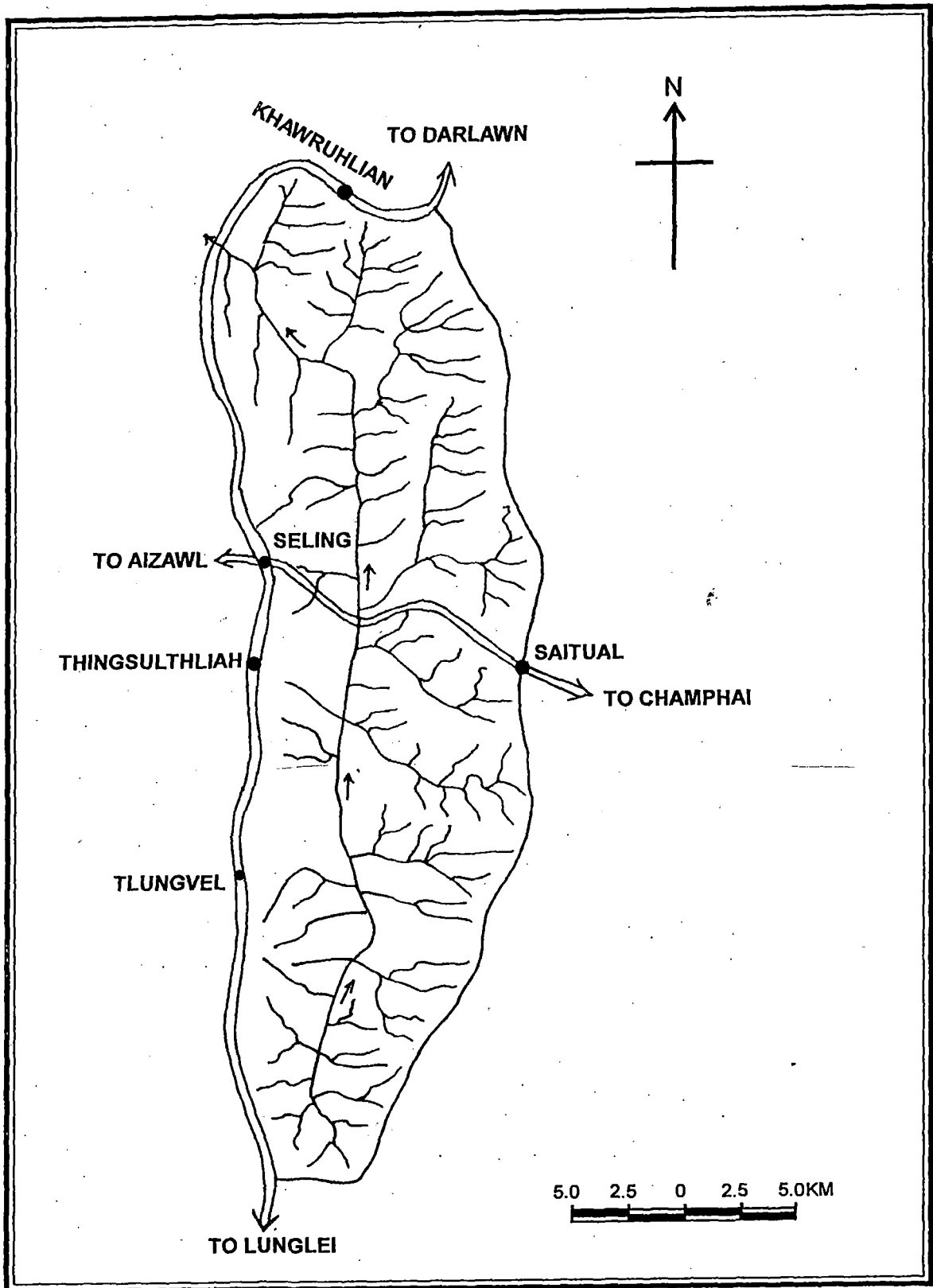


Fig. 3.1A : Map of Tuirini River

The average annual rainfall in the watershed is of the order of 231.27 cm, mean maximum temperature 25.89°C and mean minimum temperature 17.25°C. In winter, the mean minimum temperature is 12.6°C whereas the mean maximum is 22.3°C and average humidity is 77.85 per cent. The watershed receives maximum rain from south-west monsoon with maximum rainfall in the months from May - October.

Forest occupies a major portion of the watershed and belongs to tropical semi-evergreen type (Rao *et al.* 1994). The common tree species are *Michelia champaca*, *Schima wallichii*, *Gmelina arborea*, *Toona ciliata*, *Chukrassia tabularis*, *Sterculia villosa*, *S. colarata*, *Podocarpus nerifolia*, *Adina cordifolia*. Bamboos and canes are also extensively found in the watershed (Photograph 3 and 4).

Jhuming is extensively practised all over the watershed (about 80 % of population is involved in jhuming) on hill slopes whereas permanent cultivation is done in the valley plains (Photograph 5). Destruction of forest cover for jhuming has exposed the hill slopes to the direct impact of rainfall resulting in soil erosion and land degradation in the watershed (Plate 4 and 5). There are 25 villages in the watershed with the total population of 39,360 (19,864 male, 19,496 female). The literacy percentage is 85 per cent. The villages are mostly located on the eastern and western boundaries of the watershed.

3.1.2.3 Geology

The rocks of the watershed belong to Surma group of Lower Miocene epoch (Tertiary period of Kainozoic era). This group is divisible into a lower, Bhuban sub-group and upper, Boka Bil sub-group. The Bhuban sub-group is further divisible into lower, middle and upper Bhuban formations. The rock succession in the watershed has been assigned to Middle and Upper Bhuban Formations of the Bhuban sub-group. Middle Bhuban Formation is mainly 3000 m. thick and is predominantly argillaceous unit comprising shale, siltstone and mudstone. Thin beds of sandstones are also found in the area. The shales are dark grey to pale greenish, thinly bedded and crumpled at places. The siltstone and mudstone are greyish in colour, thinly bedded, hard and ripple cross laminated. The sandstones are thinly bedded and silty.

The formation shows highest topographic expression due to its hard compact nature and its resistance to weathering. Dense jungles and appreciable jhum cultivation

can be seen in the areas covered by this formation (Ganguli 1975, Ganju 1975 and Tiwari and Kumar 1997).

Middle Bhuban Formation is conformably overlain by Upper Bhuban Formation which is predominantly arenaceous with a maximum thickness of 1100 m. It is mainly composed of sandstone. Shales, siltstones and mudstones are also found in subordinate quantities. The sandstones are massive, grey and brown coloured, fine grained, ill sorted, silty and micaceous. The siltstones are massive, while the shales are dark to bluish grey, thinly laminated and splintery (Ganguli 1975, Ganju 1975 and Tiwari & Kumar 1997).

The areas covered by this formation have subdued topographic expression. Considerable jhum cultivation can be noticed in this formation.

The entire watershed is covered with thin to thick vegetation and as such the surface area of exposed rock is very less. The rocks are mainly exposed along the streams, road sections, on jhum patches and on valley slopes. Since, the rocks are structurally disturbed and geologically young, these are weak and are prone to deep weathering giving rise to silty and clayey soils.

3.1.2.4 Micro-watersheds in Tuirini watershed

Twenty five well defined micro-watersheds have been delineated in the Tuirini watershed. These are numbered 1 - 25 (Fig. 4.4A). Micro-watershed no. 18 is the largest one having an area of about 50.60 sq. km whereas no. 4 is smallest one with an area of about 4.38 sq. km. Twelve micro-watersheds are highly elongated in the N-S direction, seven are elongated in the E-W direction and the remaining are rectangular in shape.

Almost all the micro-watersheds are drained with perennial streams. Micro-watershed nos. 22, 23, and 24 on the northern extremity of the catchment flow southerly in the direction opposite to that of the main stream. All other micro-watershed, (baring 1, 2, and 25) flow either towards west or east and join the mainstream at angles ranging from 20°- 80°. One, two and 25 micro-watersheds flow in the northerly direction. All the watersheds are inhabited. Most thickly populated villages in the watershed, namely, Tlungvel, Thingsulthlah, Saitual and Seling are located in the watershed nos. 11, 16, 17 and 20 respectively.

3.2 Methodology

The type of vegetation and farming system occurring in a watershed is a very largely dependent on such factors as general climate, geomorphology, which can hardly be altered, but it is also related to soil and biological factors which can significantly be influenced by the treatment we apply. The methodology adopted to study or to collect data related to slope studies, soil characteristics, climate, geophysical characteristics, biological (resource inventory of forest types, economic species, existing cropping pattern and land use etc.) and socioeconomic parameters are mentioned here.

3.2.1 Study of slope

The slope map of the area has been prepared using the formula suggested by Wentworth (1930) which is as follows:

$$\text{Tan } \theta = \frac{\text{Average number of contour crossing per mile X contour interval}}{3361 \text{ (constant)}}$$

The constant 3361 has been derived by converting mile into feet and multiplying it with 0.6366, the constant (5280x0.6366). (1 mile=5280 feet). The θ represents the angle of slope in degrees.

However, this formula is for the mile scale which is obsolete and metric system is universally applicable now. Accordingly, the above formula has been modified and rewritten as:

$$\text{Tan } \theta = \frac{\text{Average no. of contour crossings per km X Contour Interval}}{636.6 \text{ (constant)}}$$

The constant 636.6 has been derived by converting km into metre and multiplying it with 0.6366 (1000x0.6366=636.6).

The entire watershed area has been divided into grids of 1 sq. km. (2cmx2cm). The number of contour crossings along all four sides of the grids have been counted and the average number of contours in each grid has been ascertained. These figures have been put in the above formula and the values of Tan θ has been obtained. Then from the log table the slope angles have been ascertained and the slope map is prepared.

3.2.2 Soil Survey

The soil is a dynamic layer of surface material which is constantly changing and developing under processes of adjustment to conditions of climate, parent material, topography and vegetation. An understanding of the soil resource (characteristics of soil in different physiographic units and altitudes) of a micro watershed would help in knowing the potentials and problems. The soil survey report of Govt. of Mizoram (Anon. 1997) forms the basis of the present study. The soil survey conducted is follows

- * A reconnaissance soil survey mapping of the micro watershed by using 1:50,000 scale survey of India toposheets as base.
- * Soil survey methods as mention in the Soil Survey Manual (Anon. 1970) and Soil Survey Manual (Anon. 1988).
- * Selection of sample representative area of major physiographic area of the micro-watershed to conduct soil survey in order to establish co-relation between physiography and soil.
- * Collection of soil samples from representative unit by making fresh cutting and digging to study soil profile.
- * Preparation of soil map after confirmation or cross-checking with the finding of the concerned Govt. Departments.

3.2.3 Hydrometeorological data

The major abiotic constrains that cause unsustaining effect on rainfed agriculture and influence vegetation include low and variable rainfall, temperature and light, and their seasonal variations. Other factors such as wind and atmospheric humidity is also of considerable importance. The data related to temperature, rainfall and humidity are collected from the meteorological station as well as from study site. The seasonal variation in temperature, rain fall (average. monthly rainfall, intensity of rainfall), maximum, minimum and average etc., have been computed to co-rrelate the relation of abiotic factors on the distribution of vegetation and cropping systems.

3.2.4 Geophysical parameters

Geomorphic, drainage and topographic factors control the physical behaviour of the watershed. These are required for designing runoff volume and estimation of

sediment production of rate. Various watershed shape, drainage, and topographic factors have been evaluated based on the methods suggested by Horton 1932 1945, Chorley 1957, Eyles 1965, Linsley *et al.*, 1975, Melton 1964, Miller 1964, Morisawa 1958, Schumm 1956 and Strahler 1954, 1957 & 1964). Finally, run-off and sediment production rate has been estimated based on the method suggested by Jose and Das (1982) which is as follows:

$$\begin{aligned} \text{Log } Q &= 2238.43 + 22.12 \text{ Log } (100+Rf) \\ &\quad - 608.28 \text{ Log } (100+Cr) \\ &\quad - 530.02 \text{ Log } (100+Cc) \end{aligned}$$

where, Q = runoff in sq km - cm/sq km,

$$Rf = \text{Rotundity factor } [Lb^2 / 4A]$$

$$Cr = \text{Circulatory ratio } [4 \pi A / Lp^2]$$

$$Cc = \text{Compactness coefficient } [0.282 Lp/A^{0.5}]$$

$$\begin{aligned} \text{Log SPR} &= 4919.80 + 48.64 \text{ Log } (100+Rf) \\ &\quad - 1337.77 \text{ Log } (100+Cr) \\ &\quad - 1165.64 \text{ Log } (100+Cc) \end{aligned}$$

Where, SPR= Sediment Production Rate in Ha-m/100sq km/year,

Rf=Rotundity factor,

Cr= Circulatory ratio and

Cc=Compactness coefficient.

Prioritization of watershed has been done based on sediment production rate.

3.2.5 Survey to prepare resource inventory of forest species (dominant, dominated and suppressed), economic species to suggest conservation measures

- * Collection of information from papers, reports, extension materials published by the concerned deptt.
- * Collection of information about the economic plant species growing in the micro-watershed.
 - By interviewing local inhabitants (villagers of the watershed area (medicinal plants and other economic plant species)).

- By interviewing naturopathists and faith healers (Local medicine-men).
 - By surveying village market.
- * Collection and processing of plant samples
- Below mentioned field equipments and chemicals used during the Collection and processing.
- Field equipment
 - (I) Field note book (ii) Plant press (iii) Knife (iv) Scissors
 - (v) Old news paper (vi) Polythene bag etc.
 - Laboratory equipment and chemicals
 - (I) Enamel tray (40 cm X 30 cm X 3cm) (ii) Forceps (iii) Fevicol
 - (iv) Ethyl alcohol (v) Formaldehyde (vi) Mercuric chloride etc.
 - Herbarium equipments.
 - (I) Genus and species cover (ii) Mounting board (iii) Corrugated card board (v) Blotters (vi) Label etc.
- * Pre-planned field trip and file work
- Identification of representative sites by using local map.
 - To cover important representative areas by locating routes and time etc.
 - The study area covers about 25 villages. The village and forest are grouped at different representative site to collect all major plant species.
 - Verification of the authenticity of the economic uses of plants and there after collection with the help of local people. Recording of the habit and habitat, growth behaviour, phenology uses etc., in the field note book.
- * Plant Processing
- Spreading the plant samples on folders.
 - To prevent the detachment of leaves, flowers and fruits from a twig of the plant - dipping of plants in a plastic tray containing the solution of 4 % of Paraformaldehyde.

- Placing of plant materials inside the folders or absorbers and thereafter plant is pressed inside plant press.
- Drying of plant samples and poisoning of plant materials by dipping in a tray containing 'Key Mixture' (115 gms of Mercuric Chloride dissolved in 4.5 litres of Ethyl alcohol or Rectified Spirit).
- Mounting of plants on the mounting board.

* Identification

Identification of plants with the help of :

- i). Flora of Assam (Kanjilal *et al.* 1934-1940).
 - ii). Flora of the Lushai Hills (Fischer 1938).
 - iii). Indian Trees (Brandis 1906).
 - iv). Flora of Tripura State (Deb 1981 and 1983).
 - v). Trees of Mizoram (Lalramnghinglova 1997) and
 - vi). Forest flora of British Burma (Kurz 1877).
- Confirmation of the matched species and identification of unidentified species with the herbarium of Department of Environment and Forest, Govt. of Mizoram and Department of Forestry, NEHU, MC, Aizawl.

3.2.6 Exiting cropping systems in the watershed

- Survey of all major representative sites to identify major farming system and other diversified land use practice of the microwatershed.
- Collection of productivity data of important cropping systems to identify best land use practices.

3.2.7 Socio-economic

Data regarding population, population-composition, literacy, occupation and other economic activities (*viz.* domestic animals, poultry, fisheries, piggerie, rearing etc.) have been recorded through secondary sources and after conducting actual survey to collect the information which is not available in the Govt. Deptts. and also cross check the authenticity of the data of the secondary sources.

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CHAPTER 4: RESULT

CHAPTER 4

RESULT

4.0 Geophysical parameters

4.1 Study of slope

4.1.1 General Remarks

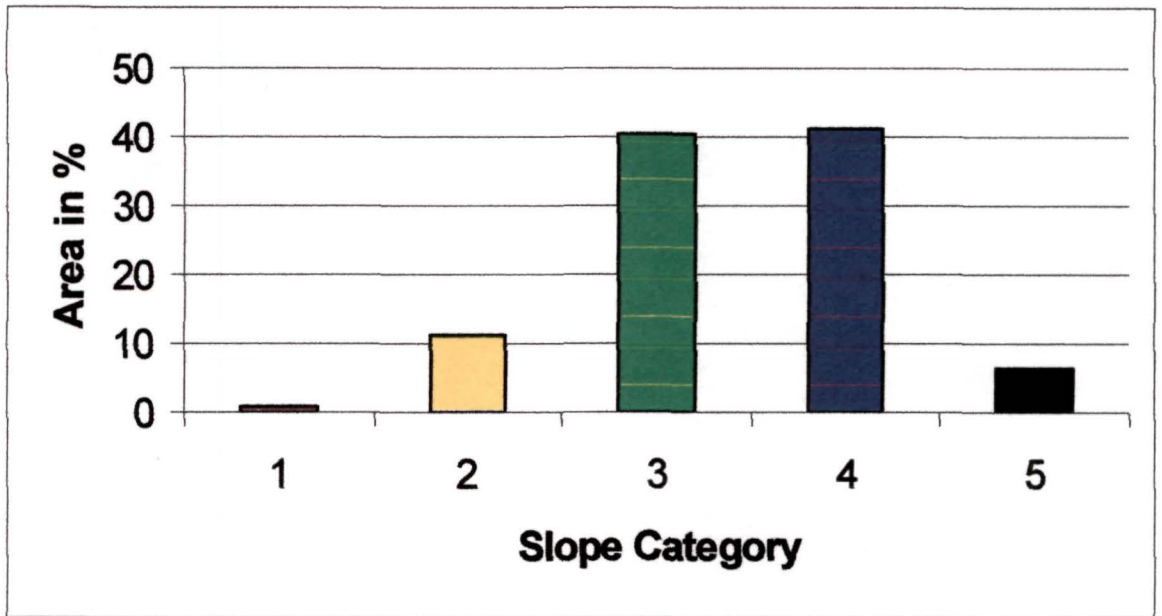
Slope is the inclination of any segmental element of the earth surface with the datum and is expressed in degrees. It is a function of the multiple complex forces such as lithologic, tectonic, climatic and biotic which control and/or guide the processes involved in its development (Singh 1979). Slope has been considered to be the fundamental component of the surface morphology of a drainage basin and it greatly influences the land use pattern. Therefore, study of slope is one of the important aspects of integrated watershed management.

Although, several methods of slope analysis are available (Calef 1950, Calef and Newcomb 1953, Chapman 1952, Eyles 1965, Miller and Summerson 1960, Raiz and Henry 1937, Smith 1938, Strahler 1956 and Wood 1942), the one proposed by Wentworth (1930) is a simple and most widely accepted method due to its lucid approach. It forms the most convenient technique of average slope determination for preparation of slope map (Prasad 1988). Therefore, this method is used in the present study albeit with a modification (see methodology) to suit the metric system of measurement.

4.1.2 Slope study of Tuirini watershed

The slope map of Tuirini watershed has been prepared on 1:50,000 scale (Fig. 4.1A). It shows that the slope values in the watershed range from 4° to 34°. This range has been divided into five classes starting from below 15° and ending with above 30° with an interval of 5°. Accordingly, five slope categories, namely, gentle, moderate, moderately steep, steep and very steep, have been worked out. These represent varying nature of surface inclination. Area-slope distribution is shown in Table 4.1.1 and spatial distribution of average slope categories is shown in figure 4.1A. The table 4.1.1 shows that the five slope categories occupy 0.64 per cent, 11.27 per cent, 40.24 per cent, 41.29 per cent and 6.56 per cent of the area respectively (Fig. 4.1B).

Fig. 4.1 B : Graph Showing Area (in percentage) of Tuirini River, Mizoram under different Slope Categories



Index

	Slope Category	Slope Class
1.	< 15° ■	Gentle Slope
2.	15° - 20° ■	Moderate Slope
3.	21° - 25° ■	Moderately Steep Slope
4.	26° - 30° ■	Steep Slope
5.	> 30° ■	Very Steep Slope

Table 4.1.1 Area-slope distribution

Sl.No.	Slope in degrees	Categories of slope	Area in Sq. Km.	Per centage of the total area.
1.	below 15°	Gentle	2.55	0.64
2.	15° - 20°	Moderate	44.95	11.27
3.	21° - 25°	Moderately steep	160.44	40.24
4.	26° - 30°	Steep	164.62	41.29
5.	above 30°	Very Steep	26.13	6.56
Total			398.69	100.00

4.1.2.1 Description of the slope categories

Gentle Slope : This category is represented by the slope less than 15°. It covers 2.55 sq. km. of the area (0.64 per cent of total area). It occurs in four isolated pockets, one at the southern extremity, two near the middle course and one near north-eastern corner of the watershed. This slope category is negligible as compared to other categories.

Moderate Slope : This category of slope (15° - 20°) covers about 44.95 sq. km. (11.27 per cent of the total area). It occurs in eleven isolated and elongated patches which are mainly distributed on the eastern and western flanks of the watershed. The area near the outlet of the watershed is also covered by this slope category. Besides, it also covers an elongated area one each in the middle of the lower course (near Saikhar Lui) and in the eastern part of the middle course near Kang Lui. The occurrence of moderate slope along the flanks of the watershed may be due to the settlements (Thingsulthliah, Saitual, Keifang and Ruallung villages).

Moderately Steep and Steep Slopes : These two categories of slopes (21°-30°) cover about 325.06 sq.km. (160.44 sq km and 164.62 sq km respectively) of the area (about 81.53 per cent of the total area respectively). These categories of slopes are evenly distributed throughout the watershed. These occur near Inrun Lui, Kalhzawl Lui, Tuikhang Lui, Lungding Lui, Phokphe Lui, Tuirini Lui, Dam Lui, Tuikhan Lui, Ramri Lui, Maltiak Lui, Rulchuk Lui, Hmar Lui, Maudarh Lui, Zawngsih Lui, Minpui Lui, Chal

Lui, and Sihpui Lui. High frequency of occurrence of these two categories of slopes has great impact on the existing land use pattern in the watershed.

Very Steep Slope : The last slope class having slope more than 30° has been categorised as very steep slope. This category covers about 26.13 sq km of the area (6.56 per cent of the total area). It occurs in seven small, elongated and five nearly rounded patches which are distributed randomly in the watershed. It covers areas near Khual Lui, Thangza Lui, Tuikhan Lui, Tamdil Lui, Maumit Lui, Inrun Lui and Patkhui Tlang.

4.2 Study of soil

4.2.1 General Remarks

Soil, next to water is, man's most vital natural resource. It controls the socio-economic conditions of a region. There is a tremendous pressure on soil to produce more of food, fodder, fuel, fiber etc. to meet the requirement of growing human and cattle population. At the same time, soil erosion is increasing at an alarming rate due to deforestation, shifting cultivation, landslides and non-scientific anthropogenic activities. According to an estimate, about 5334 million tones of soil (approximately 16.4 ton/ha) in India is eroded annually. Out of this, 29 per cent is permanently lost to the sea, 10 per cent is deposited in reservoirs and 61 per cent is transported from one place to another (Dhruva Narayan and Ram Babu 1983). There is urgent need therefore, to check the menace of soil erosion through effective soil and water conservation measures.

Proper understanding of the properties and genesis of soil is inevitable for its proper utilisation and conservation. Soil map provides information about the characteristics, genesis, development, classification and nomenclature of soil. Soil survey of Tuirini watershed has been done to prepare soil map (Fig. 4.2A). Besides, soil map of Thingsultliah block prepared by Soil Survey Division, Directorate of Agriculture has also been consulted (Anon. 1997).

4.2.2 Soils of Tuirini watershed

The soils of the Tuirini watershed belong to Entisol, Inceptisols and Ultisols orders. The soils found in the area at great group level are Hapludults, Dystrochrepts and Udorthents. The typifying pedons found in the watershed are comprised of mixed

mineralogy and belong to hyperthermic temperature class. The pedons are: Loamy Skeletal Umbric Dystrochrept, Loamy Skeletal Typic Dystrochrept, Loamy Skeletal Typic Hapludult, Loamy Skeletal Typic Udorthent, Loamy Skeletal Lithic Udorthent, Coarse Loamy Umbric Dystrochrept, Fine Loamy Humic Hapludult, Fine Loamy Typic Udorthent, Fine Loamy Umbric Dystrochrept, Fine Loamy Typic Dystrochrept and Fine Loamy Typic Hapludult.

4.2.2.1 Description of the soil mapping units

Tuirini watershed may be divided into three broad physiographic zones on the basis of elevation. These are :

- A. Zone with elevation above 1000m.
- B. Zone with elevation between 500m-1000m.
- C. Zone with elevation below 500m.

These zones are further subdivided into various soil units based on local variations on slopes. The details of these units are here under :

1. Hill top/Ridge : These are the highest ridges and water divide zones. Soils are dark brown in colour, deep to very deep, loamy skeletal, well drained and are subjected to severe erosion in these units. The mapping symbols used for these units are A (>1000m.), G (500m-1000m) and M (<500m). Soil association is loamy skeletal, Umbric Dystrochrept, loamy skeletal Typic Udorthent and loamy skeletal Typic Dystrochrept.

2. Very very steeply sloping hill sides : These are sides of the hills having slope <50 percent. Soils are dark brown to brown in colour, deep to very deep, loamy skeletal, well drained with severe erosion. The mapping units used are B (>1000m), H (500m-1000m) and N (<500m). The soil association is loamy skeletal Typic Dystrochrept, loamy skeletal Umbric Dystrochrept and loamy skeletal Lithic Udorthent.

3. Very steep hill side slopes : This unit is having slopes between 33-50 percent. The soils are dark brown in colour, very deep, loamy skeletal and are well drained with severe erosion. The mapping units used are C (>1000m), I (500m-1000m) and O (<500m). The soil association is loamy skeletal Typic Hapludult, loamy skeletal Umbric Dystrochrept and loamy skeletal Typic Dystrochrept.

4. Steep hill side slopes : This unit has slope between 25 - 33 percent. The soils are dark yellowish brown in colour, very deep, well drained, loamy with severe erosion. The mapping units used are D (>1000m), J (500m-1000m) and P (<500m). Soil association is loamy skeletal Umbric Dystrochrept and Fine Loamy Humic Hapludults.

5. Moderately steep to steep hill side slopes : The slope of this unit is in the range of 15-25 percent. Soils are dark brown in colour, very deep, loamy, well drained with severe erosion. The mapping symbols used are E (>1000m), K (500m-1000m) and Q (<500m). Soil association is Fine Loamy Humic Hapludult and Fine Loamy Umbric Dystrochrept.

6. Strongly sloping hill sides slopes : The sides having slope between 10-15 percent are included in this unit. The soils are dark brown in colour, very deep, loamy, well drained with severe to moderate erosion. The mapping symbols used are F (>1000m), L (500m-1000m), and R (<500m). The soil association is Fine Loamy Typic Dystrochrept and Fine Loamy Typic Hapludult.

7. Moderately sloping slopes : This unit is found in river valleys with moderately sloping land with the slope in the range of 5-10 percent. The soils in this unit are dark brown in colour, very deep, loamy, well drained with moderate erosion. The mapping symbol used is S (<500m). The soil association is Fine Loamy Typic Hapludult, Coarse Loamy Umbric Dystrochrept and Fine Loamy Typic Udorthent.

The detail account of these soil units is given in the Table 4.2.2.1.

Table 4.2.2.1 : Physiography and soil associations of Tuirini watershed

Physiographic units sq.km.	Soil Mapping units >1000m, 500-1000m,<500m			Description of Soil	Soil Taxonomy/ Soil Association	Area
1. Hill top/ Ridge	A	G	M	Dark brown, deep to very deep, loam well drained,skeletal with severe erosion	L.S.Umbric Dystrochrept L.S. Typic Udorthent L.S. Typic Dystrochrept	23.874
Side slopes						
2. Very very steep <50 %	B	H	N	Dark brown to brown deep to very deep, loam, well drained, skeletal with severe erosion	L.S.Typic Dystrochrept L.S.Umbric Dystrochrept L.S.Lithic Udorthent	143.577
3. Very steep 33-50 %	C	I	O	Dark brown,very deep,loam,well drained, skeletal with severe erosion.	L.S.Typic Hapludult L.S. Umbric Dystrochrept L.S.Typic Dystrochrept	117.829
4. Steep 25-33 %	D	J	P	Dark, yellowish, very deep, loam, well drained, severe erosion	L.S.Umbric Dystrochrept F.L. Humic Hapludult	39.562
5. Moderately Steep to steep 15 -25 %	E	K	Q	Dark brown, loam, very deep,well drained severe erosion	F.L. Humic Hapludult F.L. Umbric Dystrochrept	40.203
6. Strongly sloping 10-15 %	F	L	R	Dark brown, very deep loam, well drained, severe to moderate erosion	F.L. Typic Dystrochrept F.L. Typic Hapludult	20.510
River valley						
7. Moderately sloping 5 - 10 %			S	Dark brown, very deep, loam, well drained, moderate erosion	F.L. Typic Hapludult C.L. Umbric F.L. Typic Udorthent	13.054

4.2.3 Land capability classification

Preparation of soil map is generally succeeded by evaluation of land for land use planning. For generating data for proper land use planning, field experiment on individual soil mapping units in the pre-requisite. However, this is time taking process. Hence, planners and researchers resort to soil map for this purpose. Accordingly land capability classification, land use and soil suitability for agricultural and horticultural crops have been worked out for mapped soil units of the Tuirini watershed. Soil data from the Directorate of Agriculture, Govt. of Mizoram (Anon. 1997) has also been utilised.

Interpretative grouping of soil is done in land capability classification mainly based on:

- * Inherent soil characteristics
- * External land features and
- * An environmental factor that limits the use of land.

The factors that govern the behaviour of soil and its management are the nature of parent materials, colour, texture, structure, permeability and depth of soil profile. Based on the data generated on these aspects, area of the Tuirini watershed is divided into land capability classes II to IV and VI to VII. The land belonging to capability classes V and VIII are not found in the watershed.

Land capability class - II

This class constitutes good arable land and generally occurs on nearly level to gently sloping valley areas. The land of this class is prone to water logging during rainy season and is subjected to overflow. A few patches on this land remain wet round the year due to high water table. It is constituted of layers of fine loamy texture derived from alluvial deposits. The soils are very deep and the top surface is rich in organic matter.

This class of land is represented by symbol "S". It requires proper bunding, management of excess water, and flood protection measures. The crops that are adopted to wet conditions should be selected for this land.

Class - III

This occur on moderately sloping to strongly sloping side slopes and foot slopes with slope 10-15 percent. The soils are well drained, very deep, well aerated with good

moisture holding capacity. The surface texture on such land ranges from sandy loam to loam.

This is represented on the map by symbols F, L and R. This class of land is suitable for cultivation. Proper bunding and broad based terracing is suggested for these lands. Drainage channels and diversion drains may be provided to remove excess run-off.

Class - IV

These are found in moderately steep to steep side slopes of the hills with slope 15-25 percent. The soils are deep to very deep, well drained and well aerated. The top soil has loamy texture.

These are represented by the symbols E, K and G. These are suited for occasional or limited cultivation. Intensive soil and water conservation measures, viz., bench terracing, (inward sloping bench terraces) and contour farming using vegetative hedges may be adopted. Diversion drains and drainage channel sodded with grasses may be provided on such lands for safe removal of excess water. Water harvesting and recycling of water may be adopted in these areas. Suitable agronomic practices to retain maximum soil and moisture content may also be provided.

Class VI

This class of land occurs in steep to very steep hill sides and dissected hill slopes. These are shallow to moderately deep and the top soil is mainly loamy. This class is represented in the map by the symbols A, C, D, G, I, J, M, O and P.

This class of land may be used for horticulture cropping, and social forestry. The land should always remain under vegetative cover and intensive soil and water conservation measure should be adopted.

Class - VII

These are found in very very steep to escarpment side slope of hills and hillocks with slope more than 50 percent. The soils are moderately deep to very deep. These are subjected to severe erosion if vegetation cover is depleted. These are assigned to symbols B, H and N in the map.

This class of land may be used for forestry. Forest plantation in this land should be done along the contours. Maximum forest cover on these land may be maintained throughout the year for the control of erosion.

Land capability class VIII has not been separately delineated out of the class VII, since the former is more or less similar in its potentiality to that of the latter. Detailed description of these classes is given in the Table 4.2.3.

Table 4.2.3 : Land capability classification of the Tuirini watershed.

Land capability Class (1)	Sub Class (2)	Potential for use (3) (4)		Symbol (5)	Precautionary measures (6)	Area in sq.km
II Good cultivable land	Ile. Good soils on gentle slopes but subjected to slight erosion.	Suitable for cultivation of paddy,pulses, oil seeds etc.		S	Protection from erosion by proper levelling or bunding,proper drainage,contour strip cropping. Judicious use of manure and fertilizers.Application of lime to condition the soil.	13.054
III Moderately good cultivable land.	IIIe.Good soils on moderate to strongly sloping slopes but subjected to moderate erosion.	Suitable for cultivation of most crops but with precaution against land damage. Crops like paddy, maize, soyabean, moong,urd, mustard,potato, ginger etc. may be grown on rotation.		F	Terraces and bund-ing.Terrace risers, shoulder bunds, and safe disposal of excess water are pre-requisite. Crop rotation with leguminous plants. Application of time to condition soil is required.	20.510
				L		
				and R		
IV Fairly good	IVe.Good soils	Suitable for		E	Intensive erosion	40.103

Contd.....

land for occasion or limited cultivation	on moderately steep land susceptible for soil erosion.	cultivation of upland paddy,maize, soyabean, pulses, potato, ginger,Topioca, sweet potato, sugarcane etc. This land is also suited for horticultural crops like citrus fruits, banana, pineapple, arecanut etc. or other crops suited for high elevation	K G	control measures are required. Contour terracing, bunding with proper and safe disposal of excess water, grass sodding of terraces, shoulder bunds,water harvesting. Proper manuring,mulching, application of lime for conditioning of soil. Protection by permanent plant cover.
VI Land not suitable for agriculture but well suited for horticulture.	VIe.Steep to very steep land, ridge. Severe erosion if cover is removed.	Suitable for horticultural crops, pasture, sericulture and social forestry.	A C D G I J M O P	Pasturing should be controlled and properly managed. Terraces, half moon terraces, vegetative barriers for interception of slope along the contour is recommended for horticulture development. Planting of trees under social forestry. 181.265
Class VII. Suitable for forestry.	VIIe. Very very steep slope of hill. Susceptible for severe erosion if plant cover is removed.	Suitable for forestry only	B H N	Forest plantation along contour line, maximum cover throughout the year should be maintained. 143.577

4.3 Study of climate

4.3.1 General remarks

Climate is one of the most important factors of the geographical environment to which man is a subject (Bhakta 1992). It controls the man's activities like agriculture, forestry, supply of water, settlement, industries and tourism. The elements of the climate that control the economic development of a region are temperature, rainfall, number of rainy days, humidity, wind, cloudiness and sunshine. The climate of the Mizoram state is controlled by its location, physiography, pressure regime in the north-west India and Bay of Bengal, warm and moist maritime tropical air masses from the Bay of Bengal and local mountain and valley winds. In addition, the Chin Hills, Arakan Yoma Hill Tracts and Chittogong Hill Tracts also play an important role in shaping the climatic conditions of the state (Bhakta 1992 and Das 1970).

4.3.2 Climatic conditions in the Tuirini watershed

Climatic conditions of the Tuirini watershed have been studied considering the weather in an year. Bhakta (1992) divided the year into four distinct seasons based on the prevailing weather conditions . These are:

1. Winter season (December to February)
2. Summer season (March - May)
3. Monsoon season (June - September), and
4. Retreating monsoon season (October - November)

The climatic conditions prevailing during these four seasons in the Tuirini watershed are discussed below.

4.3.2.1 Winter Season

This season includes the period from December to February months. This is characterised by cool weather with occasional thunderstorm and frequent fog in the morning. The average climatic particulars, namely, temperature (maximum and minimum), number of rainy days, rainfall and humidity are shown in Table 4.3.2.1 and Fig. 4.3D. The same have been worked out for the last ten years (from 1991-2000). The mean maximum temperature for the last ten years is 22.3°C whereas the mean minimum temperature is 12.6° in this season. The average (of ten years) rainfall in the watershed is

5.7cm and the average number of rainy days are 7. It may be pertinent to mention here that rain in the winter season is under the influence of N-E monsoon. The average humidity for the last 10 years in this season is 69.7 percent.

4.3.2.2 Pre-Monsoon

The months of March, April and May constitute the pre-monsoon or summer season in the area. The temperature gradually rises by the beginning of the month of March. The season is characterised by high temperature, occasional thundershowers and the absence of fog. The morning hours are pleasant with cool weather but afternoon becomes unpleasant due to high temperature particularly in the low lying areas of the watershed. Table 4.3.2.2 (Fig. 4.3A) shows average climatic particulars of Tuirini watershed during this season for the last 10 years (1991-2000). The mean maximum temperature in this season is 28.2°C whereas the mean minimum temperature is 18.5°C. The average rainfall is 55.54cm and the average rainy days are 37. The average humidity is 74.2 percent. In the late summer season, the amount and frequency of rainfall increases and the daily range of temperature decreases. During this season, the sunny warm days are sometimes interrupted by cloudy and stormy weather.

4.3.2.3. Monsoon Season

The monsoon or rainy season in the watershed includes months of June, July, August and September. This season is characterised by cloudy weather, high humidity and weak variable winds. There is heavy rainfall and consequently the temperature falls with the onset of monsoon in the early part of June. The rainfall in the area is due to South-West Monsoon. Table 4.3.2.3 and Fig.4.3B shows average climatic particulars in the watershed for the last 10 years (1991-2000). The mean maximum and minimum temperature are 26.7°C and 20.1°C respectively. The average rainfall is 147.20cm and average rainy days are 103 in the watershed. The average humidity is 87.3 per cent.

4.3.2.4 Retreating Monsoon Season

Retreating Monsoon Season or Post Monsoon Season in the watershed covers months of October and November. The withdrawal of the monsoon is gradually followed by the clear sky, downward trend in temperature and morning fog. Table 4.3.2.4 and Fig. 4.3C shows average climatic particulars of the watershed for the last 10 years (1991-

2000). The mean maximum and minimum temperatures in this season are 26.3°C and 17.8°C respectively. The average rainfall is 22.83cm and average rainy days are 18. The average humidity is 80.2 per cent.

The Table 4.3.2.5 and Fig. 4.3E shows average climatic particulars of the Tuirini watershed from 1991-2000 whereas Table 4.3.2.6 and Fig. 4.3F shows season wise average climatic particulars of the watershed from 1991-2000.

Table 4.3.2.1: Average climatic particulars of Tuirini watershed in winter season (December- February) from 1991-2000.

Year	Mean max. temp. (degrees)	Mean min.temp. (degrees)	Total no. of rainy days	Total rainfall (in cm)	Average humidity (in per cent)
1991	21.6	12.3	8	3.42	65.3
1992	17.6	10.6	10	3.51	82.0
1993	21.9	11.0	10	9.70	69.0
1994	22.5	13.8	5	3.08	64.7
1995	21.5	14.9	4	2.50	67.0
1996	21.5	12.1	5	9.32	72.1
1997	21.8	12.1	7	10.72	78.8
1998	22.8	14.1	6	10.97	70.0
1999	28.6	12.9	3	2.8	66.0
2000	23.3	11.9	8	1.34	62.0
Average	22.3	12.6	7	5.7	69.7

Source: Compiled from the data collected from the meteorological register of Puspak Project, Zemabawk, Aizawl, Mizoram.

Table 4.3.2.2 : Average climatic particulars of Tuirini watershed in pre-monsoon season (March-May) from 1991-2000.

Year	Mean max. temp. (degrees)	Mean min.temp. (degrees)	Total no. of rainy days	Total rainfall (in cm)	Average humidity (in per cent)
1991	29.1	17.7	40	38.61	72.0
1992	27.1	18.3	30	33.46	73.4
1993	27.5	17.1	42	93.23	68.5
1994	28.4	17.6	39	48.22	69.0
1995	30.3	20.5	30	11.89	67.4
1996	28.3	22.2	32	62.69	79.5
1997	26.4	17.7	53	48.98	83.6
1998	27.1	16.9	32	80.36	74.0
1999	30.8	19.5	33	52.47	68.0
2000	27.0	17.0	38	85.52	87.0
Average	28.2	18.5	37	55.54	74.2

Source: Compiled from the data collected from the meteorological register of Puspak Project, Zemaabawk, Aizawl, Mizoram.

Table 4.3.2.3: Average climatic particulars of Tuirini watershed in monsoon season (June-September) from 1991-2000

Year	Mean max. temp. (degrees)	Mean min.temp. (degrees)	Total no. of rainy days	Total rainfall (in cm)	Average humidity (in per cent)
1991	26.4	19.5	96	167.54	90.5
1992	27.0	19.1	116	118.99	87.5
1993	24.8	18.9	95	210.30	89.0
1994	28.0	19.9	90	153.66	87.0
1995	26.5	22.0	108	136.27	81.1
1996	28.3	22.1	98	137.39	88.0
1997	26.1	20.4	106	156.25	90.0
1998	27.3	20.5	100	121.84	84.0
1999	26.5	19.4	110	153.88	89.4
2000	26.7	18.9	106	116.30	87.2
Average	26.7	20.1	103	147.20	87.3

Source: Compiled from the data collected from the meteorological register of Puspak Project, Zemabawk, Aizawl, Mizoram.

Table 4.3.2.4: Average climatic particulars of Tuirini watershed in retreating monsoon season (October - November) from 1991-2000

Year	Mean max. temp. (degrees)	Mean min.temp. (degrees)	Total no. of rainy days	Total rainfall (in cm)	Average humidity (in per cent)
1991	24.4	16.4	17	38.46	78.5
1992	25.5	16.5	22	25.42	88.5
1993	26.3	14.6	16	17.22	87.5
1994	26.6	16.2	16	12.33	71.7
1995	24.2	20.0	33	41.70	64.1
1996	26.9	21.9	23	11.20	83.0
1997	26.3	17.2	8	13.67	82.3
1998	28.3	18.8	6	12.83	77.2
1999	27.3	19.6	26	19.90	85.0
2000	27.2	17.1	10	35.59	84.0
Average	26.3	17.8	18	22.83	80.2

Source: Compiled from the data collected from meteorological register of Puspak Project, Zemabawk, Aizawl, Mizoram.

Table 4.3.2.5: Average climatic particulars of Tuirini watershed, Mizoram from 1991-2000

Year	Mean max. temp. (degrees)	Mean min. temp. (degrees)	Total no. of rainy days	Total rainfall (in cm)	Average humidity (in per cent)
1991	25.37	16.47	161	248.03	76.57
1992	24.30	16.12	178	181.38	82.85
1993	25.12	15.40	163	330.45	78.50
1994	26.37	16.87	150	217.29	73.10
1995	25.62	19.35	175	192.36	69.90
1996	26.25	19.37	158	220.06	80.65
1997	25.15	16.85	174	229.62	83.67
1998	26.37	17.75	144	226.00	76.30
1999	28.30	17.85	172	229.05	77.10
2000	26.05	16.22	162	238.75	80.05
Average	25.89	17.25	165	231.27	77.85

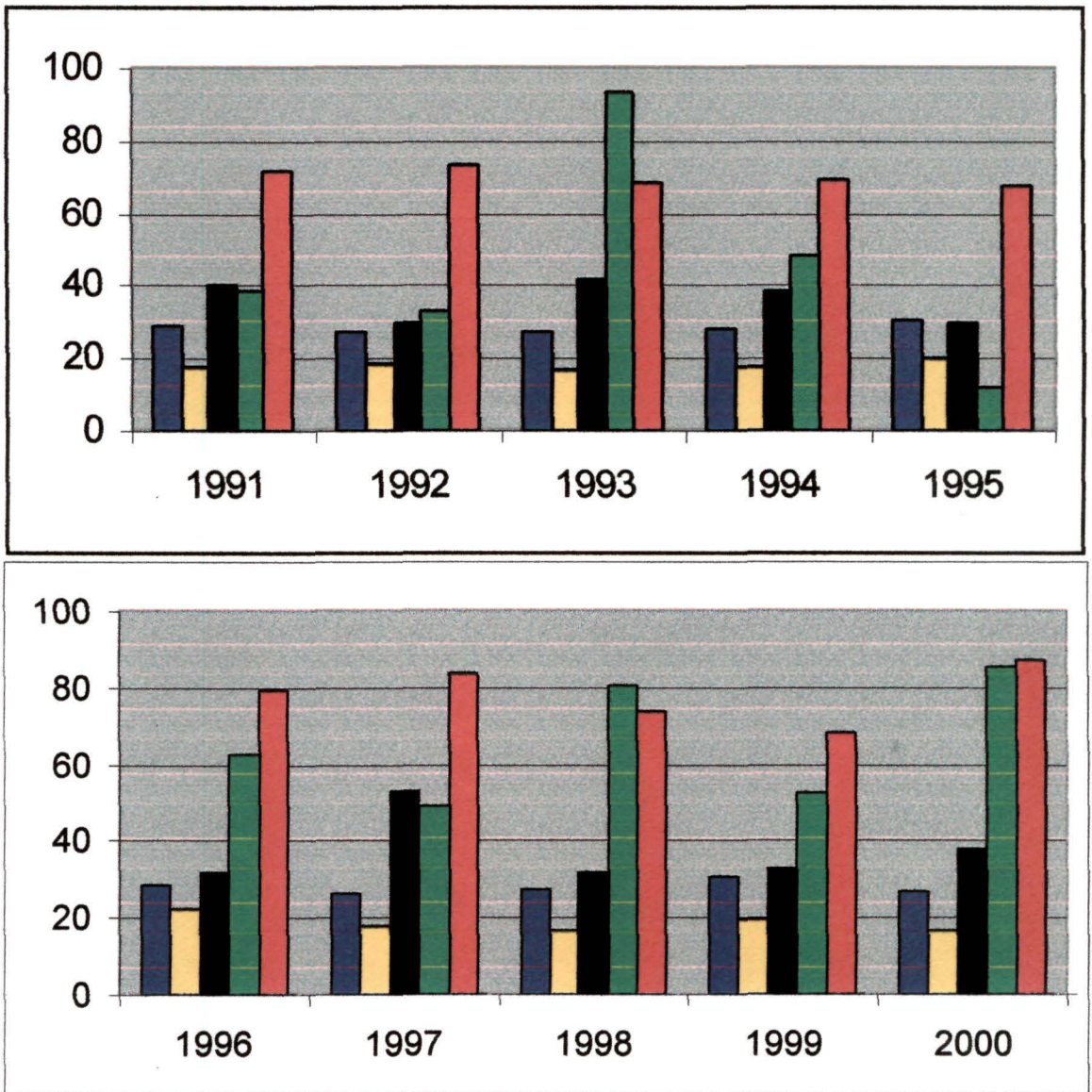
Source: Compiled from the data collected from meteorological register of Puspak Project, Zemabawk, Aizawl, Mizoram.

Table 4.3.2.6: Season wise average climatic particulars of Tuirini watershed from 1991-2000

Climatic seasons	Mean max. temp. (degrees)	Mean min.temp. (degrees)	Average rainy days	Average rainfall (in cm)	Average humidity (in per cent)
Pre-monsoon season (Mar-May)	28.2	18.5	37	55.54	74.2
Monsoon season (June-Sept.)	26.7	20.1	103	147.20	87.3
Retreating monsoon season. (Oct.-Nov.)	26.3	17.8	18	22.83	80.2
Winter season (Dec.-Feb.)	22.3	12.6	7	5.70	69.7
Average	25.88	17.25	165	231.27	77.85

Source: Compiled from the data collected from meteorological register of Puspak Project, Zemabawk, Aizawl, Mizoram.

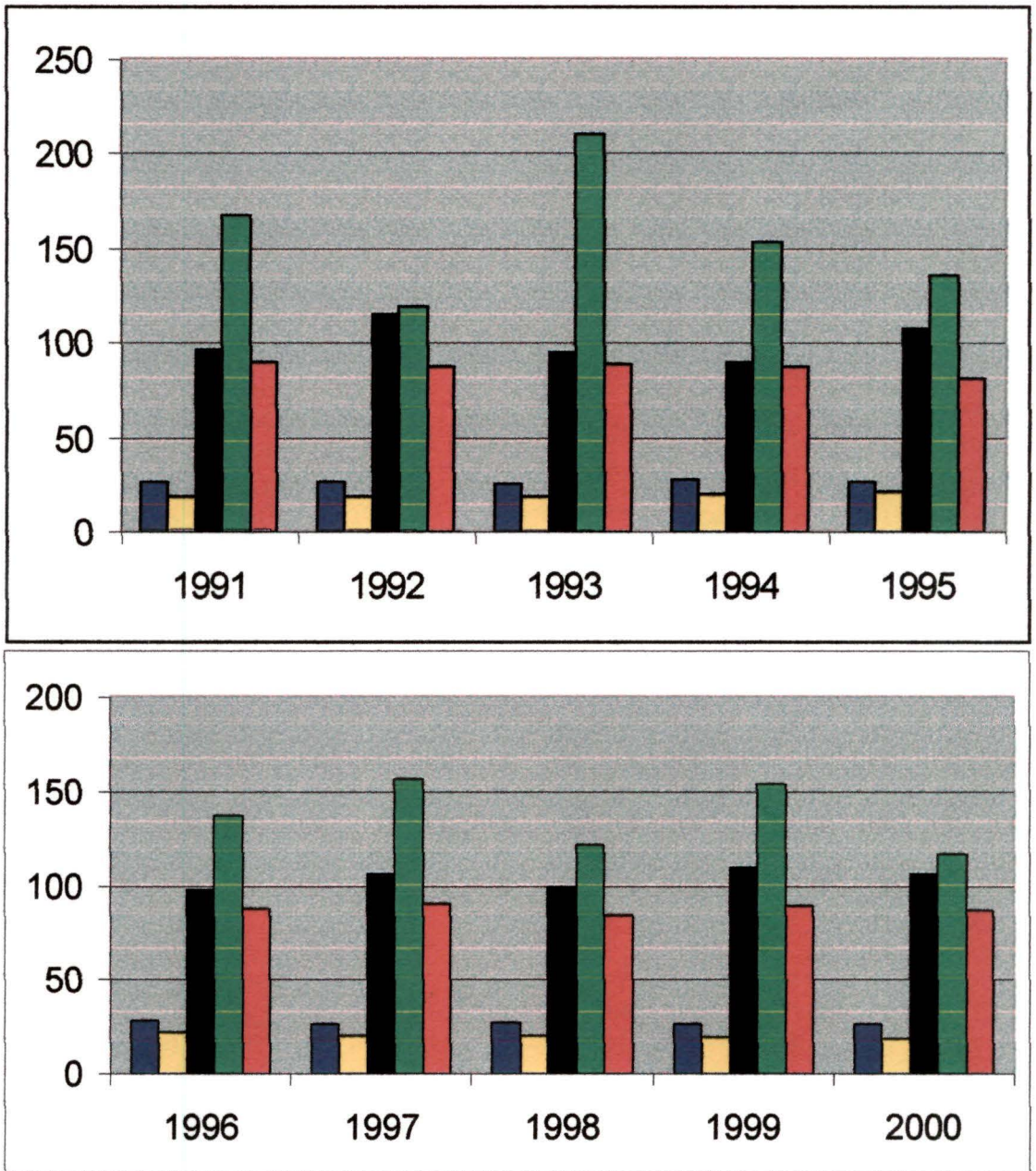
Fig. 4.3 A : Graph Showing Climatic Particulars of Study Area During Pre-monsoon Season (March-May) from 1991-2000.



Index

- Mean Max. Temp. (degrees)
- Mean Min. Temp. (degrees)
- Total no. of rainy days
- Total rainfall (in cm)
- Average humidity (in percent)

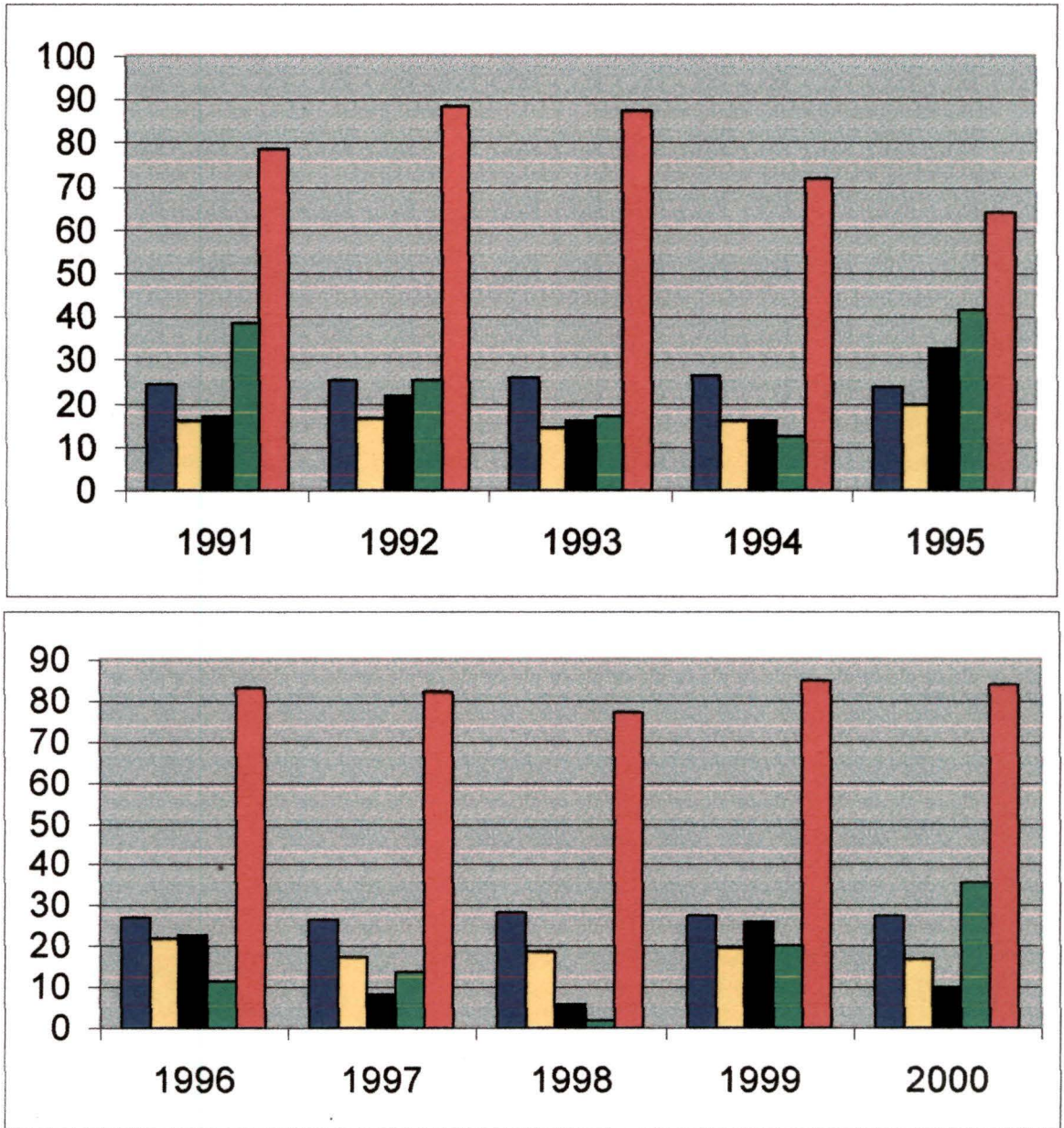
Fig. 4.3 B : Graph Showing Climatic Particulars of Study Area During Monsoon Season (June-September) from 1991-2000.



Index

- Mean Max. Temp. (degrees)
- Mean Min. Temp. (degrees)
- Total no. of rainy days
- Total rainfall (in cm)
- Average humidity (in percent)

Fig. 4.3 C : Graph Showing Climatic Particulars of Study Area During Retreating Monsoon Season (October-November) from 1991-2000.



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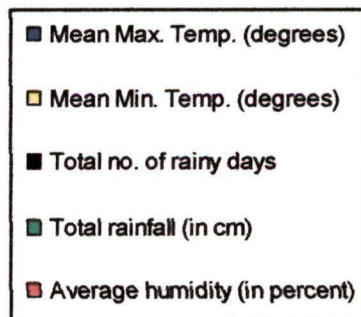
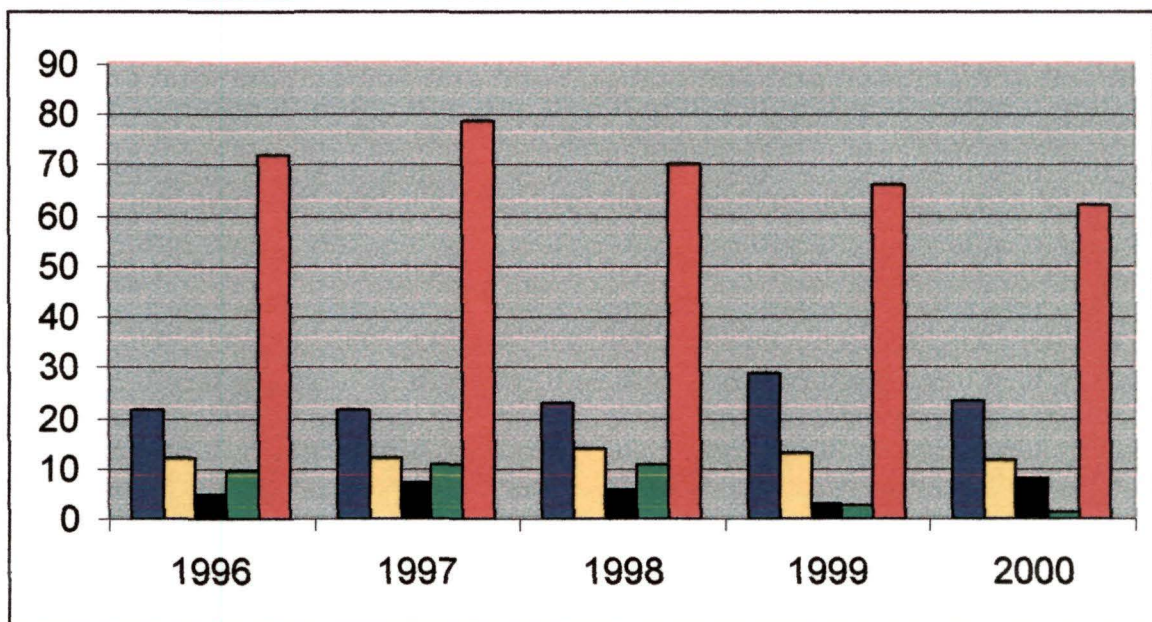
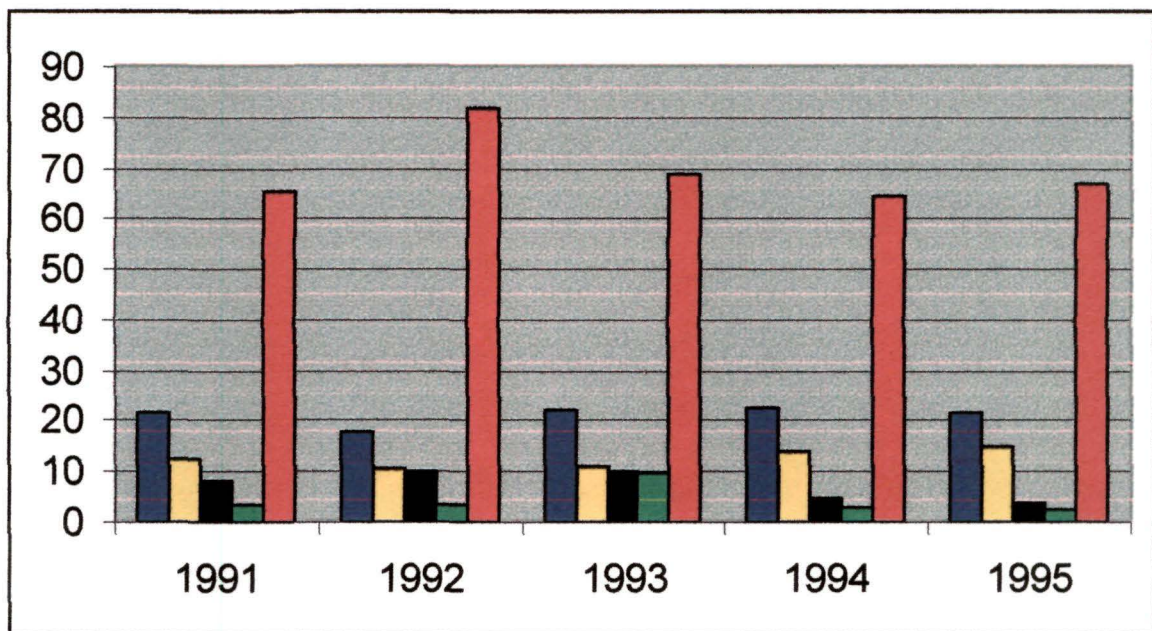


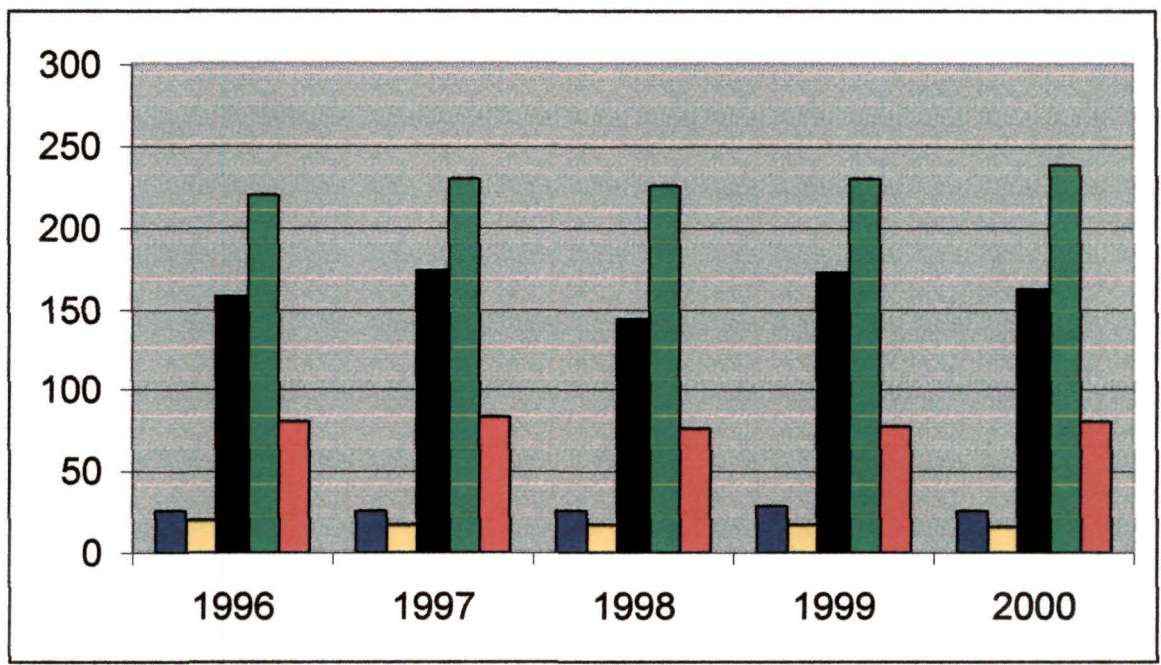
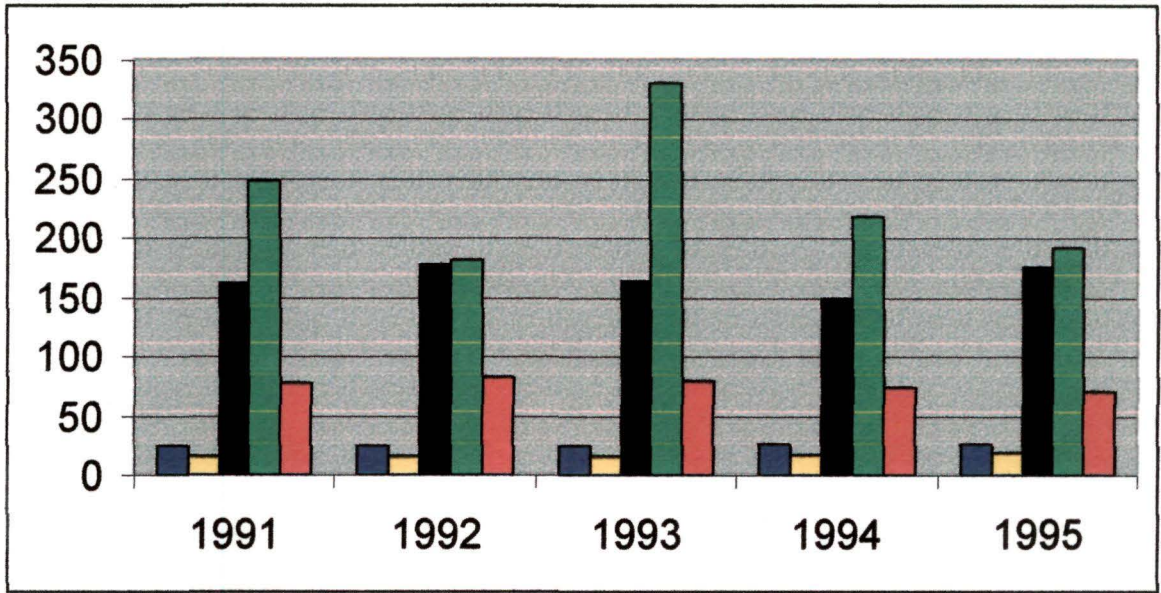
Fig. 4.3 D : Graph Showing Climatic Particulars of Study Area During Winter Season (December-February) from 1991-2000.



Index

- Mean Max. Temp. (degrees)
- Mean Min. Temp. (degrees)
- Total no. of rainy days
- Total rainfall (in cm)
- Average humidity (in percent)

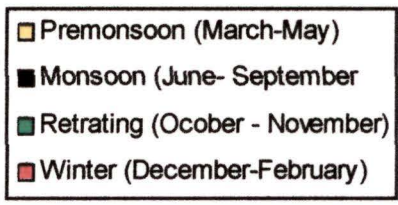
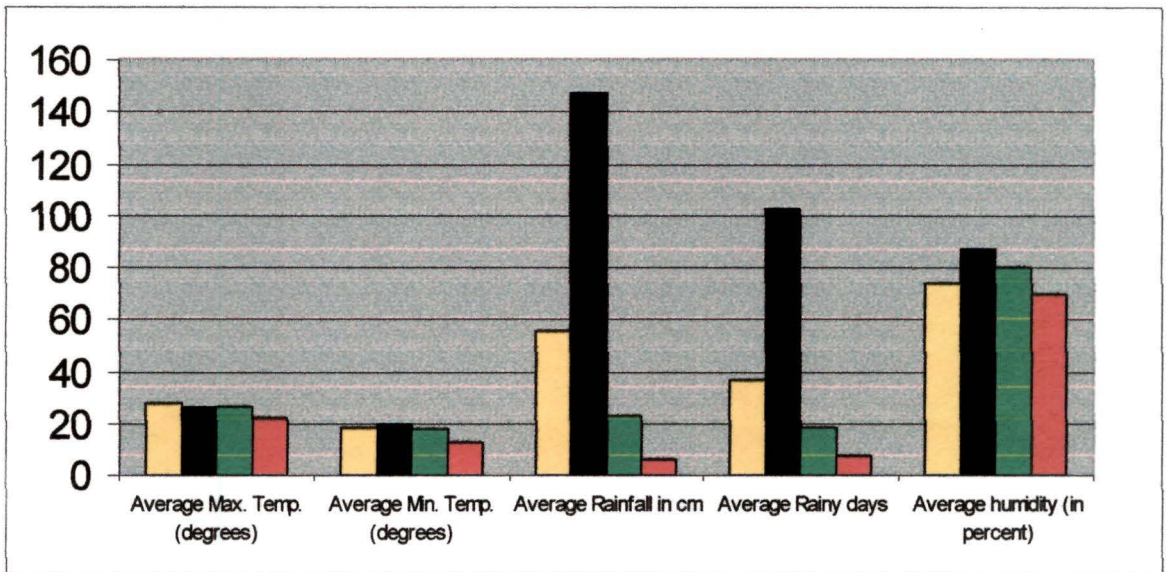
Fig. 4.3 E : Graph Showing Average Climatic Particulars of Study Area from 1991-2000.



Index

- Mean Max. Temp. (degrees)
- Mean Min. Temp. (degrees)
- Total no. of rainy days
- Total rainfall (in cm)
- Average humidity (in percent)

Fig. 4.3 F : Graph Showing Seasonwise Average Climatic Particulars of Study Area from 1991-2000.



4.4 Physiography of Tuirini watershed

4.4.1 General Remarks

The growing pressure on land for food, fibre, fodder and industrial expansion due to ever increasing population has given rise to competing and conflicting demands on finite land and water resources. About 175 mha of land in India, constituting about 53 per cent of her total geographical area, suffers from deleterious effect of soil erosion and other forms of land degradation (Biswas *et al.* 1999). It is estimated that in India, about 5334 million tones of soil (approximately 16.4 ton/ha is eroded annually, out of which 29 per cent is permanently lost to the sea, 10 per cent is deposited in reservoirs and 61 per cent is transported from one place to another (Samraj and Raghunath 1990, Dhruva Narayan and Babu 1983). Keeping in view of the ever increasing population and need for food security for future generation, all efforts are being made to check the menace of soil erosion. For this, the water and land resources need to be developed, used and managed in an integrated and comprehensive manner. Soil and water conservation measures carried out on a watershed basis play a prominent role in the strategy of comprehensive land and water management.

Since watershed is a surface area drained by a part or the totality of one or several water courses, it can be taken as a basic erosional landscape element where land and water resources interact in a perceptible manner. The proper use of land and water resources of a watershed, therefore, is must for optimum production utilization with minimum hazard to natural resources. This can only be achieved by proper understanding of the physical behaviour(character) of the watershed. Evaluation of various morphometric parameters and examination of their interrelationship are a necessary input for understanding the physiography of any watershed. Moreover, quantitative analysis of drainage system is an important aspect of characterisation of watershed (Strahler 1964).

Keeping this in view, evaluation of different morphometric parameters of Tuirini watershed have been carried out to understand its physical behaviour. The data thus generated is used for estimation of run-off and sediment yield.

4.4.2 Estimation of morphometric parameters of Tuirini watershed

Proper evaluation of hydrologic behaviour of a watershed must be made before preparing a comprehensive watershed management plan. Evaluation of different watershed parameters and their inter-relationship is essential to know the hydrologic behaviour of a watershed.

Tuirini watershed is divided into 25 well defined micro-watersheds (4.4A-C). The various morphometric attributes of independent nature were computed for each of the micro-watersheds of Tuirini watershed from the contour and drainage maps. These attributes are helpful in calculating different morphometric parameters of the watersheds.

These are as follows :

- a) Watershed area (A)
- b) Length of the watershed (L_b): It is the longest side of the triangle enclosing the watershed.
- c) Perimeter of the watershed (L_p).
- d) Length of the main stream (L_s) : Length of the principal drainage line.
- e) Cumulative length of the stream (L_u) : It is the total length of the streams of different order.
- f) Horizontal distance parallel to main stream (L_h) : It is the distance parallel to principal drainage flow.
- g) Length of the remotest point to the outlet (L_r) : It is the distance between outlet and the hydraulically farthest point.
- h) Maximum elevation (H_s) : It is the elevation of the highest point in the watershed.
- I) Minimum elevation (H_d) : It is the elevation of the lowest point in the watershed.
- j) Elevation of the remotest point (H_r) : It is the elevation of the hydraulically remotest point in the watershed.
- k) Watershed relief (H) : It is the difference in elevation between the remotest point (H_r) and lowest point in the watershed.

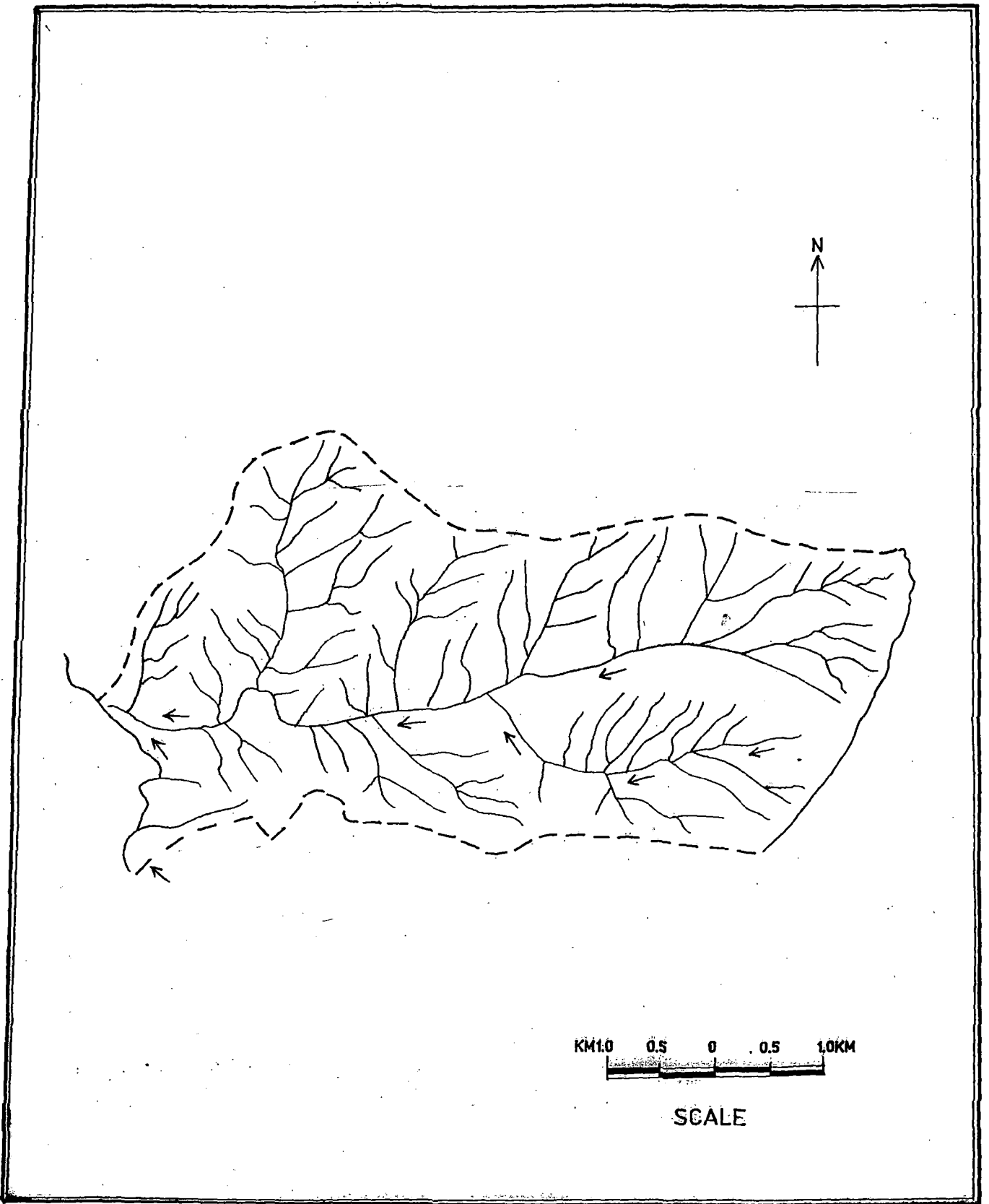


Fig 4.4B Drainage Map of Microwatershed No. 12

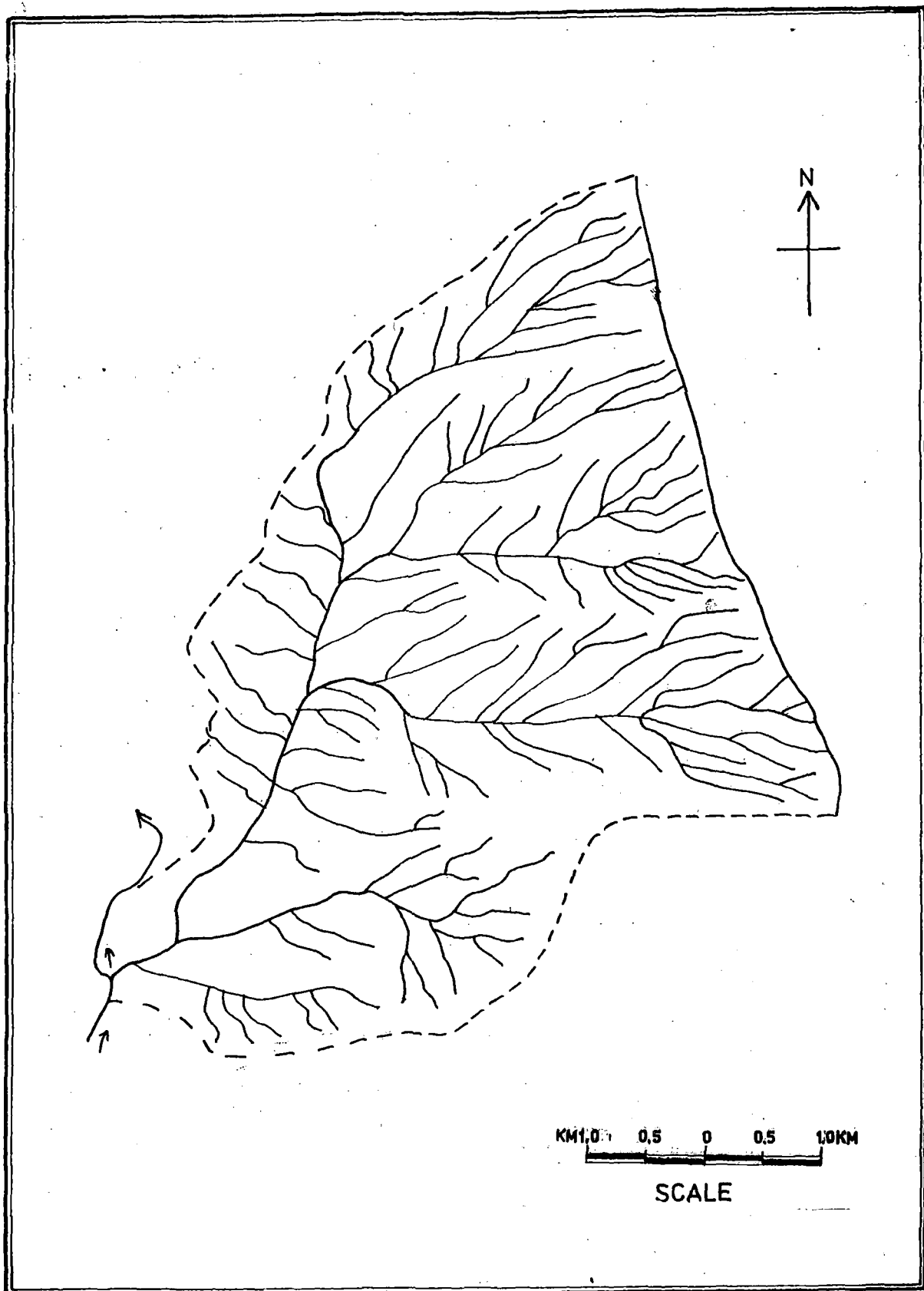


Fig 4.4C Drainage Map of Microwatershed No.22

- l) Number of stream order (N_i) : It is the total number of streams of a particular order.
- m) Total number of stream (N_s) : It is the total number of streams of different orders.
- n) Contour interval (N) : It is the difference in elevation between the two successive contours.
- o) Equivalent diameter (D) : It is the diameter of a circle having equal area of the watershed.
- p) Equivalent circumference (C) : It is the circumference of a circle having equal area of the watershed expressed in km.
- q) Equivalent area (A_c) : It is the area of a circle having diameter equal to the length of the watershed.

These parameters are mentioned in Table 4.4.2.

Table 4.4.2: Morphometric parameters of independent nature

Micro-watershed No.	A sq.km	Lb km	Lp km	Ls km	Lu km	Lh km	Lr km	Hs m	Hd m
1.	6.71	4.10	11.55	5.50	52.10	4.75	4.50	1060	450
2.	8.50	3.60	11.75	4.60	30.83	4.25	4.50	980	450
3.	6.42	4.30	13.50	6.00	23.23	4.75	6.00	1446	450
4.	4.38	3.70	10.50	4.60	12.20	2.65	5.50	1220	360
5.	5.10	4.00	11.50	3.80	17.00	2.75	3.75	1416	360
6.	5.93	3.50	10.35	4.40	22.10	3.00	3.25	1443.9	360
7.	8.68	5.00	17.25	7.50	43.34	4.75	7.50	1156	360
8.	5.63	5.25	13.25	7.50	33.95	4.75	8.50	860	330
9.	19.06	6.25	18.50	6.25	71.50	5.20	7.75	1780	330
10.	10.83	6.25	17.00	6.50	42.50	5.90	8.00	1500	300
11.	15.40	5.75	18.15	7.25	67.00	6.70	7.00	1149	300
12.	20.45	7.75	21.50	8.45	87.00	7.80	8.50	1700	290
13.	12.38	5.25	19.50	6.90	57.00	6.00	8.65	1140	260
14.	7.41	6.00	15.75	4.10	43.50	3.10	6.75	940	250
15.	27.48	8.75	26.40	13.00	108.70	9.25	12.50	1440	250
16.	20.22	7.50	21.20	10.00	78.00	6.35	12.50	1030	235
17.	32.12	8.50	31.00	12.00	149.00	8.60	13.00	1160	240
18.	50.60	12.50	41.00	13.80	223.00	11.50	13.90	1900	240
19.	13.86	8.00	22.10	8.60	39.50	8.00	10.50	1064	130
20.	22.75	7.75	18.50	7.50	132.00	6.50	10.00	935	175
21.	14.96	6.50	20.00	9.95	60.00	7.50	7.65	921	110
22.	24.15	7.50	23.90	8.50	100.50	7.90	9.50	1900	130
23.	20.86	7.50	23.37	10.20	126.50	8.20	9.25	1820	125
24.	11.95	7.75	17.57	9.10	43.00	7.50	9.00	700	80
25.	23.45	8.75	22.40	12.00	61.50	9.60	6.00	1064	99

contd.....

Watershed No.	Ci Contour interval	Ns	Hr m	D	C	Ac
1.	20	36	960	2.92	9.17	13.19
2.	20	60	900	3.20	10.05	10.17
3.	20	41	1446	2.86	8.98	14.51
4.	20	30	1220	2.36	7.41	10.74
5.	20	34	1416	2.55	8.00	12.50
6.	20	45	995	2.74	8.63	9.61
7.	20	79	1050	3.32	10.44	19.62
8.	20	63	860	2.67	8.40	21.63
9.	20	104	1780	4.92	15.47	30.66
10.	20	69	1500	3.71	11.66	30.66
11.	20	123	1149	4.42	13.87	25.95
12.	20	124	1700	5.10	16.02	47.14
13.	20	90	1140	3.99	12.52	21.63
14.	20	76	940	3.07	9.64	28.26
15.	20	194	1440	5.91	18.57	60.10
16.	20	148	1020	5.08	15.96	44.15
17.	20	245	1160	6.29	19.76	56.71
18.	20	349	1900	8.02	25.21	122.65
19.	20	80	1064	4.04	12.71	50.24
20.	20	138	930	5.30	16.44	44.15
21.	20	80	920	4.36	13.70	33.16
22.	20	138	1820	5.88	18.46	44.15
23.	20	126	1820	5.15	16.18	44.15
24.	20	92	700	3.90	12.25	44.14
25.	20	73	1064	5.46	17.16	60.10

Morphometric parameters of any watershed can be expressed in terms of its shape, drainage and topographic factors. These factors are helpful in designing run-off and sediment yield and are discussed hereunder.

4.4.2.1 Watershed shape factors

The shape of watershed has a considerable effect on the stream discharge characteristics and as such on sedimentation. Various forms related to shape of a watershed are as follows :

a) **Shape index (Si)** : This is a dimensionless factor and calculated by the equation (Horton 1932):

$$Si = \frac{Ls^2}{A}$$

where A= area of the watershed and Ls is the length of the main stream. When Si approaches unity, erosion tends to be maximum, with higher values of Si, erosion decreases.

b) **Form factor (Ff)** : According to Strahler (1957), the ratio of the basin area to the square of the basin length in the form factor. It can be expressed as :

$$Ff = \frac{A}{Lb^2}$$

where Lb is the length of the watershed.

c) **Compactness coefficient (Cc)** : It is a measure of a watershed compactness and is determined by the following equation (Morisawa 1958).

$$Cc = \frac{0.282 Lp}{A^{0.5}}$$

where Lp is the perimeter of the watershed.

d) **Elongation Ratio (Re)** : Schumm (1956) defined it as the ratio of the diameter of a circle of the same area as the watershed to the maximum length of the basin. He proposed the following equation to determine the Re. He said that this ratio varies between 0.6 and 1 over a wide range of climatic and geological conditions. Values

nearer to 1 are typical type of regions of very low relief whereas values in the range of 0.6 to 0.8 are generally associated with stony and steep ground slope.

$$R_e = \frac{1.128 A^{0.5}}{L_b}$$

e) **Circulatory ratio (Cr)** : Miller (1964) defined Cr as the ratio of the area of the watershed to the area of a circle having the same circumference as the perimeter of the basin. Thus,

$$C_r = \frac{4 \pi A}{2P^2}$$

f) **Rotundity factor (Rf)** : Charley, Malm and Zelski (1957) used the following relationship to express Rf:

$$R_f = \frac{\pi L_b^2}{4 A}$$

If $R_f = 1$, the basin outline is a circle.

These watershed shape factors are computed for the 25 micro-watersheds of Tuirini watershed and are given in the Table 4.4.2.1

Table 4.4.2.1 : Shape parameters of the micro-watersheds of Tuirini watershed, Mizoram

Watershed No.	Si	Ff	Cc	Re	Cr
1.	4.50	0.39	1.25	0.71	0.63
2.	2.48	0.65	1.13	0.91	0.77
3.	5.60	0.34	1.50	0.66	0.44
4.	4.82	0.32	1.41	0.63	0.49
5.	2.82	0.31	1.43	0.63	0.48
6.	3.26	0.48	1.19	0.78	0.69
7.	6.47	0.34	1.65	0.66	0.36
8.	9.98	0.20	1.57	0.50	0.40
9.	2.04	0.48	1.19	0.78	0.69
10.	3.90	0.27	1.45	0.59	0.47
11.	3.41	0.46	1.30	0.76	0.58
12.	3.49	0.34	1.34	0.65	0.55
13.	3.84	0.44	1.56	0.76	0.40
14.	2.26	0.20	1.63	0.51	0.37
15.	6.14	0.31	1.42	0.67	0.49
16.	4.94	0.35	1.32	0.67	0.56
17.	4.48	0.52	1.54	0.75	0.41
18.	3.76	0.32	1.62	0.64	0.37
19.	5.33	0.21	1.67	0.52	0.35
20.	2.54	0.39	1.11	0.70	0.80
21.	6.61	0.35	1.45	0.67	0.46
22.	2.99	0.42	1.37	0.73	0.53
23.	4.98	0.37	1.44	0.68	0.47
24.	6.90	0.21	1.43	0.52	0.48
25.	6.13	0.30	1.30	0.62	0.58

4.4.2.2 Drainage pattern factors

The efficiency of a drainage system and resulting run-off rate depend upon the drainage pattern. The following are the factors that define the drainage pattern :

(a) Stream order

Horton (1932 and 1945) first introduced the scheme of stream ordering in the United States. This was slightly modified by Strahler (1954 and 1964). According to this, all the first unbranched streams at the beginning of the stream flow are designated as first order. When two first order streams join, they form second order stream, when two second order streams join, they form a third order stream and so on. The main stream into which all the streams finally discharge in the segment of the highest order.

Stream ordering of Tuirini watershed has been done following this scheme and the number of streams belonging to different orders have been counted (Table 4.4.2.3). The main stream belongs to sixth order.

(b) Bifurcation ratio (Rb)

Rb was defined by Horton (1932) as

$$Rb = \frac{N_i}{N_{i+1}}$$

where N_i = Number of streams of given order.

N_{i+1} = Number of streams of next higher order.

Rb would not precisely be the same from one order to next, but it would always tend to be constant throughout the series.

(c) Drainage density (Dd)

Horton (1932) defined Dd as the ratio of the cumulative length of the stream of a watershed to its area. Therefore,

$$Dd = \frac{Lu}{A}$$

In general, low Dd indicates region of highly resistant, highly permeable sub-soil material under dense vegetative cover and low relief. Conversely, high Dd indicates region of impermeable sub-surface material, sparse vegetation and mountainous relief.

(d) Stream frequency (Sf)

Sf was defined by Horton (1945) as a measure of number of streams per unit drainage area. It is calculated by the equation

$$Sf = \frac{Ns}{A}$$

The higher values of Sf indicate higher intensity of erosion.

(e) Stream grade (Sg %)

It is the ratio of the difference in the elevation of the highest point at which the stream emerges and the elevation of the discharge point to the length of the main stream given in percentage. It is given by the relation

$$Sg [\%] = \left(\frac{Hs - Hd}{Ls} \right) \times 100$$

The higher the value of Sg(%), the higher would be the extent of erosion.

(f) Length of overland flow (Lo)

The surface run-off of rain water before it is localized into definite channels is the length of overland flow (Horton 1945).

Linsley *et al.* (1975) evaluated the approximate value of the length of overland flow using the following formula :

$$Lo = \frac{1}{2Dd}$$

It is one of the most important independent variables affecting both the hydrologic and physiographic development of the drainage basin.

(g) Time of concentration (Tc)

This is the time required for the water to travel from the hydraulically remotest point to the outlet and is expressed by

$$Tc = 0.0195 \{ Lr^3/H \}^{0.385}$$

The above drainage parameters are shown in Table 4.4.2.2.

Table 4.4.2.2 : Drainage pattern parameters of the micro-watersheds of Tuirini watershed, Mizoram

Watershed No.	Rb	Dd in per m.	Sf in per sq.km.	Sg in percent	Lo in Kms.	Tc in minutes
1.	5.41	0.0077	5.36	11.09	0.64	9.31
2.	3.74	0.0036	7.05	11.52	0.13	30.76
3.	4.46	0.0036	6.38	16.10	0.13	31.58
4.	3.53	0.0027	6.84	18.69	0.17	30.22
5.	2.81	0.0033	6.65	27.78	0.21	17.94
6.	2.83	0.0037	7.58	17.81	0.13	18.50
7.	5.67	0.0049	9.09	10.61	0.10	47.07
8.	4.82	0.0060	11.18	7.06	0.08	60.20
9.	4.39	0.0036	5.45	23.20	0.13	34.00
10.	5.28	0.0033	6.36	18.46	0.12	40.98
11.	3.92	0.0043	7.98	11.71	0.11	40.13
12.	3.89	0.0041	6.06	16.68	0.11	41.31
13.	3.29	0.0046	7.26	12.75	0.10	50.54
14.	5.54	0.0058	10.25	16.82	0.11	41.67
15.	4.32	0.0039	7.05	9.15	0.12	68.84
16.	3.92	0.0038	7.31	7.95	0.12	80.80
17.	3.18	0.0046	7.62	7.66	0.10	79.53
18.	3.49	0.0044	6.89	12.02	0.11	68.46
19.	5.75	0.0028	5.76	10.86	0.17	61.76
20.	4.75	0.0058	6.25	10.13	0.08	63.39
21.	9.28	0.0040	5.34	8.15	0.12	45.27
22.	4.72	0.0041	5.71	20.82	0.12	43.80
23.	4.63	0.0060	6.03	16.61	0.08	42.43
24.	4.27	0.0035	7.69	6.81	0.13	60.55
25.	5.41	0.0026	3.11	8.04	0.19	31.97

Table 4.4.2.3 : Streams orders and bifurcation ratio of the micro-watersheds of Tuirini watershed, Mizoram

Water-shed No.	No. of I order stream	No. of II order stream	No. of III order stream	No. of IV order stream	No. of V order stream	No. of VI order stream	Total No. stream	Average Rb
1.	29	6	1	-	-	-	36	5.41
2.	47	9	3	1	-	-	60	3.74
3.	33	6	1	1	-	-	41	4.46
4.	23	5	1	1	1	-	30	3.53
5.	25	4	2	2	1	-	34	2.81
6.	32	6	2	1	1	-	42	2.83
7.	63	13	2	-	1	-	79	5.67
8.	43	7	2	-	1	-	53	4.82
9.	83	16	4	1	-	-	104	4.39
10.	53	13	2	-	1	-	69	5.28
11.	102	16	3	1	1	-	124	3.82
12.	100	19	3	1	1	-	124	3.89
13.	67	17	4	1	1	-	90	3.29
14.	61	12	2	-	1	-	76	5.54
15.	150	35	7	1	1	-	194	4.32
16.	114	26	6	1	1	-	148	3.92
17.	194	36	8	4	2	1	245	3.18
18.	270	60	14	3	1	1	349	3.49
19.	66	11	2	-	-	1	80	5.75
20.	107	24	5	1	-	1	138	4.75
21.	64	14	1	-	-	1	80	9.28
22.	105	24	5	-	-	1	135	4.72
23.	97	22	5	1	-	1	126	4.63
24.	69	18	3	1	-	1	92	4.27
25.	58	12	2	-	-	1	73	5.41

4.4.2.3 Topographic factors

Relief and topographic features are indicative of the potential energy of a drainage basin by virtue of its elevation above a given datum. The various topographic factors affecting the performance of a watershed that have been estimated are as follows :

(a) **Total watershed relief (H)** : The difference in elevation between the remotest point in the watershed to the discharge point of a watershed is termed as total watershed relief and is expressed as

$$H = H_r - H_d$$

(b) **Relief ratio (Rh)** : Schumm (1956) gave a measure of Rh as the ratio of total watershed relief (H) to the horizontal distance along the longest dimension of the basin parallel to the principal or the horizontal distance on which H is measured (Lh) and is expressed as

$$R_h = H/L_h$$

It measures the overall steepness of a watershed. The higher the Rh values, the higher is the intensity of erosion.

(c) **Relative relief (Rr)** : Melton (1964) used the following expression to measure Rr :

$$R_r = H/L_p \times 100$$

(d) **Ruggedness number (Rn)** : This is the product of the total watershed relief (H) and the drainage density

$$R_n = H \times D_d$$

Ruggedness number is high when both Rr and Dd are high. Extremely high values of Rn occurs when both variables are large *i.e.* when slopes are not only steep but long as well.

(e) **Channel maintenance factor (Cm)**:

It was proposed by Schumm (1956). It gives the number of sq. kms. of watershed surface required to sustain one linear km of channel and is expressed as

$$C_m = 1/D_d$$

These topographic factors are shown in the following Table 4.4.2.4

Table 4.4.2.4 : Topographic parameters of the micro watersheds of Tuirini watershed, Mizoram

Micro-watershed No.	H in m	Rh	Rr	Rn	Cm per km
1.	510	0.107	4.41	3.92	129.87
2.	450	0.105	3.82	1.62	277.77
3.	996	0.209	7.37	3.58	277.77
4.	860	0.33	8.19	2.32	370.37
5.	1056	0.38	9.18	3.48	303.03
6.	635	0.21	6.13	2.34	270.27
7.	690	0.14	4.00	3.38	204.08
8.	530	0.11	4.00	3.18	166.66
9.	1450	0.27	7.83	5.22	277.77
10.	1200	0.203	7.05	4.68	256.41
11.	849	0.12	4.67	3.65	232.55
12.	1410	0.18	6.55	5.78	243.90
13.	880	0.14	4.51	4.04	217.39
14.	690	0.22	4.38	4.00	172.41
15.	1190	0.12	4.50	4.64	256.41
16.	785	0.12	3.73	2.88	263.15
17.	920	0.10	2.96	4.23	217.90
18.	1160	0.14	4.04	7.04	227.27
19.	934	0.11	4.32	2.61	357.14
20.	755	0.11	4.08	4.26	172.41
21.	810	0.108	4.05	3.24	250.00
22.	1690	0.21	7.07	6.92	243.90
23.	1695	0.206	7.25	10.17	166.66
24.	620	0.08	3.52	2.17	285.71
25.	974	0.10	4.30	2.50	384.61

4.4.3 Estimation of run-off (discharge) and sediment production rate

It is often desirable to predict the total volume of run-off that may come from a watershed in a unit time to design storage structures and flood modulation in addition to many other uses. Similarly, sediment yield characteristics are an accepted concept for the prioritization of watersheds for recommending various conservation practices.

A number of empirical and conceptual run-off and sediment yield models are available to prioritize the watershed units for formulating soil and water management plans. Generally such models require soil, slope, land use/land cover and drainage as input in spatial mode and it is often difficult to generate such inputs in a short time. In such conditions, the morphometric parameters of a watershed become crucial for estimating run-off and sediment yield and finally prioritising such watersheds for soil and water conservation and management measures.

4.4.3.1 Estimation of run-off

Jose and Das (1982) developed a multivariate model to establish run-off from a watershed taking into consideration the broad physiographic characteristics. Their mathematical model is discussed in methodology chapter and is followed for the purpose of estimating run-off. The data is presented in the Table 4.4.3.1 and Fig. 4.4D.

4.4.3.2 Estimation of sediment production rate

Sediment Production Rate (SPR) is ideally determined by gauging the watershed. There is no gauging station in Tuirini watershed. Paucity of time and the need compels the planners to resort to empirical approaches.

SPR of each micro-watershed has been calculated on the basis of broad physiographic characteristics using the model suggested by Jose and Das (1982). The data is presented in the Table 4.4.3.2 and Fig. 4.4E.

This model does not provide absolute values of soil loss or sediment yield at the outlet but gives a relative erodibility of micro-watersheds for taking up conservational measures.

Table 4.4.3.1 : Run-off (discharge) from the micro-watersheds of Tuirini watershed, Mizoram

Watershed No.	Rotundity Factor (Rf)	Circulatory Ratio (Cr)	Compact Coefficient (Cc)	Discharge
R1	1.9665	0.6371	1.2573	50.5015
R2	1.1968	0.7732	1.1365	35.3400
R3	2.2597	0.4426	1.5021	48.5447
R4	2.4518	0.4993	1.4143	56.7390
R5	2.4588	0.4851	1.4348	55.6832
R6	1.6208	0.6956	1.1982	44.8281
R7	2.2601	0.3665	1.6508	42.4997
R8	3.8410	0.4029	1.5743	59.4694
R9	1.6083	0.6996	1.1947	44.4484
R10	2.8306	0.4708	1.4565	58.7327
R11	1.6853	0.5871	1.3040	50.2093
R12	2.3046	0.5558	1.3404	57.5119
R13	1.7447	0.4090	1.5626	38.8011
R14	3.8132	0.3752	1.6315	51.8833
R15	2.1868	0.4952	1.4201	53.3332
R16	2.1837	0.5650	1.3295	56.1054
R17	1.7654	0.4198	1.5423	40.5881
R18	2.4240	0.3780	1.6253	39.1093
R19	3.6232	0.3565	1.6736	44.8040
R20	2.0002	0.8079	1.1103	39.1671
R21	2.2162	0.4694	1.4579	51.3910
R22	1.8284	0.5310	1.3714	51.2510
R23	2.1161	0.4798	1.4427	51.2324
R24	3.9428	0.4865	1.4328	76.6876
R25	2.5620	0.5871	1.3042	60.8084

Fig. 4.4D : Graph showing Mean Annual Discharge (Run off) in sq. km.-cm./sq. km. from the Micro Watershed of Tuirini River, Mizoram.

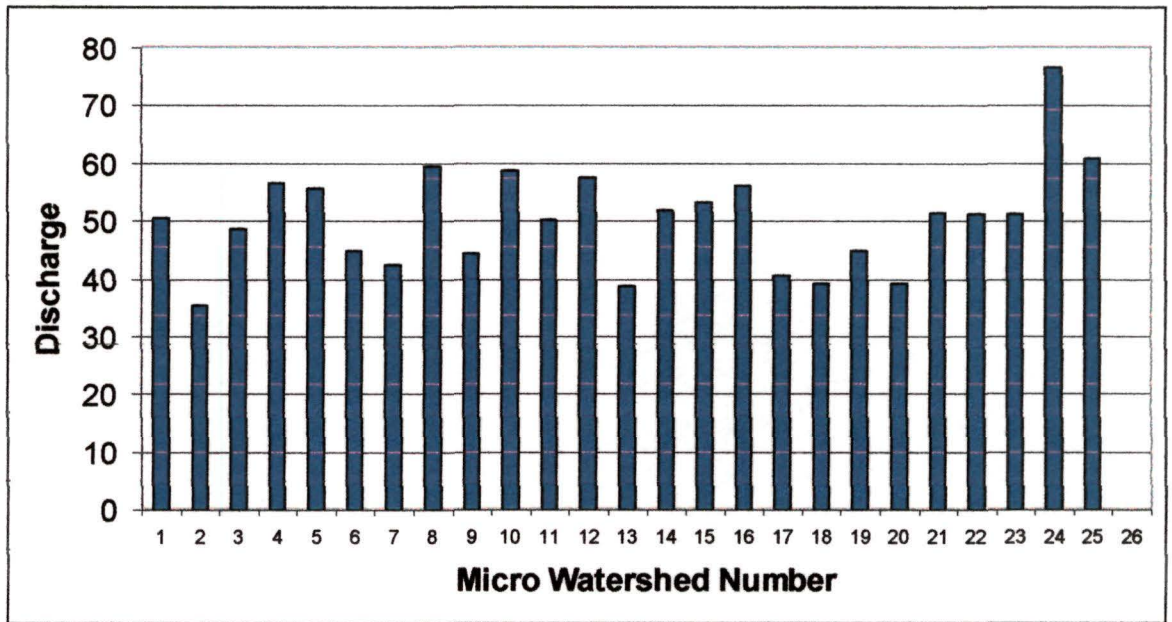
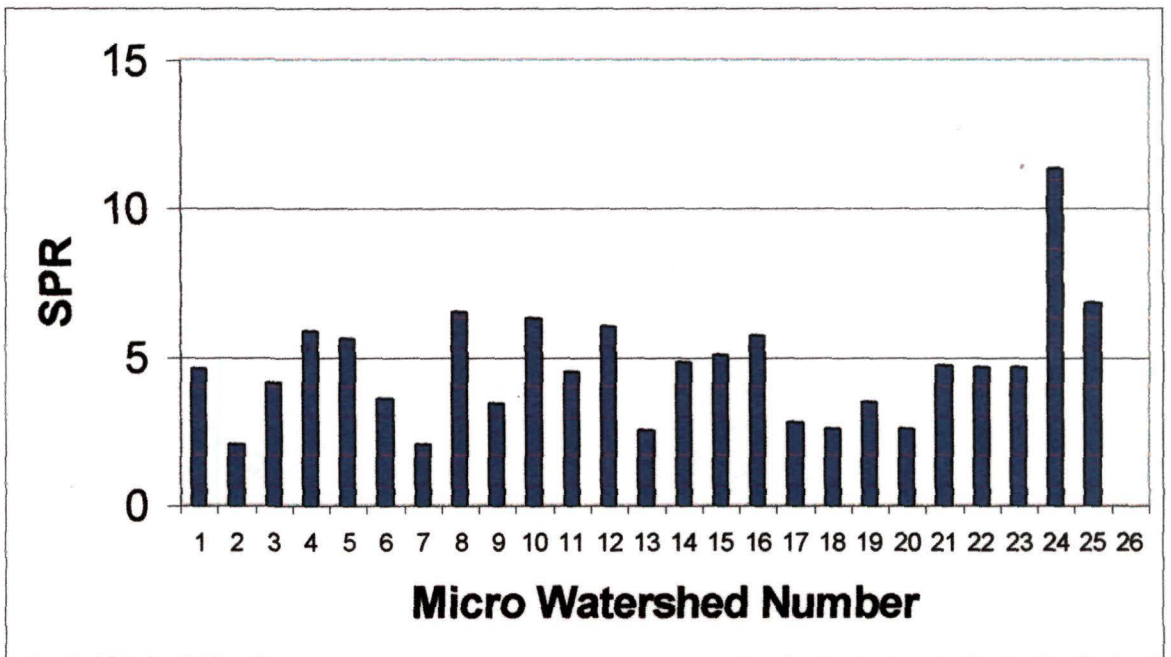


Table 4.4.3.2: Sediment production rate from the micro-watersheds of Tuirini watershed, Mizoram

Watershed No.	Rotundity Factor (Rf)	Circulatory Ratio (Cr)	Compact Coefficient Rate (Cc)	Sediment Production
R1	1.9665	0.6371	1.2573	4.5994
R2	1.1968	0.7732	1.1365	2.0679
R3	2.2597	0.4426	1.5021	4.1562
R4	2.4518	0.4993	1.4143	5.8689
R5	2.4588	0.4851	1.4348	5.6205
R6	1.6208	0.6956	1.1982	3.6205
R7	2.2601	0.3665	1.6508	2.0799
R8	3.8410	0.4029	1.5743	6.4949
R9	1.6083	0.6996	1.1947	3.4238
R10	2.8306	0.4708	1.4565	6.3196
R11	1.6853	0.5871	1.3040	4.5025
R12	2.3046	0.5558	1.3404	6.0349
R13	1.7447	0.4090	1.5626	2.5397
R14	3.8132	0.3752	1.6315	4.8110
R15	2.1868	0.4952	1.4201	5.1121
R16	2.1837	0.5650	1.3295	5.7147
R17	1.7654	0.4198	1.5423	2.8040
R18	2.4240	0.3780	1.6253	2.5842
R19	3.6232	0.3565	1.6736	3.4844
R20	2.0002	0.8079	1.1103	2.5924
R21	2.2162	0.4694	1.4579	4.7338
R22	1.8284	0.5310	1.3714	4.6837
R23	2.1161	0.4798	1.4427	4.6797
R24	3.9428	0.4865	1.4328	11.3613
R25	2.5620	0.5871	1.3042	6.8203

Fig. 4.4E : Graph showing Sediment Production Rate (SPR) in Ha-m/100sq km/year from the Micro Watersheds of Tuirini River, Mizoram.



4.5 Biophysical parameters

4.5.1 Resource inventory of forest species

The area as a whole enjoys moderate climate, neither very cold nor very hot. The average winter temperature varies from 12.6°C to 22.3°C and in summer it varies from 20.1°C to 26.7°C. The average annual rainfall is approximately 231.27cm and is influenced by the S-W monsoon which commences from June and continues upto September. The number of rainy days averages 165. The difference between the mean summer and mean winter soil temperature is more than 5°C and the mean soil temperature is lower than 22°C. Thus the climate of the area is Humid-Tropical (Anon 1997, Lalnundanga 2000 and Sinha *et al.* 2000).

The study area comes under Tropical Semi-Evergreen forest. This type of forest covers the central bio-geographic zone and occupies 50 per cent of the total geographical area of Mizoram.

The villagers of the watershed area were interviewed to know uses of tree species, bamboo species and medicinal plants in their day-to-day life and their dependence over adjoining forests (Photographs 9-13). The most preferred tree species, bamboo species and medicinal plants were collected with the help of village resource men and herbarium was prepared to preserve the plant samples. These were identified with the help of *Flora of British India, Vol. 1-V11* (Hooker 1872-1892), *Indian Trees* (Brandis 1893), *Forest Flora of British Burma, Vol. 1-11* (Kurz 1877), *Flora of Assam* (Kanjilal *et al.* 1934-1940), *Flora of Lushai Hills* (Fisher 1938), *Flora of Tripura state, Vol. 1-11, Vols 1-11* (Deb 1981-1983), *Forest Flora of Meghalaya, Vols 1-11* (Haridasan and Rao 1985&1987) and *Hand Book of Forest Trees of Mizoram* (Lalramnghinglova 1997). The important journals which have been consulted are *Journal of Economic Taxonomic, Botany* (Jodhpur), *Bulletin of Botanical Survey of India* (Calcutta). *A Glossary of Botanical terms* (Jackson 1900 : Reprint 1986) and *Botanical Latin* (Stream 1966) are used for terminological notations and abbreviations.

4.5.1.1 Ethnomedicinal plants

The ethnomedicinal plants recorded from the study area are presented herewith. The plants names are recorded after cross checking and confirmation from various sources. All together 78 plants were recorded having ethnomedicinal value. The ten plants species which are very popular in the watershed are mentioned herewith.

1. *Mizo name* - Lungkhup
Botanical name *Adina cordifolia* (Wild ex Roxb) A.E.
118:1996, CIMP 1:12.1995, IMP 2:1253,
IMPC 3:117:1995, TIMP 5:74.1997.
Family Rubiaceae.
Place of availability Tlungvel, Sihfa, Tawizo and Maite.
Brief description A big size tree, solid stem, grey colour, thick bark, leaf size - Big, pubescent, simple stipulate, flower brown, flowering in June-July; Fruiting August-September. However, Chatterjee and Pakrashi (1997) have Reported flowering in the month of August and fruiting from October-December.
Uses Bark is crushed and boiled in water. Boiled water is used to cure stomach ulcer and diarrhea.

2. *Mizo name* *Thuamriat*
Botanical name *Alstonia scholaris* Brown (syn. *Alstonia cuneata* wall.) GIMP : 5. 1956, IMP 2:1565-1935, TIMP 4:102.1995, CIMP 1:26 1995, FFM: 599-1985.
Family Apocynaceae.
Place of availability Common everywhere in the study area.

<i>Brief description</i>	A middle sized deciduous tree, bark dark grey, produces bitter milky juice; Whorled leaf with eight number of leaflets in each whorl; flower greenish white, flowering in Feb-March; fruits long follicle, seeds with brown hair, fruiting in April-May.
<i>Uses</i>	Milky juice is used as ointment to cure cuts and wounds. Milky juice is used as ointment to cure cuts and wounds.
3. <i>Mizo name</i>	Chhawntual
<i>Botanical name</i>	<i>Aprosa octandra</i> (Buch. Ham.ex.Don) FFM. 2 : 773.1987; FTM : 77.1997; CCENI:220. 1994.
<i>Family</i>	Euphorbiaceae.
<i>Place of availability</i>	Common in the study area
<i>Brief description</i>	An evergreen fire resistant tree of small size, trunk with many branches; bark thick, pale yellow in colour; leaf-new foliage red in colour, alternate, linear, acute, cuspidate-entire; flower yellow, long male spike; calyx pubescent; Flowering-November – December, Fruiting - Feb-March.
<i>Uses</i>	Cures stomach ulcer. Decoction of bark is taken one cup after meal.
4. <i>Mizo name</i>	Khamdamdawi
<i>Botanical name</i>	<i>Berginia ciliata</i> (Haw.) Sternb. CCENI:59.1994; CIMP 1:57.1995; CMPD : 54.1982; IMP 2:993.1935; IMPC 5:16.1996.

<i>Family</i>	Saxifragaceae
<i>Place of availability</i>	Grows on rocky hill slope, common in the study area.
<i>Description</i>	Creeper, big stout stem; root develops from the eye of the creeper; leaf-reddish brown on the lower surface at the young stage, old leaves green dark on the above surface and paler beneath, leaf shedding in the month of September-October, flower-white, Flowering: May- June; fruiting - August-September. Although Jain <i>et al</i> 1991 reported flowering and fruiting during Feb-April.
<i>Uses</i>	The stems are dried, crushed and powder is mixed in water and a cup of mixture is taken thrice in a day to cure severe diarrhea and dysentery.
5. <i>Mizo name</i>	Khuanglawi
<i>Botanical name</i>	<i>Blumea laciniata</i> (Roxb.)DC.FT 2:206.1983 FUG 1:454.1994; NPEI: 46.1991.
<i>Family</i>	<i>Asteraceae</i>
<i>Place of availability</i>	Tuikhurhlu, Thingsulthliah, Lenchim, Darlawng, Phulmawi and Seling.
<i>Brief description</i>	A moderate light demanding herb with an erect reddish colour stem; leaf sharply lobed, sinuate, flower yellow, flowering: March-April; Fruit achenes; fruiting in the month of May and June.
<i>Uses</i>	Crushed root paste is applied on snake bite.
6. <i>Mizo name</i>	Tuihlo

Botanical name *Cassia alata* Linn. FA 2:13.1938; FBI 2:264.1976,FFM1:3191985;CCENI :71.1994; CIMP 2: 147.1996.

Family Caesalpinaceae

Place of availability Mostly in the kitchen garden of Saitual, Mualmam, Sesawng, Thingsulthliah and Tuikhurhlu.

Description Large shrub attains height up to 2.5m; solid stem, bark dark grey; leaf sub-sessile, leaflet oblong, cuspidate, flower large, yellow; flowering October-November; fruit four Wing pods; fruiting in the month of December.

Uses Paste of leaves is used as ointment to cure skin diseases caused by *Tinea versicolor* (Ring worm).

7. *Mizo name* Zawngtei
- Botanical name* *Chikrassia tabularis* Wright and Arn. FBI: 241.1834; FM:157:1981; GIMP : 63.1956; CIMP 2:179.1996.
- Family* Meliaceae.
- Place of availability* Khumtung, Maite and Bualte.
- Brief description* A big tree resistant to jhum fire; bark black Or brown, deeply fissured; leaf pinnate, leaflet 5-8 pairs, alternate, ovate-lanceolate; flower pinkish white; flowering April and May; fruit capsule, woody dark brown; seed winged, brown flat; fruiting in December-March (Lalnundanga 2000).

- Uses* Decoction of bark or seed cover is used to cure gastric problem and diarrhea.
8. *Mizo name* Thakthingsuak.
- Botanical name* *Cinnamomum bejolghota* (Buch.Ham).
Sweet. IMP 2:2147.1935; FFM 720.1987;
CIMP:65.1956; CCENI : 76.1994; CIMP 4:185.1997.
- Family* Lauraceae.
- Place of availability* Seling, Phulmawi and also seen in other areas like Ralvawng.
- Brief description* A small tree, moderate light demander, resistant to jhum fire, crown very dense, bark dark gray with rectangular depressing or crack; leaf opposite, elliptic obtuse; flower yellowish white; flowering February-March; fruit ellipsoidal, fruiting April to June.
- Uses* Cures liver disorder-Decoction of bark one tea spoon, thrice a day is used by the villagers.
9. *Mizo name* Hmawng Zaman
- Botanical name* *Ficus benjamina* Linn. GIMP: 118.1956;
CCENI : 111.1994; CIMP 5:371.1998.
- Family* Moraceae.
- Place of availability* Lenchim, Tlungvel and Tawizo.
- Brief description* An evergreen moderate size tree with drooping branches; bark gray, smooth; leaf alternate, oblong, cuspidate; male flower few, pedicel and spathe present; flowering June-July; fruiting August-September.

<i>Uses</i>	Decoction of bark is used for treatment of malarial fever (one cup thrice) in a day.
10. <i>Mizo name</i>	Archangkawm.
<i>Botanical name</i>	<i>Oroxylum indicum</i> (L.) Berth ex Kurz. GIMP:182.1956; AE:150.1996; ADPS:464.1994. CCENI :154.1994.
<i>Family</i>	Bignoniaceae.
<i>Place of availability</i>	Darlawng, Edenthar, Sihfa and Phulmawi.
<i>Description</i>	A small to medium size shade bearer deciduous tree; bark dark gray; leaf opposite, leaflet ovate, entire, acuminate, peduncle thick; flower reddish purple outside and pale pinkish yellow inside; flowering- March; fruit flat capsule, tapering at both ends, many seeds winged; fruiting May-June.
<i>Uses</i>	Bark is used for the treatment of rheumatism.

4.5.1.2 Bamboo species

In order to know the bamboo's species diversity and the most common species available in abundance, all the villages which come under Tuirini watershed were surveyed. Bamboo is also associated with succession after disturbance by shifting cultivation. The bamboo species collected from the study area are altogether 9 in number. Lalramnghinglova and Jha (1995) reported 9 genera and 22 species of bamboos in Mizoram. The species collected are arranged alphabetically.

1. *Bambusa oliveriana* Gamble, Ann. Roy. Bot. Gard. cal. 7:130.1986.
Brandis, Indian Trees 670:1906, Varmah and Bahadur Ind.For.Rec.(n.s.) Bot. 6(1):2.1980, Bennet and Gaur Thirty seven Bamboos: 31,1990.
- | | |
|---------------------|-----------------|
| <i>Mizo name</i> | Talan. |
| <i>Distribution</i> | Tawizo village. |

- Description* A moderate sized, tufted rare bamboo; culm 13-15m high, 2.5cm in diameter, glossy green; branches many from the base upward; culm sheath thin, pale, glabrous on both sides or hirsute on the back when young.
- Associates* *Schima wallichii*, *Acrocarpus fraxinifolius*.
- Uses* Mz : Conservation purposes (Laha & Jha, 2000).
2. *Bambusa tulda* Roxb. Gamble, Ann. Roy. Bot. Gard. Cal. 7:30.1896; Hook Fl. Brit. Indica. 7:387.1897; Brandis Indian Trees 668.1906; Varmah and Bahadur in Indian For. Rec.(n.s.). Bot. 6(1):2.1980.
- Mizo name* Rawthing.
- Distribution* Seling, Tlangnuam, Edentharr, Lenchim, Darlawng, Tlungvel, Phulmawi, Seling, North Lungpher, Mualpheng, Maite and Chanin.
- Description* An evergreen or deciduous, tufted bamboo. Culms 7-25m high and 5-10cm in diameter, glabrous, Green when young, grey-green on maturity, unbranched in the lower portion; nodes slightly thickened, lower one with fibrous root, internodes 40-70cm white scurfy when young, white ring below the node, many branch grows from each nodes; culm sheath long and broad; leaves linear lanceolate, glaucescent and puberulous beneath.
- Associate* *Lagerstromia parviflora*, *Thysanolaena maxima*, *Adina cardifolia*, *Dillenia indica*, *Garuga pinnata* etc.
- Uses* Mz : Edible bamboo species, mature culm used for making furniture, basket etc.
EW: In northern Thailand, it is most important edible bamboo species (Jackson 1978). In

the production of pulp and paper (Bhargava 1945 and Bhola 1976).

3. *Bambusa polymorpha* Munro in Trans.Linn.Soc.Lond.26:98.1868; Brandis, Indian Trees 669.1906; Varmah and Bahadur in Indian For.Rec.(n.s.).Bot. 6(1):2.1980; Tiwari, A mono. Bamboo 47:1994.

Mizo name Betua

Description A large densely tufted evergreen bamboo. Culm 15-25m high, 8-16cm in diameter, greyish green culm sheaths, broader at base and narrowed into a rounded top, covered on dorsal surface, dark to brown deciduous hairs; leaves linear lanceolate, petiole 1.5-2.5cm long, ligule very thin, auricle with brown and bristle.

Associates *Tectona grandis*, *Caralia brachiata*, *Litsea* species, *Styrax polyspermum*, *Schima wallichii* etc.

Uses Mz : Edible species, mature bamboo used in house construction, making mat etc.
EW : Used in house construction in Manipur (Singh 1986), Pulp and paper (Bhargava, 1945), walls, floor and roof of house in Burma (Gamble, 1896), and agarbatti sticks (Chakraborty 1988).

4. *Bambusa vulgaris* Schrad.Ex.Wendell. Brandis. Indian Trees, 670.1906, Cammus, Les, *Bambusa* : 112.1913; Varmah and Bahadur in India, For.Rec. (n.s.). 1307.6(1):2.1980; Bennet and Gaur, Thirty seven Bamboos : 43.1990; Tiwari, Monograph on Bamboo.51:1994.

Mizo name Vairua

Distribution Hualtu, Chanin, Maite, Thingsulthliah, Lenchim, Darlawng, Mualpheng, Seling, Sihfa and Tawizo.

5-	<p><i>Description</i> A medium size Bamboo; culms 10-18m high, and 10cm in diameter, bright green, glossy, erect, matured-yellowish; branching from mid portion of culm up to the top; culm-sheat rounded and truncate at top, surface covered with thick appresses brown black hairs, leaves narrowly lanceolate, rounded at the base, glabrous on both surface, margin scabrous.</p> <p><i>Associates</i> <i>Persia petiolaris</i>, <i>Castanopsis tribuloides</i>, <i>Dillenia pentagyna</i>, <i>Embllica officinalis</i>, <i>Callicanpa arborea</i> etc.</p> <p><i>Uses</i> Mz : Young shoots edible (3rd choice), mature culms for pole, flooring, roofing, fencing, furniture etc.</p> <p>EW : For fencing in Manipur (Sing, 1986).</p>
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5. *Dendrocalamus giganteus*. Munro in Gamble, Ann. R.Bot.Gard.Cal. 7:87. 1896; Brandis, Indian Trees 678.1906; Tiwari Monograph Bmaboo, 60.1994.

Mizo name Rawpui

Distribution Chanin and Baktawng.

Description A very tall bamboo species, branches slender, culm 25m tall and 20-30cm diameter, thick walled, covered with white waxy crust in young stage and dull green later on, inter nodes upto 50cm long, nodes with root scars. Culm-sheats shinning inside, dull yellow and covered with dark brown hairs on the upper surface, leaves variable in size, oblique, oblong, acuminate, smooth above and hairy beneath.

Associates A few clumps in Gardens.
Uses Mz : Used as water pitcher and flower vases etc.
EW : Better raw material for paper making (Guha
et al. 1975).

6. *Dendrocalamus hamiltonii* Nees. et Arn. ex Munro. In Gamble, Ann. Roy. Bot. Gard. Cal. 7:84.1896; Bor, F1. Assam. 5:9.1940; Varmah and Bahadur Indian For. Rec. (n.s.) Bot. 6(1):3.1980; Tiwari, Monograph Bamboo. 63: 1994.

Mizo name Phulrua
Distribution Edenthar, Tualbung, Seling, Tlangnuam, Tuikhurhlu, Thingsulthliah, Darlawn, Tlungvel, Phulmawi, Phaibawk, Sihfa, Lungpher, Mualpheng, Khumtung, Tawizo, Maite, Hualtu, Chanin, Saitual and Sesawng.

Description A tall bamboo species, culms curved downwards, culm very large upto 30m tall, branching dense above than mid culm, greyish-white when young with dense appressed pubescence, dull green in old age, lower nodes with root scars; lower culm sheath larger in size, glabrous, shining inside, with stiff brown hair on the upper surface, truncate at the top, leaves very large on new shoots but small on side branches, broadly, lanceolate, ends in an acuminate scabrous twisted point, serrate on the margin, smooth on the ventral and rough on the dorsal surface.

Uses Mz : Edible bamboo species (2nd choice), mature culms used for pole, flooring, making

basket, mat, Rhizome dried and used as fuel wood.

7. *Dendrocalamus longispathus*, kurz. Gamble, Ann.Roy.Bot.Gard.Cal.7:89. 1896, Brandis Indian Trees.667.1906, Bennet and Gaur, Thirty seven Bamboos. 57:1990.

Mizo name Rawnal

Distribution Edenthar, Seling Tlangnuam, Tuikhurhlu, Lenchim, Thingsulthliah, Darlawn, Tlungvel, Seling, Sihfa, Lungphir north, Aichalkawn, Mualpheng, Hualtu, Khumtung, Tawizo, Maite, Chanin and Baktawng.

Description A moderate size bamboo of 10-18m high, 8-12cm in diameter, green when young, grey-green in old age. Nodes with roots; culm sheath parallel, inner surface glabrous and outer surface clothed densely with patches of stiff dark-brown hairs, leaves oblong-lanceolate, acuminate, short stalked, may in oblong; leaf sheath with brown pubescence, margin ciliate, glabrous.

Associates *Albizia chinensis*, *phoebe attenuata*, *Sapium baccatum*, *Tectona grandis*, *Schima wallichii*, *Erythrina* species, *Mesua ferrea*, *Pteruspermum acerifolium* & *Melocanna baccifera*.

Uses Mz : Young shoot edible, Mature calm fencing, house construction; basket etc.

EW : As ornamental(Tiwari 1994) for pulp (Bhargara 1992) arid in Tripura for basket etc. (Chakraborty 1988).

8. *Dendrocalamus sikkimensis* Gamble, Bor.in Fl. Assam 5:7.1940, Varmah and Bahadur in India For.Rec. (n.s.)6(1):2.1980; Tiwari in Monograph Bamboo. 74:1994.

Mizo name Rawmi

Distribution Tawizo, Maite and Tlungvel.

Description A moderate size upto 20m high, 10-15cm in diameter, dark-green, culm sheath densely covered with golden brown hairs; leaves oblong-lanceolate, tapers into a twisted point, shortly petiolate, smooth above and rough below.

Associates *Melocanna baccifera*, *Erythrina* species, *Milletia pachycarpa*, *Tectona grandis* etc.

Uses

Mz : For making basket and fuel wood.

EW :In Sikkin lepchas and Bhutias uses for making the 'Chungas' for carrying milk etc.

9. *Dendrocalamus strictus* (Roxb.) Nees. Munro in Trans. Linn. Soc.Lon. 26:147.1868; Bennet and Gaur, Thirty seven Bamboo. 61.1990; Tiwari Monograph Bamboo 77:1994.

Mizo name Tursing

Distribution Mualpheng, Seling, Phulmawi, Sesawng and Tawizo.

Description A medium size densely tuft bamboo species, deciduous attains upto 15m height and 3-7cm diameter; Young culm pale blue-green and old culm dull green or yellowish; culm curved above half of its height; basal nodes with roots, nodes swollen; lower culm sheaths shorter with golden-brown hairs on the back, rounded at the top, margin hairy; leaves linear-lanceolate, small in higher altitude, tip

sharply acuminate with twisted points and softly hairy.

Associates *Tectona grandis*, *Erythrina indica*, *Embllica officinalis*.

Uses Mz : House construction.
EW : Suitable species for reclamation of ravine lands (Srivastava and Qureshi 1966). Raw material for paper (Tiwari 1994).

10. *Melocanna baccifera* (Roxb.) Kurz. Syn.-*M. bambusoides* (Trin). Gamble in Ann.R.Bot.Gard. Calcutta. 7:118.1896; Tiwari in Monograph Bamboo 104:1994; Laha ICAF & FP : 2000.

Mizo name Mautak

Distribution Very common in watershed, associated with succession after second or third shifting cultivation cycle.

Description An evergreen, gregarious culms attains height upto 15m and diameter 2-25cm. Young culm green whereas old culm straw coloured; nodes with a circular band of white bloom 5cm below, branching appear from the top of the culm all equal and slender; culm sheaths yellowish-green in young stage but yellowish brown when old; whitish hairs on the dorsal surface; Lingule with toothed margin. Leaves oblong-lanceolate, base oblique and apex acuminate, margin ciliate, thick leaf sheath with silvery bristles.

Associates Grows in degraded jhum land. The species found in association are *Albizia* species, *Erythrina stricta*, *Gmelina arborea*, *Tectona grandis*, *Schima*

wallichii, Dillenia pentagyna, Eurya acuminata, Styrax polyspermum, Pterospermum acerifolium, Castrnopsis tribuloides etc.

Uses

Mz : Young shoots edible (1st choice). Used in house construction. furniture making etc.
EW : Source of superior pulp (Mc Clure, 1958), Tabashir an ancient elixir isolated from culms (Singh 1986).

Abbreviations used:

- AE : Applied Ethnobotany.
ADPS : Ayurvedic Drugs and their Plants Sources.
CCENI : Cross-Cultural Ethnobotany of Northeast India.
CMPD : Common Medicinal Plants of Darjeeling and Sikkim.
CIMP : Compendium of Indian Medicinal Plants.
FA : Flora of Assam.
FBI : Flora of British India.
FFM : Forest Flora of Meghalaya.
FM : Flora Medica.
FT : The Flora of Tripura State.
FTM : Hand book of Forest Trees of Mizoram.
FUG : Flora of the Upper Gangetic Plains.
GIMP : Glossary of Indian Medicinal Plants.
IMP : Indian Medicinal Plants.
IMPC : Indian Medicinal Plants - a compendium of 500 species.
IT : Indian Trees.
MP : Medicinal Plants.
NPEI : Notable Plants in Ethnomedicine of India.
SGIMP : Supplement of Glossary of Indian Medicinal Plants.
TIMP : The Treatise of Indian Medicinal Plants.

4.5.1.3 Tree species

The major tree species of the watershed area are collected and identified. The uses etc. are recorded as reported by the villagers of the watershed. The only tree species which are mostly used by the villagers are documented in Table 4.5.1.3.

Table 4.5.1.3: Important tree species growing in the natural forest or in plantation

1.	Thlanvawng	<i>Gmelina arborea</i> Roxb	Verbenaceae	-Moderate size, deciduous trees up to 30m height bark greyish-Yellow; leaves-ovate, flavous and tomentose beneath; flowers- yellowish or yellow brown (Feb-March); Fruit - Drup 2-3cm long ovoid, orange or yellow when ripe.	<ol style="list-style-type: none"> 1. Timber class - B-I 2. Good timber used for furniture. - The pulp of fruit applied to cure itching sores. 3. Natural forest and plantation
2.	Bulbawr J.H.R.	<i>Phoebe attenuate</i> Nees.	Lauraceae	- Moderate size upto 20m height, dark grey bark; leaves crowded at the end of branchlets; flowers-panical stout, 4-8 cluster at branch end; stamens in 3 series, overy globes, depressed flowering - March-April; fruits ellipsoid, enclosed at the base of hardened pubescent perianth segments; fruiting September-October (Lalramnghinglova, 1997).	<ol style="list-style-type: none"> 1. Timber Class - C 2. Good Timber and fuel wood species. 3. Natural forest (source)
3.	Bul - eng	<i>Phoebe hainesiana</i> Brandis	Lauraceae	- Large tree upto 25m in height; bark grey; Leaves - clustered at the end of branchlets, oblanceolate to obovate; flowers -stout peduncle, densely greyish tomentose, flowers in the month of May; fruits- fleshy broadly ellipsoid; fruiting October-November.	<ol style="list-style-type: none"> 1. Class - C 2. Yellow wood, Valuable timber 3. Natural forest (Scarce).
4.	Thingvawkpui	<i>Sapium baccatum</i> Roxb.	Euphorbiaceae	Straight bole, dense crown, 30-35m high; bark - blackish or dark-grey; leaves-ovate-lanceolate; flower-minute, greenish-yellow, panicle up to 15cm long; flowering Feb-March; fruit Globe purple in colour, fruit appears Aug.-Oct.	<ol style="list-style-type: none"> 1. Class - E 2. Good fire wood and also used in Plywood industry. 3. Natural forest (very common)

contd.....

- | | | | | | |
|----|---------------|---|---------------|---|---|
| 5. | Vang | <i>Albizia chinensis</i>
(Osbeck) Merr. Syn.
<i>A. stipulata</i> (Roxb) | Mimosaceae | A large size tree up to 35m; bark brown; horizontally wrinkled; leaf-leaf rachis 20-25cm long with one large gland near the base, pubescent beneath; flower yellowish-white, sepals toothed, petals and ovate; fruits-pod up to 12cm, light brown in colour | <ol style="list-style-type: none"> 1. Class - E 2. Good timber for furniture leaves as fodder or green manure.
-Bark used as lotion for cuts and skin diseases.
(Lalramnghinglova,1998) 3. Natural forestry (very common). |
| 6. | Kangteknu JHR | <i>Albizia procera</i> (Roxb)
Benth. | Mimosaceae | A tall deciduous tree up to 30m height; bark yellowish-grey; leaves-young leaf silvery, leaflets 4 -10 pairs, flowers pinkish-white, sessile, calyx toothed; corolla deeply cleft; flowering May-June fruits 10 - 20cm long pods, glabrous, reddish brown in colour; fruiting period from July- next April. | <ol style="list-style-type: none"> 1. Class - B - 11 2. -Good timber for Agriculture implement.
-Poultice of leaves is applied to ulcers.
-Crushed bark for fish poisoning. 3. Natural forest; farm, garden. (common) |
| 7. | Khiang | <i>Schima walichi</i> | Theaceae | Large size tree 15-40m height, with avoid crown; bark blackish brown with longitudinal fissures; leaves-elliptic lanceolate, puberulous beneath; flowers -white scented, axillary, petals-5 flowering in April-May, fruits, grey, seeds. | <ol style="list-style-type: none"> 1. Class - C 2. -Good timber also used as fire wood.
-Crushed fruits boiled and applied to cure scorpion bite. 3. Natural forest.(abundant) |
| 8. | Siksil | <i>Pterospermum acerifolium</i> wild. | Sterculiaceae | Large size tree attains height up to 35m, crown oval, leaves-oval-orbicular, brownish tomentose beneath, dark-green above; flower dull-white large in size, flowering May-June; fruits-capsule woody, tomentose seeds long, compressed; fruiting Oct-Feb. | <ol style="list-style-type: none"> 1. Class - C 2. In making furnitures and planks-The flowers are used as anti tonic in ulcer and the leaves as heomostatic
(Lalnundanga 2000) |



9.	Thingsai	<i>Castanopsis tribuloides</i> (Sm) D.C.Var <i>typica</i> King.	Fagaceae	Medium sized evergreen tree; bark longitudinally cracked, dark grey; leaves elliptic-lanceolate, dark green above, yellowish beneath; flowers-terminal on slender peduncles, male spike fascicled and female spike solitary; flowering Aug.-Sept. fruits-sesile on naked stalk, nuts, 1-3, glabrous; fruiting Oct. - Feb.	<ol style="list-style-type: none"> 1. Class - C 2. In making furniture-whitish Kernel nuts edible. 3. Natural forest/Kitchen, Garden-abundant.
10.	Makpazangkang JHR	<i>Cassia javanica</i> L. Sp. <i>nodosa</i> (Buch)	Caesalpiniaceae	Moderate size ornamental tree, bark grey; leaves dark green and shining above, petiole very short; flowers-pinkish-white; flowering May-June; fruits pods 20-40cm long; fruiting Aug. - March.	<ol style="list-style-type: none"> 1. Class - D 2. Wood is fuel wood. 3. Natural forest and plantation -Normal distribution.
11.	Sahatahpui JHR	<i>Chisocheton paniculatus</i> (Roxb) Hirn.	Miliaceae	A middle size tree; bark blackish or dark; leaves-young leaves hairy dark green, elliptic-lanceolate petiole short; flower-pale yellow, scented; flowering June-July; fruits-capsule, orange red; fruiting Dec. - Jan.	<ol style="list-style-type: none"> 1. Class - B 2. Fuel wood and fencing work. 3. Natural forests-abundant.
12.	Theiria	<i>Carallia branchiata</i> (lour) Merr. Syn. <i>C.licida</i> Roxb, <i>C.integerrima</i>	Rhizophoraceae	A medium sized evergreen tree, crown dense and oval, bark brown with horizontally wrinkles; Leaves-broadly elliptic, oblong-obovate; flowers yellowish-green sesile; flowering Nov.-Jan.-fruits-berry globose; fruiting May-July.	<ol style="list-style-type: none"> 1. Class - D 2. As fuel wood 3. Natural forest(abundant)
13.	Herhse	<i>Mesua ferea</i> L.	Guttiferae (Clusiaceae)	A moderate-sized evergreen tree, brown spherical, crown spherical, dark-brown bark; leaves-young leaves red, upper surface dark green and glossy; wax like powder underneath, flowers-greenish white; petals white; flowering Apr.-May; fruits-drub; seeds 1-4, dark brown with shining with hairy testa; fruiting Sep.-Oct.	<ol style="list-style-type: none"> 1. Class - B-11 2. Strong timber used for house posts. Oils extracted from flowers used as medicine. (Lalramnghinglova and Jha 1997). 3. Natural forest gregorious distribution-declared as state tree.

14.	Kawrthindengte JHR	<i>Dillenia pentagyna</i> Roxb.	Dilleniaceae	A large deciduous tree, upto 30m height; bark grey or pale brown; leaves elliptic-oblong, margin shallowly wavy; flowers-like pinkish or greenish yellow, large, petals margin wrinkled; flowering Mar.-Apr.; fruits with enlarge fleshy sepals fruit in June - August.	<ol style="list-style-type: none"> 1. Class - F 2. wood used for house posts and as fuel wood. -Bark crushed and boiled in water used to cure chronic wounds. 3. Natural forest (abundant).
15.	Sihneh-Zik-Var JHR	<i>Eurya cerasifolia</i> (D.Don)	Theaceae	A small evergreen tree; bark dark-grey; leaves oblong-elliptic, very short petiole; flowers-very small white, unpleasant odour, sepals silky; flowering Apr. - May; fruits small, fleshy berry, fruiting Sept. - Nov.	<ol style="list-style-type: none"> 1. Class - F 2. -wood used for posts and as fuel. Leaves boiled with rice and pork and eaten. 3. Natural forest. Kitchen Garden (abundant).
16.	Khaukhim	<i>Firmiana colorata</i> (Roxb) Syn. <i>Sterculia colorata</i> , Roxb	Sterculiaceae	A small deciduous tree bark grey; leaves ovate or orbicular, petiole as long as the blade, flowers - brightly orange red, calyx tubular, petals brown; flowering in April; fruits follicle; pink; fruiting May - June.	<ol style="list-style-type: none"> 1. Class - F. 2. Used for bibe and fuel wood. -Natural forests wounds. 3. Natural forests (abundant.)
17.	Bulpui	<i>Persea peteolari</i> (HKF) syn. <i>Alseodaphne peteolaris</i> H.K.F.	Lauraceae	A large tree, dense crown; bark grey; leaves obovate oblong or elliptic oblong; flowers - yellow, rusty pubescent, panicles - 25cm across, flowering May-June; fruits oblong-elliptic ripen fruits black, fruiting Aug.- Oct.	<ol style="list-style-type: none"> 1. Class - C 2. Wood used as timber or fire wood. 3. Natural forest(Rare availability and endemic to North-East India)

4.5.2 Cropping system

4.5.2.1 Agriculture

Land is to be considered as the most important aspect of production, especially of agricultural production. The explosive population growth in some parts of the world is outpacing that of agricultural output. Agricultural scientists are of opinion that about 47 per cent of 37 million acres of land in the world may be considered cultivable under the existing pattern of cultural environment (Roy and Mukherjee 1996). Literally, the word 'agriculture' means the cultivation of soil. The soil may be cultivated for various purposes - such as farming, tree culture, animal husbandry and for many other varied activities. In real sense, agriculture relates to the gamut of man's primary activities other than mining (Sadhukhan 1984). Zimmermann (1944) viewed that "Agriculture covers those productive efforts by which man settled on land, seeks to make use of it, if possible accelerate to improve upon natural genetic growth processes of plant and animal life, to the end these process will yield the vegetative and animal products needed or wanted by man". These concepts help us to understand that agriculture links to man's environment or interacting with soil relating to raising of plants and animals for food, fibre and fodder. The common concept of agriculture means the production of crops for food, fibre and other purposes (Sadhukhan, 1984). The climatic factors (temperature and rainfall) and physical factors (topography and soil) are deeply associated with agriculture. Temperature and rainfall are two natural parameters which indicate the differences in plant growth. Experiments reveal that the critical limit of monthly average temperature for plant growth should be at least 43°F/6°C (Roy and Mukherjee 1996). If the monthly average temperature falls below the critical temperature points, the plant life ceases to continue. On the other hand, the excessively high temperature is also not favourable for plant survival. Next to temperature, rainfall play an important role in agriculture practices specially its timely arrival, adequacy, consistency and regularity and is the greatest single factor in agriculture. Any deviation from the set of normal pattern in these respects brings imbalance and the crops are affected. The adverse crop fluctuations due to weather are directly reflected in the form of distress among the agro- based rural population (Das 1970).

Economically, the study area fully depends on agriculture. Temperature conditions (mean annual range from 17.25° - 25.89°C and adequate rainfall (231.27 cm in average) are suitable for agriculture. Agriculture practice, relating to food crop production requires preferably plain topography, which is practically not available in the area. As a result, despite having favourable climatic conditions, the area is lacking in food crop production. In this watershed, about 351.19 sq.km. is occupied by the slope more than 20°. The common staple food crop rice is produced on hill slopes under jhuming system of cultivation. About 10.751 sq km of land is under rice cultivation which provides 3230.09 tonnes of paddy in a year (Table 4.5.2.1). Approximately 21,53,333 kg of rice may be obtained out of annual paddy production. Compared to total population 39,360, it is assumed that per head annual share of rice is about 55 kg. If three times meals are managed from per kg of rice for a person, with this share of rice a person can manage only 83 days in a year. This analysis reveals that the population in Tuirini watershed faces shortage of food for 282 days in a year. As per present growth rate, the population will reach 56,863 by 2010 in the watershed. In general, crop production is low under jhuming. Moreover, production is decreasing constantly due to the shortening of jhum cycle and erosion of top soil. Under this condition the gap between production and consumption is increasing. Other than rice, maize is also produced in the area (2.6 sq km with annual production of 977.5 tonnes) which is not a staple food of the people. Therefore, it has no contribution in achieving the self sufficiency in food grains, which is a long cherished dream of the people of the area. Cash crops like potato, sugar cane, tobacco and cotton are produced in the area. About 1.017 sq.km. of area is under such crops. The production of these cash crops (818.3 tonnes per annum) is having negligible impact in the overall economic advancement of the area. Area in hectares under different cropping systems (Photographs 19-22) and production thereof in the villages of the Tuirini watershed is given in Tables 4.5.2.1-4.5.2.3. Table 4.5.2.4 gives data regarding the total area in sq km in the watershed under different cropping systems and production thereof whereas Table 4.5.2.5 gives information about the ongoing NWPRRA projects in the watershed.

Table 4.5.2.1 : Village wise land under cropping and their production in Tuirini watershed, Mizoram as on 1999

Sl.No.	Name of Village	Rice (wet and hill)		Maize	
		Area (in ha)	production (in Tons)	Area (in ha)	Production (in Tons)
1.	Sesawng	40.0	180.0	27.0	130.0
2.	Seling	13.0	27.90	10.0	47.0
3.	Tlangnuam	25.0	111.0	15.0	72.0
4.	Thingsulthliah	60.0	249.0	51.0	187.0
5.	Tlungvel	34.0	141.0	20.0	67.0
6.	Darlawng	10.0	21.0	6.0	24.0
7.	Phulmawi	16.0	63.0	11.0	51.0
8.	Khumtung	21.0	50.0	13.0	40.0
9.	Baktawng	50.0	164.0	22.0	21.0
10.	Hualtu	47.0	260.0	5.0	14.0
11.	Maite	NA	NA	NA	NA
12.	Tawizo	40.0	70.0	10.0	105.0
13.	Lenchim	42.0	82.0	3.0	8.0
14.	Mualpheng	38.0	95.0	4.0	10.0
15.	Ruallung	84.0	610.0	3.0	9.0
16.	Rulchawm	65.0	120.0	7.0	16.0
17.	Keifang	70.0	190.0	18.0	100.0
18.	Saitual	140.0	210.0	10.0	24.0
19.	Hmawngkawn	NA	NA	NA	NA
20.	Tualbung	66.0	170.0	2.0	2.5
21.	Khawruhlian	155.5	276.15	5.0	14.0
22.	Khanpui	31.2	98.04	15.0	44.0
23.	Lailak	17.4	42.0	5.0	6.0
24.	N.Lungpher	NA	NA	NA	NA
25.	Sihfa	NA	NA	NA	NA
		1075	3230.9	260.0	977.5

Source : District Agriculture Office, Aizawl (E), Aizawl, Mizoram, 1999.

Table 4.5.2.2 :Village wise land under cropping and their production in Tuirini watershed, Mizoram as on 1999

Sl.No.	Name of Village	Sugar cane		Tobacco		Cotton	
		Area (in ha)	Production (in tonns)	Area (in ha)	Production (in tonns)	Area (in ha)	Production (in tonns)
1.	Sesawng	3.0	225.0	5.0	1.0	2.0	2.0
2.	Seling	-	-	-	-	-	-
3.	Tlangnuam	3.0	216.0	-	-	-	-
4.	Thingsulthliah	15.0	100.7	3.5	7.0	1.0	1.0
5.	Tlungvel	3.0	147.0	-	-	-	-
6.	Darlawng	-	-	-	-	-	-
7.	Phulmawi	1.2	67.0	-	-	-	-
8.	Khumtung	-	-	-	-	-	-
9.	Baktawng	-	-	-	-	-	-
10.	Hualtu	-	-	7.0	117.0	-	-
11.	Maite	-	-	-	-	-	-
12.	Tawizo	-	-	3.0	8.0	-	-
13.	Lenchim	-	-	-	-	-	-
14.	Mualpheng	-	-	-	-	-	-
15.	Ruallung	-	-	-	-	-	-
16.	Rulchawm	-	-	-	-	-	-
17.	Keifang	-	-	-	-	-	-
18.	Saitual	-	-	-	-	-	-
19.	Hmawngkawn	-	-	-	-	-	-
20.	Tualbung	-	-	-	-	-	-
21.	Khawruhlian	1.0	2.0	4.0	3.0	3.0	1.5
22.	Khanpui	3.0	6.0	2.0	1.0	-	-
23.	Lailak	-	-	-	-	-	-
24.	N.Lungpher	-	-	-	-	-	-
25.	Sihfa	-	-	-	-	-	-
Total		29.2	763.7	25.5	33.7	6.0	4.5

Source : District Agriculture Office, Aizawl (E), Aizawl, Mizoram, 1999.

Table 4.5.2.3: Village wise land under cropping and production in Tuirini watershed, Mizoram as on 1999

Sl.No.	Name of Village	Potato	
		Area (in ha)	Production (in tonns)
1.	Mualpheng	40.0	160.0
2.	Khawruhlian	1.0	4.0
Total		41.0	164.0

Note : Figures for other villages are not available.

Source : District Agriculture Office, Aizawl (E), Aizawl, Mizoram, 1999.

Table 4.5.2.4: Area under agriculture crops and production in Tuirini watershed, Mizoram, as on 1999

Sl.No.	Crops	Area (in Sq.Km).	Production (in tonns)
1.	Rice (Hill & wet)	10.751	3230.09
2.	Maize	2.6	977.5
3.	Sugarcane	0.292	763.7
4.	Tobacco	0.255	33.7
5.	Cotton	0.06	4.5
6.	Potato	0.41	16.4

Note : Data for other agricultural and horticultural crops are not available.

Source : District Agriculture Office, Aizawl (E), Aizawl, Mizoram, 1999.

Table 4.5.2.5: Ongoing N.W.P.R.R.A. project in Tuirini watershed, Mizoram, as on 1999

Name of watersheds	No. of Villages. under project.	Area proposed for the treatment in sq.km)		
		Arable	Non-arable	Total
Middle Tuirini watershed	2	4.5	6.0	10.5
Saibual watershed	1	2.5	8.17	10.67
Total	3	7.0	14.17	21.17

Source : Statistical abstract, Department of Agriculture and Minor-Irrigation, Mizoram, 1998-1999.

4.5.2.2 Horticulture

Though the area is blessed with favourable physical conditions relating to horticulture, it is not yet fully developed in horticulture practices as expected. As a result proper information on horticulture is not available. It is found that the horticultural products available in the area are marketed locally. The orange, pineapple and banana are important horticultural products. The topography is not suitable for food crop production, so horticulture can be developed with proper schemes. The development of horticulture can help the people to earn more cash and at the same time food processing factories can be established. Only development of horticulture can compensate for the backwardness in food crop production. Most of the important villages are connected with the state capital Aizawl by a well developed road and this will provide a good market for horticultural products of the area.

4.5.2.3 Livestock

The existence of man and subsequent development of economic activities could be doubtful at best, had the world been devoid of animals. 'Huntington' (in Roy and Mukerjee 1996) observed that out of 3,500 species of animals, only 19 have been domesticated. The purpose of domestication has been to yield food directly or indirectly since the time immemorial. Thus the oriental people with much lower level of technology and with the dearth of development of inanimate energy still primarily

depend on their domestic animals for agricultural purposes (Sadhukhan, 1984). Rearing of particular animal has become a part of agricultural practice in the areas of agro-based economy, where it is considered as mixed farming. The rearing of certain animals in the hilly area is different from that of the plain areas. Practically farming system in hilly areas does not require the use of animals in agriculture practices. The study area mostly comprises with hills which is covered with the thick forest and bushes. As a result, so called grazing pastures are not available for domesticated herbivorous. The mixed farming system has not developed in the area to even a limited extent. Animals are not domesticated by the farmers for use in agricultural activities. Many families rear cattles, goats, sheeps, buffaloes and mithuns mainly for meat consumption. The number of milk producing animals is not significant in the watershed. Hence, the contribution of dairy farming animals to the rural economy is almost negligible. It has been observed that the number of cattles, goats and sheeps has increased during the period 1987-1992 and decreased between 1992-1997.

		1987	1992	1997
1.	Cattle	1750	1952	349
2.	Goat	593	323	236
3.	Sheep	0	33	16

The trend from 1992-1997 reveals that by 2002 the projected number of these cattles, goats and sheeps will be 62, 173 and 8 respectively. The only significant increasing trend shown by the number of pigs has gone from time to time. At the present rate of increase, the number of pigs will reach 19,085 by 2002 (projected). The increasing trend in pig's population may be attributed to their easy rearing, fondness of local people for their meat and their contribution in rural economy. A piglet becomes adult in about a little over one year and its meat on an average is sold for about Rs 6000.00 to Rs.7000.00. Buffaloes and Mithuns were recorded in the watershed only in 1997. As a result, the increase or decrease in their number cannot be ascertained as of now. On the other hand, high rate of increase in poultry fous population has been noticed. Their population has increased from 19,534 in 1987 to 60,061 in 1997. If the present trend of increase in poultry fous continues the number of poultry fous will reach 1,60,234 (projected) by the year 2002. This shows that

there is ample scope for poultry farming in the watershed. Moreover, it can be practiced with low capital investment and the return is also very high. Village wise population statistics of different livestock population in the watershed is shown in Tables 4.5.2.3A-D and in Table 4.5.2.3E total number of livestock in the watershed are shown.

Table 4.5.2.3A : Number of Live stock in Tuirini watershed, Mizoram

Sl.No.	Name of Village	Bovine (Cattle)			Coprine (Goat)		
		1987	1992	1997	1987	1992	1997
1.	Sesawng	6	33	-	-	-	-
2.	Seling	57	31	15	0	0	61
3.	Tlangnuam	38	39	10	0	34	41
4.	Thingsulthliah	14	69	2	0	25	0
5.	Tlungvel	19	45	8	0	0	0
6.	Darlawng	53	41	8	0	0	18
7.	Phulmawi	128	116	2	0	0	41
8.	Khumtung	40	53	0	0	0	0
9.	Baktawng	135	132	15	0	0	0
10.	Hualtu	48	70	0	18	63	0
11.	Maite	3	26	89	0	0	0
12.	Tawizo	39	58	0	65	0	0
13.	Lenchim	42	55	0	0	16	58
14.	Mualpheng	37	91	0	0	0	0
15.	Ruallung	54	97	0	101	20	0
16.	Rulchawm	92	109	5	8	55	0
17.	Keifang	173	151	0	49	28	0
18.	Saitual	133	182	0	54	59	0
19.	Hmawngkawn	15	12	0	9	3	0
20.	Tualbung	204	220	98	34	0	0
21.	Khawruhlian	47	84	0	19	0	2
22.	Khanpui	173	59	82	99	0	2
23.	Lailak	160	129	0	85	0	0
24.	N.Lungpher	20	32	12	40	20	8
25.	Sihfa	20	18	3	12	0	5
Total		1750	1952	349	593	323	236

**Source : Sixteenth Quinquennial Livestock Census of Mizoram - 1997,
Directorate of Animal Husbandry and Veterinary Deptt., Mizoram,
Aizawl.**

Table 4.5.2.3B: Number of Livestocks in Tuirini watershed, Mizoram

Sl.No.	Name of Village	Porcine (Pig)		
		1987	1992	1997
1.	Sesawng	7	52	321
2.	Seling	138	267	125
3.	Tlangnuam	54	86	954
4.	Thingsulthliah	102	208	1391
5.	Tlungvel	289	350	499
6.	Darlawng	50	75	120
7.	Phulmawi	158	393	667
8.	Khumtung	26	113	110
9.	Baktawng	83	110	350
10.	Hualtu	182	219	729
11.	Maite	80	98	208
12.	Tawizo	172	213	264
13.	Lanchim	78	139	94
14.	Mualpheng	71	194	63
15.	Ruallung	74	95	196
16.	Rulchawm	28	52	115
17.	Keifang	49	79	208
18.	Saitual	105	159	879
19.	Hmawngkawn	14	20	35
20.	Tualbung	120	260	321
21.	Khawruhlian	243	597	538
22.	Khanpui	7	52	321
23.	Lailak	58	41	47
24.	N.Lungpher	60	108	148
25.	Sihfa	70	85	105
Total		2318	4065	8808

**Source : Sixteenth Quiquennial Livestock Census of Mizoram - 1997,
Directorate of Animal Husbandry and Veterinary Deptt., Aizawl,
Mizoram.**

Table 4.5.2.3C: Number of live stocks in Tuirini watershed, Mizoram**Sheep**

Sl.No.	Name of Village	1987	1992	1997
1.	Seling	0	0	16
2.	Hualtu	0	14	0
3.	Tawizo	0	5	0
4.	Ruallung	0	14	0
Total		0	33	16

Buffalo

Sl.No.	Name of Village	1987	1992	1997
1.	Khanpui	0	0	12
2.	Mualmam	0	0	5
3.	Saitual	0	0	4
4.	Tualbung	0	0	231
Total		0	0	252

Mithun

Sl.No.	Name of Village	1987	1992	1997
1.	Tawizo	0	0	224
2.	Lenchim	0	0	30
Total		0	0	254

Source : Sixteenth Quinquennial Live stock census of Mizoram-1997, Directorate of Animal Husbandry and Veterinary Deptt., Aizawl, Mizoram.

Table 4.5.2.3D: Number of poultry in Tuirini watershed, Mizoram

Sl. No.	Name of Village	Poultry Fouls			Ducks		
		1987	1992	1997	1987	1992	1997
1.	Sesawng	849	910	2559	0	0	87
2.	Seling	692	1007	2176	0	0	18
3.	Tlangnuam	10	272	484	0	4	5
4.	Thingsulthliah	3136	3206	3225	51	26	71
5.	Tlungvel	426	2038	3285	0	40	131
6.	Darlawng	142	87	398	0	15	0
7.	Phulmawi	91	152	400	0	0	0
8.	Khumtung	288	355	1647	14	29	0
9.	Baktawng	757	813	1403	0	102	0
10.	Hualtu	872	852	4778	59	19	0
11.	Maite	403	503	1241	0	0	0
12.	Tawizo	353	460	933	0	0	0
13.	Lenchim	298	400	1443	0	0	13
14.	Mualpheng	632	713	1619	0	0	0
15.	Ruallung	845	840	8690	26	28	13
16.	Rulchawm	859	1289	2875	98	57	0
17.	Keifang	2715	272	4103	232	149	9
18.	Saitual	4366	5860	7174	199	262	13
19.	Hmawngkawn	37	61	84	0	0	0
20.	Tualbung	456	557	2613	0	0	0
21.	Khawruhlian	1506	826	5429	0	0	0
22.	Khanpui	287	671	2274	0	0	0
23.	Lailak	168	226	615	0	0	0
24.	N.Lungpher	77	91	129	12	15	0
25.	Sihfa	34	52	484	0	0	0
Total		19,534	22,513	60,061	691	746	360

Source : Sixteenth Quinquennial Live stock census of Mizoram - 1997, Directorate of Animal Husbandry and Veterinary Deptt., Mizoram, Aizawl.

Table 4.5.2.3E: Total number of Live stock in Tuirini watershed, Mizoram

Sl.No.	Live stock	1987	1992	1997	2002(Projected)
1.	Bovine (Cattle)	1,750	1,952	349	62
2.	Coprine (Goat)	593	323	236	173
3.	Porcine (Pig)	2,318	4,065	8,808	19,085
4.	Sheep	0	33	16	8
5.	Buffalo	0	0	252	-
6.	Mithun	0	0	254	-
7.	Poultry Fouls	19,534	22,513	60,061	1,60,234
8.	Ducks	691	746	360	174

Source : Sixteenth Quinquennial Live stock census of Mizoram - 1997, Directorate of Animal Husbandry and Veterinary Deptt. Mizoram, Aizawl.

4.6 Socioeconomic parameters

Initially man was subordinate to nature. With superior intellect, man ultimately won the struggle for survival with the aid of culture which not only strengthened his physical existence but also helped him to flourish. “ Culture means education, learning, experience, religion, civilised behaviour, suppression of vicious animal instincts, cooperation, the law of fairplay and justice suppressing the law of jungle” (Zimmermann 1946). According to Zimmermann (1946) “Culture is the sum total of all the devices produced by man, with the aid and consent of nature, to assist him in the attainment of his objectives (Roy and Mukherjee 1996).

4.6.1 Population

Human resource is the most precious of all the resources. Man plays dual role as a producer and a consumer of resources (as a resource creator man contributes his labour, primarily mental and secondarily physical). His aspiration gives him the uniqueness and puts him in a superior position. As a beneficiary he enjoys the advantage of advancing civilisation (Sadhukhan, 1984). He interacts with nature and

builds up a cultural way of life. Man is essentially an element of nature but he is different from the other elements of nature by virtue of his capacity to think and act accordingly. The more he liberates himself from the struggle of physical labour, the more he reaps the fruit of real wealth for the future (Roy & Mukherjii 1996). According to Zimmermann (1944) 'Man is the most dynamic agent of production and the beneficiary of the entire process of resource development and utilization'.

Apart from his role as a producer or creator, man's role as a consumer is equally important in the scheme of resource development. It is indeed true that the human wants boost the process of production. Resources are developed only to satisfy certain human wants. Human wants may broadly be classified into (a) Basic wants and (b) Cultural wants. Basic wants include primarily the need for food, clothing, shelter and thus are related with material aspect of our life (Roy and Mukherjii, 1996).

Village wise population of the watershed is given in the Table 4.6.1A. The table shows that the population distribution pattern is highly uneven in the watershed and there is a sharp contrast between vast areas of scanty population and dense population. Most of the villages are located over the ridges along the road, which present linear pattern of settlement in the watershed (Photographs 6 and 7). Out of the 39,360 total population, 19,864 (51 per cent) and 19,496 (49 per cent) are represented by male and female populations respectively. On the basis of population distribution the villages are grouped in three categories which is shown in the Table 4.6.1B.

Table 4.6.1A: Village wise population statistics of the Tuirini watershed as on 1.4.1999.

Sl.No.	Name of villages	No. of Houses	No.of Electrified houses	POPULATION		
				Male	Female	Total
1.	Sesawng	384	196	821	790	1,611
2.	Seling	358	350	950	1,080	2,030
3.	Tlangnuam	239	222	990	818	1,808
4.	Thingsulthliah	579	567	1,620	1,672	3,292
5.	Darlawng	87	65	252	286	538
6.	Tlungvel	267	387	1,569	1,550	3,119
7.	Phulmawi	65	23	136	132	268
8.	Khumtung	209	153	485	455	940
9.	Baktawng	500	329	1,506	1,570	3,076
10.	Hualtu	144	109	420	340	760
11.	Maite	127	109	427	388	815
12.	Tawizo	65	39	146	119	265
13.	Lenchim	64	40	145	133	278
14.	Mualpheng	126	112	345	431	776
15.	Ruallung	154	127	534	428	962
16.	Rulchawm	203	183	604	506	1,110
17.	Keifang	685	520	2,015	2,015	4,030
18.	Saitual	895	705	2,479	2,310	4,789
19.	Hmawngkawn	30	19	70	75	145
20.	Tualbung	112	78	315	318	633
21.	Khawruhlian	703	661	2,156	2,203	4,359
22.	Khanpui	290	184	852	832	1,684
23.	Lailak	52	15	155	158	313
24.	N.Lungpher	142	76	336	362	698
25.	Sihfa	208	171	536	525	1,061
Total		6,688	5,455	19,864	19,496	39,360

Source : Reports on Block Statistics, 1999, Directorate of Economics & Statistics, Mizoram, Aizawl.

Table 4.6.1B: Categories of villages in the Tuirini watershed based on population

Population distribution category	No.of Villages	Population range	Name of village
1. Thinly populated area	10	Up to 800 persons	Phulmawi,Hmawngkawn, Lailak, Tawizo,Lanchim, Darlawng,Hualtu,Tualbung, Mualpheng,N.Lungpher.
2. Medium Populated area	8	Up to 2000 persons	Khumtung, Maite,Ruallung, Sesawng,Tlangnuam,Sihfa, Rulchawm, Khanpui
3. Thickly populated area	7	Above 2000 persons	Thingsulthliah,Tlungvel, Baktawng,Seling Keifang, Saitual, Khawruhlian.

The distance between the villages, barring a few ones, is 12.8 km on an average (Table 4.6.1C). At the same time, population is less than 800 in the ten villages of the watershed out of 25 villages. The distance and the population factors are the main hindrance in the socio-economic development of the people of the watershed. The projected population of the watershed would be in the order of 118 per cent, 140 per cent and 144 per cent in the years 2004, 2009 and 2010 respectively and the total population would reach upto 56, 863 by the year 2010 (Table 4.6.1D). Therefore, suitable schemes may be evolved and implemented in the watershed to fulfill the socio-economic aspirations of the people.

Table 4.6.1C: Locational distance of the villages from Rural Development Block H.Q. in Tuirini watershed, Mizoram, as on 1-4-1999.

Sl. No.	Name of the villages	Distance in Km
1.	Sesawng	10
2.	Seling	2
3.	Tlangnuam	1
4.	Thingsulthiah	0
5.	Tlungvel	14
6.	Darlawng	13
7.	Phulmawi	19
8.	Khumtung	25
9.	Baktawng	27
10.	Hualtu	60
11.	Maite	75
12.	Tawizo	65
13.	Lenchim	55
14.	Mualpheng	47
15.	Ruallung	40
16.	Rulchawm	39
17.	Keifang	35
18.	Saitual	40
19.	Hmawngkawn	41
20.	Tualbung	65
21.	Khawruhlian	80
22.	Khanpui	32
23.	Lailak	30
24.	N.Lungpher	75
25.	Sihfa	52

Source : Reports on Block Statistics, 1999, Directorate of Economics and Statistics. Mizoram, Aizawl.

Table 4.6.1D : Total population (projected) in Tuirini watershed, Mizoram.

Year	Male	Female	Total
1999	19,864	19,496	39,360
2004	23,472 (118.16) = 118.00 %	23,056 (118.26) = 118 %	46,528 (118.21) = 118 %
2009	27,727 (139.58) = 139 %	27,266 (139.85) = 140 %	54,993 (139.72) = 140 %
2010	28,667 (144.32)	28,196 (144.62) = 145 %	56,863 (144.47) = 144 %

4.6.2 Education

Education is the primary source of knowledge. Man achieves knowledge and wisdom from both formal and informal education. In the present study the base of formal education *i.e.* the aspect of educational institute has been emphasized. There are 97 educational institutes in this watershed which include 52 Primary Schools, 26 Middle Schools, 17 High Schools, 1 Higher Secondary School and a College. The distance between the villages has been considered as the basis for location of schools, specially in the case of Primary and Middle schools.

The Table 4.6.2A shows that the number of boys (2559) out weight that of girls (2348) in Primary schools in 1999. The projected figures for the years 2004, 2009 and 2010 are 3,097, 3,747 and 3,892 for the boys and 2,777, 3,284 and 3,396 for the girls respectively. As far as Middle school level is concerned, it would be a matter of interest to know that the girls surpass the boys in the total student population. The table also reveals that from the Middle School education level to Higher Secondary education standard, boy students are surpassed by the girl students. In Middle school level, in 1999, the number of boys was 1,270 whereas that of girls was 1,285. The projected figures of the boys will reach to 1,501, 1,774 and 1,834 in years 2004, 2009 and 2010 respectively. Contrary to this, the projected figures for the girls for the above years is 1,529, 1,796 and 1,857 respectively. In High school standard the number of boys and girls were 7,39 and 8,19 respectively in 1999. The projected

figures are 8,74 (in 2004), 1,034 (in 2009) and 1,069 (in 2010) for the boys and for girls these are 9,69 (in 2004), 1,146 (in 2009) and 1,185 (in 2010). In 1999, in Higher secondary standard the student population was consisting of 132 boys and 143 girls. In College level education, the boys outnumbered the girls. The number of boys was 71 as against 49 of the girls. The projected figures are 84 (in 2004), 99 (in 2009) and 102 (in 2010) for boys and 58 (in 2004), 69 (in 2009) and 71 (in 2010) for the girls.

It is evident from the Table 4.6.2B that the total number of student population in the watershed was 9,415 in 1999 and its projected figure is 11,204 (for 2004), 13,333 (for 2009) and 13,803 (for 2010). At the same time the total teacher population of 539 (1999) is projected to be 622, 741 and 767 in years 2004, 2009 and 2010 respectively. As far as projected figure is concerned, it is noteworthy that the rate of increase by 2004 for students of both genders in all the segments does not exceed 118 per cent, except for the boys in the primary school level (121 per cent). The projected figure for 2009 indicate that the rate of increase varies between 139 per cent and 140 per cent, except for the boy student population in the primary education level (146 per cent). Similarly, the projected figures for both boys and girls student population by 2010 will also varies between 144 per cent and 145 per cent excepting again for the boys in the primary school segment (152 per cent). In terms of total number of students, the rate of increase by the years 2004, 2009 and 2010 is expected to be 119 per cent, 141 per cent and 147 per cent respectively.

Table 4.6.2A: Particulars relating to educational statistics in Tuirini watershed, Mizoram, as on 1-4-1999

Year	Primary School			Middle School		
	Boys	Girls	Total	Boys	Girls	Total
1999	2559	2348	4907	1270	1285	2555
2004	3097	2777	5874	1501	1529	3020
*	(121.0)	(118.27)	(119.71)	(118.19)	(118.21)	(118.20)
	=121%	=118%	=120%	=118%	=118%	=118%
2009	3747	3284	7031	1774	1796	3570
*	(146.42)	(139.86)	(143.29)	(139.69)	(139.77)	(139.73)
	=146%	=140%	=143%	=140%	=140%	=140%
2010	3892	3396	7288	1834	1857	3691
*	(152.09)	(144.63)	(148.52)	(144.41)	(144.51)	(144.46)
	=152%	=145%	=148%	=144%	=144%	=144%

(contd..)

Year	High School			Higher Secondary School			College		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1999	739	819	1558	132	143	275	71	49	120
2004	874	969	1843	156	169	325	84	58	142
*	(118.27)	(118.46)	(118.29)	(118.18)	(118.18)	(118.18)	(118.31)	(118.37)	(118.33)
	=118%	=118%	=118%	=118%	=118%	=118%	=118%	=118%	=118%
2009	1034	1146	2180	184	200	384	99	69	168
*	(139.92)	(139.93)	(139.92)	(139.39)	(139.86)	(139.64)	(139.44)	(140.82)	(140.00)
	=140%	=140%	=140%	=139%	=140%	=140%	=139%	=145%	=140%
2010	1069	1185	2254	190	207	397	102	71	173
*	(144.66)	(144.69)	(144.67)	(143.94)	(144.76)	(144.36)	(143.66)	(144.90)	(144.12)
	=145%	=145%	=145%	=144%	=145%	=144%	=144%	=145%	=144%

Note: * projected figures

Figures in the parentheses indicate their per centage increase.

Table 4.6.2B: Teacher-student ratio in the schools of Tuirini watershed as on 1999

Particulars	1999	2004*	2009*	2010*
No. of Students	9415	11204 (119.00)	13333 (141.61)=142%	13803 (146.61) = 147%
No. of Teachers	539	622 (115.40)=115%	741 (137.48)=137%	767 (142.30) = 142%

Note : * Projected Figures.

Figures in parentheses indicate their percentage increase.

Source : I) Sub-Division Education Office, Aizawl (E) II.

ii) District Education Office, Aizawl (E).

iii) Directorate of Technical and Higher Education, Mizoram, Aizawl.

iv) Reports on Block statistics, Deptt. of Economics and Statistics, Mizoram, Aizawl.

4.6.3 Health care facilities

Every human being is quite aware of his health. People believe that “Health is Wealth”. Consciousness of people regarding health is also considered as an index of cultural development in the society. Availability of medical facilities in an area relating to the population has been attempted in this study. Number of available health centers in any area forms the basis for the evaluation of health care in that area. The health facilities available in the Tuirini watershed are given in Table 4.6.3.

Table 4.6.3: Details of the health centres in the Tuirini watershed, Mizoram

Type of Health Centers	Location
1. Primary Health Centre	Thingsulthliah and Saitual
2. Sub-Health Centre	Sesawng, Seling, Tlangnuam, Thingsulthliah, Tlungvel, Phulmawi, Khumtung, Baktawng, Hualtu, Maite, Lenchim, Rulchawm, Keifang, Saitual, Tualbung, Khawruhlian, Sihfa.

It is evident from the above table that out of the 25 villages in the watershed, primary health centres have been established in two villages only and sub-health centres in 17 villages. In addition to primary health centres, Thingsulthliah and Saitual villages are also provided with a sub-health centre each. The table also shows that rest of the six villages in the watershed do not have any medical facility and have to depend on the centres available in the neighboring villages. It has been observed from the survey in the watershed that the existing health centres and sub-centres are not fully equipped. There is need therefore, to strengthen these in addition to opening of new sub centres in the remaining six villages.

4.6.4 Water supply facilities

Having drinking water facility is considered as vital and a fundamental feature in our life. Either from Govt. level or local civic body level drinking water facilities have been provided in the villages of the watershed. Drinking water is supplied to the people with the help of driller water pumps (hand pumps) and public water points. All the villages are provided with either drilled water pumps or public water points. The number of such water point pumps varies from village to village based on population. There are 6 nos. of drilled water pump and 214 public water points in the watershed (Table.4.6.4.). Besides, the villagers also fetch drinking water from the natural spring sources found in the neighborhood of the villages.

Table 4.6.4 : Particulars of water supply source and other means of recreational facilities in Tuirini watershed, Mizoram as on 1.4.1999.

Sl.No.	Name of Village	No. of drilled water pump	No. of Public water point	No. of Comm-unity Hall	No. of playground.
1.	Sésawng	2	7	1	1
2.	Seling	2	7	1	1
3.	Tlangnuam	4	5	1	1
4.	Thingsulthliah	9	12	1	1
5.	Tlungvel	2	29	1	1
6.	Darlawng	1	5	0	1
7.	Phulmawi	1	2	1	1
8.	Khumtung	2	2	1	1
9.	Baktawng	2	11	1	2
10.	Hualtu	0	10	1	1
11.	Maite	0	6	1	1
12.	Tawizo	0	5	0	1
13.	Lenchim	0	6	1	1
14.	Mualpheng	0	1	1	1
15.	Ruallung	2	3	1	1
16.	Rulchawm	4	15	1	1
17.	Keifang	12	6	1	1
18.	Saitual	9	17	1	2
19.	Hmawngkawn	0	1	0	0
20.	Tualbung	0	8	1	1
21.	Khawruhlian	6	34	2	2
22.	Khanpui	2	15	0	0
23.	Lailak	0	4	1	1
24.	N.Lungpher	0	1	0	0
25.	Sihfa	0	2	1	1
	Total	60	214	21	25

Source : Reports on Block Statistics, 1998-1999. Deptt. of Economic and Statistics, Mizoram, Aizawl.

4.6.5 Recreational facilities

Recreational activities are a part and parcel of our social life. Sports, games, music etc. are considered as parameters to evaluate the index of cultural development. Community halls are available in all the villages excepting Darlawng, Tawizo and N. Lungpher. These halls are used by the people to conduct public meetings and social and cultural activities. Similarly, playgrounds are also available in each of the village excluding three namely, Hmawngkawn, Khanpui and N. Lungpher.

At present, more than one community halls and playgrounds are available only in a few big villages (Table 4.6.4). As the population is increasing, more recreational facilities will be required by the year 2010. In big villages, more community halls and playgrounds will be needed for extending recreational facilities.

4.6.6 Means of communication

The area is lagging behind in the communication facilities. There are two sub-posts offices with telegraph facilities available at Saitual and Thingsulthliah. Branch post offices are available at Mualpheng, Rulchawm, Keifang, Sihfa, Tualbung, N. Lungpher, Sesawng, Seling, Khumtung, Baktawng, Hualtu, Maite, Khanpui and Khawtuhlian villages. Recently telephone facilities have been extended in some of the villages of the watershed. Regarding banking facility, it is found that one branch of State Bank of India is available at Saitual followed by Rural Bank branches at Thingsulthliah, Tlungvel and Khawruhlian.

4.6.7 Transport facilities

As far as transport facility is concerned road is the only dependable means of transportation in the area. In the western part of the watershed a part of N.H. 54 is running from north to south connecting Aizawl with Lunglei. A part of Aizawl-Champhai road also traverses the watershed between Seling and Saitual. In the eastern part of the watershed, a road is under construction. Some village, namely, Lenchim, Tawizo and Maite, are located away from the state highway.

4.6.8 Industrial/manufacturing activities in the watershed

Manufacturing involves increasing usefulness or enhancing value of raw or semi finished material. Commercial manufacturing is based on assembling the raw materials in all establishments (whether cottage, workshop or factory building), upgrading their usefulness by enhancing their form and sending them to the consumers. Among various forms of manufacturing 'Handicraft' and 'House hold or Cottage industry' are grouped under the small scale sector manufacturing activity. Handicraft manufacturing is the earliest form of manufacturing in which the craftsman is the industrial worker, whereas the difficulty of collecting raw materials and marketing the finished products led to the development of house hold or cottage industry (Sadhukhan, 1984).

The study area absolutely depends on agriculture for livelihood. The remoteness of and non-availability of raw materials are the main hindrances for the growth of the industries in the study area. However, a few manufacturing centres are available in the area which are running on small scale level or sector. It is found that only 11 registered manufacturing units are available in the watershed (Table 4.6.8). However, these are located only in the four villages of the watershed namely, Thingsulthliah, Saitual, Keifang and Lenchim. This indicate that the remaining 21 villages do not have any manufacturing unit. Less than 1 per cent of the total population is employed in registered manufacturing units. It is observed that the source of income, other than agriculture products and working in registered farms, are collection of forest timbers, fuel wood and bamboos. Besides, a section of people also live on petty business, daily labour, carpentary works, tailoring works and government jobs. The increasing population will require more earning opportunities which can be fulfilled from the horticultural practices and poultry farming and fisheries etc.

Table 4.6.8 : Particulars of registered industries of Tuirini watershed, Mizoram, as on in 1999.

Sl.No.	Name of Industries, Location, No. of Registration No., Date.	No. of Employed person	Annual production on value	Item of production.
1.	Zingi Bakery, Thingsulthliah 58/1/02157/pmt/tiny.27.6.94.	6	Rs 3,16,314/-	Breads, Cakes & Biscuits.
2.	Hnamte Steel Fabrication, Thingsulthliah 58/01/0229/pmt/tiny.25.7.95	4	Rs 1,60,000/-	Doors, Grill, Windows & Gates.
3.	V.L.Hriati Tailoring, Thingsulthliah 58/01/02361/pmt/tiny/28.11.95	4	Rs 20,000/-	Ladies Garments, Tailoring charge.
4.	Zoawi Poultry Farm, Thingsulthliah. 58/01/03396/pmt/tiny/10.3.95	3	Rs 22,000/-	Egg production, Dressed chicken
5.	Eastern Tailoring, Keifang 58/01/03396/pmt/tiny/26/10/95	7	Rs 25,000/-	Readymade Garment.
6.	Zuui Hollow Block Industry Keifang. 58/01/02228/pmt/tiny/ 1.5.95.	21	Rs 6,00,000/-	Cement Hollow Block.
7.	V.T. Tailoring, Saitual. 58/01/03364/pmt/tiny/12/2/99.	3	Rs 12,000/-	Tailoring charges.
8.	Blue Blood Cotton Mill, Saitual 50/01/03570/pmt/tiny/19/7/99.	5	Rs 15,000/-	Quilts, Pillows and Mattresses.
9.	Je-El-Ar Steel Fabrication, Saitual. 59/01/3854/pmt/tiny/17.5.00.	10	Rs 94,000/-	Steel gates, Grills and Doors.
10.	Bethlehem Furnitures, Saitual. 58/01/3858/pmt/tiny/17.5.00.	10	Rs 94,000/-	Sitting room sets, Dinning sets. etc.
11.	L.M.K. Furniture, Lenchim. 58/01/3088/pmt/tiny/9/12/00.	3	Rs 1,5300/-	Windows, Door frames Furnitures.

Source : Director of Small Industry, District Industrial Centre, Aizawl, Mizoram, 1999.

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CHAPTER 5: DISCUSSION
AND
CONCLUSION

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Slope

5.1.1 General discussion

Slope, in fact, is of geomorphic and economic significance. The nature of lithology, process of erosion, nature of tectonic movement, climate of the region and time factor play an important role in determining slope into straight concave or convex surfaces.

Table 4.1.1 and Fig. 4.1B shows that 88.09 per cent of the area is having slope more than 20°. Moving water in such area gets enough velocity required for the transportation of all the load supplied to the stream from the upper courses. The sediment loss from the watershed is, therefore, naturally high in addition to high rate of run-off. This view is supported by the discharge and sediment loss data (Table 5.4.2).

The area-slope distribution table shows that about 81.53 per cent of the area of Tuirini watershed has moderately steep to steep slope (21°-30°). It is supposed to be an indicator of youth stage of land form (Singh 1980). It further shows that 21°-30° slope group may be called as a characteristic angle of the basin. Steep slopes are as such indicative of youthful stage of the land form as the erosional agents here are unequivocally active. The phenomena reverse in the case of land forms with gentle slopes which have superseded their youth stages (Pande, 1990). The gentle, moderate and very steep slopes constitute about 0.64, 11.27 and 6.65 per cents of the area respectively. Further examination of the distribution table indicate that maximum area falls under steep slope category upwards and increasing slope category downwards. This indicates late first stage and early second stage of Davis Cycle of Erosion for the watershed (Pande 1990).

The five slope categories selected to express geomorphic details are not true to the angular scale. These are meant to give generalised picture (Pande 1990). For instance, a slope, instead of being uniform, may be concave or convex or marked by many other irregularities. These have, however, been overlooked in drawing the average slope map (Fig.4.1A). Since the slopes have great influence in landuse, these

five slope categories may further be scrutinized and useful information may be gathered on the basis of slope sub-categories for micro-level planning.

5.1.2 Suggested land use based on average slope

Table 4.1 shows that more than 88 per cent of the area of the watershed has slope more than 20° and only about 12 per cent area has slope <20°. Mac Gregor (1957) observed that land having gradient more than 18° is not of much economic significance under British conditions as far as agriculture is concerned. Taking this into account one may infer that most of the land in the watershed is unusable. During the course of field study, it has been noticed that in many a place the gradient of jhum land appears as steep as 70°. The result is heavy run-off and soil erosion (Table 5.4.2). The utilization of land resources for agricultural purposes in the watershed is made irrespective of its capability leading to environmental hazards.

In spite of the fact that Mac Gregor suggested 18° gradient as the upper limit of cultivation in England, land with gradient upto 25° is recommended for cultivation keeping in view the prevailing practices of cultivation in the state. The land use type proposed for the Tuirini watershed based on the average slope is shown in the Table 5.1.

Table 5.1: Proposed land use type for Tuirini watershed based on average slope

Sl. No.	Slope Class	Slope Angle	Suggested landuse	Area sq.km.
1.	Gentle Slope	< 15°	Suitable for wet land cultivation of puddy mustard etc.	2.55
2.	Moderate Slope	15°- 20°	Suitable for upland crops like, Paddy, Maize, beans, chillies, pulses, potato, ginger, sugarcane, topioca, turmeric oil seeds, sweet potato etc.	44.95
3.	Moderately Steep Slope	21°- 25°	Suitable for plantation crops like, banana, citrus fruits, pineapples, papaya etc.	160.44
4.	Steep Slope	26°- 30°	Suitable for forestry & fodder like timber and fuel trees, fodder species etc.	164.62
5.	Very Steep Slope	> 30°	Suitable for social forestry.	26.13
Total				398.69

The topography and slope have affected the economic activities in the watershed. There is practically no enough land for cultivation. The people of the watershed, therefore, resort to cultivate the steeper slopes. This leads to excessive run-off and soil erosion. The fertility of the soil and its moisture content is also adversely affected.

5.2 Soil

5.2.1 Land evaluation for its suitability under different cropping systems

Land evaluation is the process of estimating the potential of land for the alternate kind of use. The overall suitability of a particular mapping unit is assessed on the basis of quality of land which in turn is ascertained from the land characteristics like depth and texture of soil, slope, relief, drainage, erosional hazards, moisture availability, rock out crops and skeletal materials.

FAO's (Anon. 1979) framework for evaluation of land for particular land utilisation type (LUT) has recommended that the comparison of land with land use should be carried out in terms of land qualities and the same has been followed here.

The soils of the Tuirini watershed have been evaluated for their suitability for different land use types (Table 5.2.1). The study indicates that the following land utilisation types are suitable for the Tuirini watershed:

- 1. Upland crops:** Paddy, maize, beans, chillies, pulses, potato, ginger, sugarcane, tapioca, turmeric, oilseeds, sweet potato etc.
- 2. Forestry and fodder:** Timber and fuel trees, fodder species etc.
- 3. Plantation crops:** Banana, citrus fruits, pine apples etc.
- 4. Wet land cultivation:** Paddy, mustard etc.

These LUTs may help in maintaining the ecological balance in the study area and may also be useful in reducing the miseries of the shifting cultivation.

Table 5.2.1 Relative suitability classes under different Land Use Types (LUTs)

Sl. No.	Physiographic units	Forestry crops	Plantation crops	Upland crops	Upland paddy	Area sq. km.	Suggested landuse
1.	A, G, M	S3	S3	S3	S3	23.874	Forestry
2.	B, H, N	S3	S3	S3	N	143.577	Forestry
3.	C, I, O	S3	S3	S3	S3	117.829	Plantation crops
4.	D, J, P	S2	S2	S2	S3	39.562	Plantation crops
5.	E, K, Q	S2	S2	S2	S3	40.203	Upland crops
6.	F, L, R	S2	S2	S2	S3	20.510	Upland crops
7.	S	S2	S2	S2	S2	13.054	Upland paddy

5.3 Climate

Tables 4.3.2.1 - 4.3.2.6 show average climatological particulars and seasonal variations of temperature, rainfall, rainy days and humidity for the last 10 years (1991-2000). It is clear from the Table 4.3.2.5 that the mean annual maximum and minimum temperature for the last 10 years (1991-2000) are 25.89°C and 17.25°C respectively. The mean annual rainfall is 231.27cm and average annual rainy days are 165. The average annual humidity is 77.85 per cent. The distribution of rain fall in the watershed is uneven. Table 4.3.2.6 shows that the rain fall is mainly concentrated during the pre-monsoon (55.54cm) and monsoon(147.20cm) seasons. Therefore, these seasons are favourable for the growth of crops and other plants. The retreating monsoon and winter season receive 22.83cm and 5.70cm rainfall. Due to this, dry or semidry conditions prevail for more than a half of the year (retreating and winter seasons) and the soil retains less moisture content in these seasons. As a result, cultivation is not possible in these seasons. Effort should be made for the irrigational facilities through check dams etc. in order to enhance the production of food grains.

5.4 Geophysical

5.4.1 General discussion

The parameters like bifurcation ratio (Rb), drainage density (Dd), stream frequency (Sf), form factor (Ff), circulatory ratio (Cr) and elongation ratio (Re) are also termed as erosion risk assessment parameters and have been used during the study for prioritising sub-watersheds for conservational measures, along with the sediment production rate.

The values of Ff in the present area range from 0.20 to 0.65. These values can be considered medium to high. Low Ff basins have flatter peak flows for longer duration whereas the basins with medium to high Ff have high to very high peak flows for shorter duration (Biswas, *et al.* 1999).

The elongation ratio (Re) at an average of 0.55 indicates fairly high degree of elongation of the basins which may be due to structural control in the development of the basins (Singh and Bhatt 1996). The values of this parameter approach one as the shape becomes a circle. The elongation ratio in the study area has values between 0.50 to .91 with an average value of 0.64. The micro-watershed no 2 has the highest value of Re *i.e.* 0.91.

If the values of circularity ratio (Cr) approach one, the basin is more or less a circle in shape. The values of Cr in the study area range between 0.35 to 0.80 thereby indicating elongated nature of the micro-watersheds (Biswas *et al.* 1999 and Singh and Bhatt 1996).

Most of the studies suggest that the bifurcation ratio (Rb) tends to be constant for a particular basin and for drainage basins having uniform lithology, climate and stages of development. This ratio varies from a minimum of two in a flat drainage basins to 3-5 in mountainous or highly dissected drainage basins (Singh and Bhatt 1996). The higher values of Rb are the characteristics of watersheds where the drainage has been affected by structural disturbances (Biswas *et al.* 1999) whereas the lower values of Rb point to less structure disturbances by the basins (Strahler 1964). In the latter case, the drainage pattern has not been distorted because of the structural disturbances. Rb is also indicative of the shape of the basin. An elongated basin is likely to have a high value of Rb whereas a circular basin is likely to have low value

of Rb (Nag 1998). Extreme values of Rb indicate strong geological control in their development (Sharma 1986). The values of Rb in the present area range from 2.81 - 5.75 excepting for micro-watershed no. 21 where it is exceptionally high, *i. e.*, 9.28. These values closely resemble with those meant for mountainous and highly dissected basins.

Drainage density (Dd) is primarily controlled by the nature of the bed rock and overburden. In highly permeable rocks, it will be low (Gokhale and Rao 1981). The watersheds having high values of Dd have low permeability underlying rocks like shales, mudstones etc., whereas those with low values of Dd may have permeable rocks like sandstones having secondary porosity and permeability. Intermediate values of Dd may indicate varied lithology like sandstone and shales with varied hydrological characters (Singh and Bhatt 1996). The values of Dd for the micro-watersheds of Turini catchment range between 0.0026 - 0.0077 m/sq.m which is in the intermediate range. This is indicative of the presence of varied lithology (sandstone, shale, siltstone etc.) and most of the micro-watersheds have got moderately developed network of streams and are subjected to torrential runoff causing intense flood.

Stream frequency (Sf) also varies as the Dd does. High values of Sf and Dd indicate coarse texture whereas their low values indicate fine texture. This is due to the fact that impermeable rocks like shale allow more surface runoff and permit the development of closely-knit drainage network. Permeable rocks have high infiltration capacity and do not permit the development of closely-knit drainage network (Singh and Bhatt 1996).

Length of overland flow (Lo) is the surface runoff of the rain water before it is localised into definite channels. Its values, say for example, 0.13 km indicate that the rain water has to run over the ground for about 0.13 km before it is collected into a stream. The higher values of Lo point to a retarded drainage development and *vice-versa* (Singh and Bhatt 1996). Horton (1945) observed that Lo is an important independent variable affecting the quantity of water to exceed a certain threshold of erosion. The values of Lo in the study area range between 0.064 - 0.190 which are on the lower side and indicate closely developed network of streams and the area has high relief.

The values of Ruggedness number (Rn) in the area show the range 1.62 - 10.17. These values indicate that the area has steep and composite ground slope and the variation in the average slope shows considerable change in the relief of the watersheds.

The values of all other parameters are in agreement with the fact that about 55 per cent of the area is subjected to severe erosion (Tiwari and Jha 1997).

5.4.2 Prioritization of watersheds

Priority and grading of micro-watersheds within the watershed under very high, high, medium, low and very low are fixed according to their sediment yield index, jhuming intensity value and run-off etc. In the present study, Sediment Production Rate (SPR) has been taken as the basis for prioritising micro-watersheds of Tuirini watershed as has been recommended by the Soil Conservation, Ministry of Agriculture, Govt. of India (Anon. 1970). Priority classes have been finalised by arranging SPR in the descending order. Micro-watersheds having SPR more than 5.00 have been put in a very high priority class, those having SPR between 2.50 - 4.50 in the high priority class, and those with SPR upto 2.50 in the low priority class (Table 5.4.1). Table 5.4.2 gives the estimated values of SPR along with priority numbers to serve as a basis for much of the current study and planning of conservation needs in both research and action plan.

Table 5.4.1: Prioritisation scheme of Tuirini watershed based on the values of SPR

Priority Class	Sediment Production Rate
1. Low Priority (LP)	upto 2.50
2. High Priority (HP)	2.51- 4.50
3. Very High Priority (VHP)	above 5.00

Table 5.4.2- Mean annual run-off, sediment production rate and priority classes of the micro-watersheds of Tuirini watershed, Mizoram.

Watershed No.	Mean Annual Run-off	Sediment Production Rate	Priority Classes
1.	50.5015	4.5994	VHP
2.	35.3400	2.0679	LP
3.	48.5447	4.1562	HP
4.	56.7390	5.8689	VHP
5.	55.6832	5.6205	VHP
6.	44.8281	3.6205	HP
7.	42.4997	2.0799	LP
8.	59.4694	6.4949	VHP
9.	44.4484	3.4238	HP
10.	58.7327	6.3196	VHP
11.	50.2093	4.5025	VHP
12.	57.5119	6.0349	VHP
13.	38.8011	2.5397	HP
14.	51.8833	4.8110	VHP
15.	53.3332	5.1121	VHP
16.	56.1054	5.7147	VHP
17.	40.5881	2.8040	HP
18.	39.1093	2.5842	HP
19.	44.8040	3.4844	HP
20.	39.1671	2.5924	HP
21.	51.3910	4.7338	VHP
22.	51.2510	4.6837	VHP
23.	51.2324	4.6797	VHP
24.	76.6876	11.3613	VHP
25.	60.8084	6.8203	VHP

LP= Low Priority HP= High Priority VHP=Very High Priority

Table 5.4.3 and Fig. 5.4A shows that about 55 per cent (219.0360 sq km area in 15 micro-watersheds) of the Tuirini watershed is considered as belonging to very high priority class and needs immediate attention for conservational measures. Besides, about 40 per cent of the area (162.4710 sq km area in 8 micro-watersheds) belongs to high priority class. Thus, high and very high priority classes constitute about 95 per cent of the area of Tuirini catchment. Engineering measures of soil and water conservation are essential and should be given top priority to avoid further degradation of the valuable natural resources from the Tuirini watershed. This can be achieved by evolving suitable watershed management plans.

Table 5.4.3: Details of the priority classes of Tuirini watershed

Priority Class	No. of Micro-watersheds	Area in sq.km.	Area in per cent
Low Priority	2	17.183	4.3099
High Priority	8	162.4710	40.7512
Very High Priority	15	219.0360	54.9389
	Total 25	398.6900	100.0000

5.5 Biophysical

It is found that the watershed abounds in many commercially and medically valuable plants. The most preferred tree species, bamboo species and medicinal plants have been listed along with their description.

Although climatic conditions are suitable for agriculture, the area is lagging behind in food crop production due to undulating topography. Jhuming is extensively practiced in the watershed and the production under jhuming is low. The production is further decreasing due to the shortening of the jhum cycle and the erosion of top soil. As a result, the gap between production and consumption is increasing. The present production of paddy (3,230.09 tonnes) from 10.751 sq km of area is enough only for 83 days in an year for the total population of the watershed *i. e.* 39, 360 and the people face shortage of rice for the remaining 282 days. Maize is also cultivated in 2.6 sq km

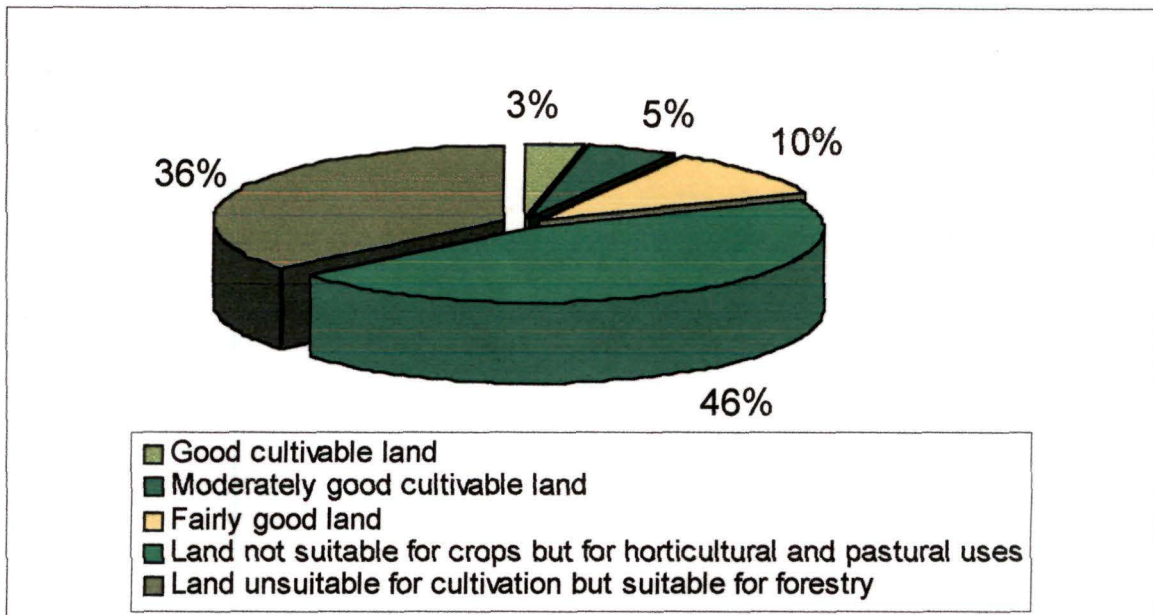


Fig. 4.2 B : Graph Showing Area (in percentage) of Tuirini River, Mizoram under different Land Capability Classes.

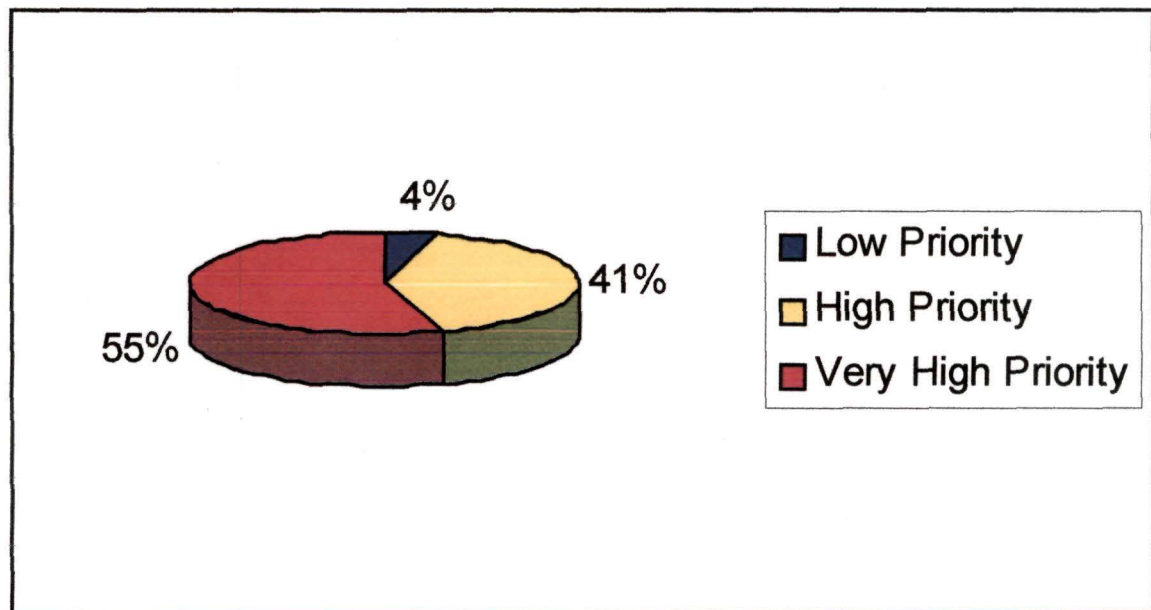


Fig. 5.4 A : Graph Showing Area (in percentage) of Tuirini River, Mizoram under different Priority Classes.

of the area with the annual production of 977.5 tonnes. Production of cash-crops has negligible effect on the economy of rural poor as, at present, only 1.017 sq km of the area in the watershed is under such crops. The topography, climate and soil of the watershed are highly suitable for practicing horticulture. However, this sector has not yet been fully exploited. The orange, banana and pine-apples grow very well in the area and there is a need to plant them in a large scale. The data shows that the piggeries and poultry farming are flourishing in the watershed and contribute significantly towards the income of the rural poor.

5.6 Socio-economic

The population is fastly increasing in the watershed. The total population at present is 39,360 (1999) which is projected to be 46,528 (in 2004; 118 per cent increase), 54,993 (in 2009; 140 per cent increase) and 56,867 (in 2010; 144 per cent increase). Long - term strategies have to be evolved to provide quality education to the people of the watershed. Existing health facilities have to be improved and new health centers may be opened. Water supply facilities in the villages need to be enhanced and means of communication be strengthened. Small scale industries have to be set up for generating employment and for boosting economy.

5.7 Watershed management plans

Several design and models have been suggested to solve the problems of shifting cultivation or hill farming system. The three tier system was suggested by ICAR, Shillong (Singh 1986), *i. e.*, cultivation of trees at the hill tops, horticulture crops in the middle portion of the hill slopes and forming terraces at the lower portions of the hill slopes for cultivation of crops. This model may not be suitable for the farmers having small land holdings in the Tuirini watershed.

The Directorate of Agriculture, Govt. of Mizoram, Aizawl introduced Contour Trench Farming system (in Jha 2000). There are many drawbacks in this model, *viz*, depth width and length of contour trench at different slope per cents and spacing between the two contour trench do not have any scientific basis. Continuous contour trenches may cause land slip due to steepness of hill slopes. The rate of soil

erosion is high in the Tuirini watershed. The contour trench may trap silt load carried along with the run-off up to two years and may be filled thereafter. A farmer will need additional labour for the maintenance of trenches.

We need a technology which would be able to tackle socio-economic, geophysical and biophysical problems in the Tuirini watershed. Therefore, before introduction of modern technology, one should study in depth, the psycho-socio-cultural profiles of the farmers, particularly the social organisation, social behaviour and social cognition associated with shifting cultivation and permanent settlement pattern. This study would provide empirical foundation to formulate strategies for cognitive and behavioural modification of individuals to facilitate permanent settlement patterns relating to agriculture, forestry and animal husbandry. The jhum control should be need-based and location-oriented. The model tested elsewhere may not be suitable in the Tuirini watershed it needs to be modified by studying the existing agricultural practices, biophysical and geophysical problems and the need of the farmers.

Jha (2000) has introduced TGhCFS and CTTGCFS models as an alternative to shifting cultivation. These models may be introduced after modification in hill farming system in the watershed. These models exert control over the biophysical, geophysical and socio-economic problems associated with shifting cultivation or hill farming system. These are capable of providing four basic things, namely, food, fodder, timber and fuel wood on a sustainable basis and will have control over soil erosion, nutrient and moisture loss and would generate year round employment. The salient features of these models are given below.

Model 1 : Tree-Greenhedge-Crop farming System

This system ensures:

- * Fruitful utilisation of uncultivable waste land
- * Minimum use of fertilizers (by introducing NFTs) and favours use of green manure.
- * Production of resources to meet local demands as well as national need.
- * Recycling of available resources

- * Economic rehabilitation of farmers by creating perpetual income opportunities through quick sustained returns from agricultural crops, fruits, vegetables and fuel wood and huge income from timber sale.

Characteristics of ideal multipurpose tree species

A good multipurpose tree species should have the following characteristics (Jha 1992):

- * Production of fire wood, timber, green manure, fodder on sustained basis.
- * Fast growing and good coppicer
- * Minimum competition between crops and MPTs. The problem like sun light penetration etc. can be tackled by judicious canopy management.
- * Tree species having nutritious and palatable leaves are preferred, in order to supplement the leaf fodder during lean period, and
- * MPTs having ability to fix nitrogen in addition to other productive benefits should be preferred.

Choice of crops

In selection of crops to be grown in the interspace attention must be given to the following points:

- * The crops should not deteriorate the soil
- * Spacing of the NTFs and crops should be planned according to their requirements.
- * Intercrop may be used as green manure for improving organic matter content of the soil. This may also check weeds and soil erosion.
- * It should also be born in mind that grain-farming timing of the crop should not coincide with flowering and bud differentiation in fruit trees. During non-bearing periods, farmers can grow any crop.

Gains from the TGCFS model

***Productivity**

An appropriate agroforestry model like TGhCFS improves the productivity of degraded hill farm or jhum land. On-farm demonstration of this model was conducted in the year 1993 in the three villages of Mizoram. The result showed increase in the productivity of the crops and nutrient status of soil and decrease in the soil erosion. Upadhaya and Jha (1997) had estimated net revenue from shifting cultivation on TGhCFS model and concluded that “apart from being eco-friendly and sustainable, this model is about 18 times more lucrative than the shifting cultivation”.

*** Environmental impact**

A well-designed and properly managed agroforestry model generates several positive environmental impacts on sloping land having leguminous hedgerows plantings on the contour lines. It checks run-off and soil erosion. The foliage of the hedgerows can be used as mulch or green manure or for animal feed.

Model 2: Contour Trench-Tree-Greenhedge-Crop Farming System

In this model, greenhedges are established on the contour lines at the lower side of the contour trench. This tree based agroforestry model was tested by Jha in the year 1996 near Zemabawk, Aizawl, Mizoram. The Directorate of Agriculture, Govt. of Mizoram introduced contour trench system in Mizoram. They introduced the same without any scientific investigation. The formula for calculating the distance between two contour trenches at different slope per cents was not developed.

The aim of planting hedgerows on the lower side of the contour trench is to ensure protection to the hedge farming species. The hedge farming species are planted in the downward side of the trench. The silt is deposited in the contour trench. Otherwise the silt load damages the germination and hampers the growth of the green hedge farming species. The trench traps the silt load in the initial two years. The hedge farming species gets sufficient protection and establishes properly within two years. After the second year the hedge rows protect the farm from soil and nutrient losses. The hedge rows obstruct the run-off and water gets sufficient time for percolation. Thus, this system also increases the moisture level of the soil. The green

hedge also increases the nutrient status of the soil as stated under Tree Green hedge Crop Farming System.

Limitations of CTTGCFS model

In Mizoram, the labour is scarce and co-operative labour system prevails in jhum farming. The villagers would not take interest in digging trenches. Considering the soil loss, the trenches can survive for a maximum period of two to three years. Farmers have to dig trench again. Moreover, the soil structure is favourable for landslide and landslip.

Above two models have been suggested for the Tuirini watershed keeping in view its biophysical, socioeconomic and geophysical characteristics. However, there may be a need to modify these depending on the local variations in these characteristics.

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Photo Plate 1

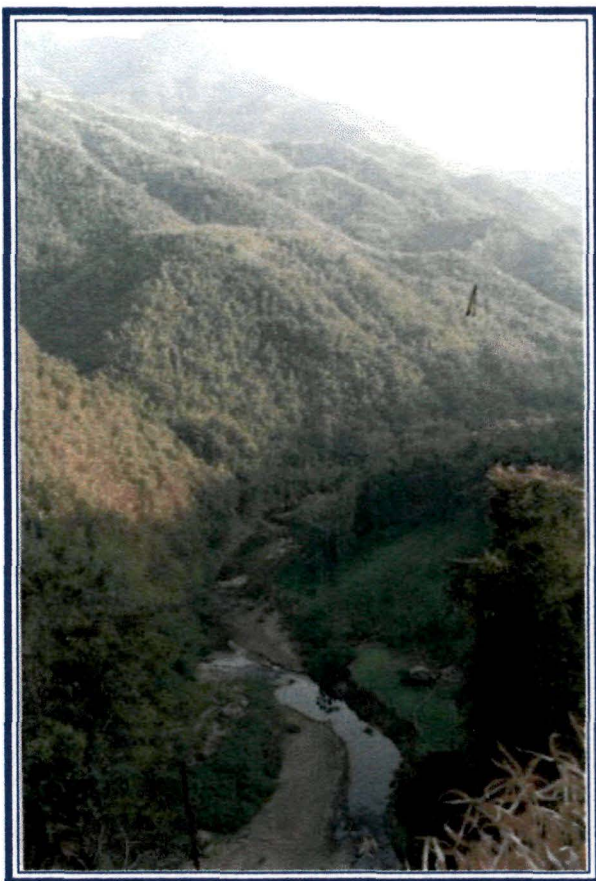


Photograph No. 1 - A view of Tuirini watershed from the bridge on Seling - Saitual Road. Prevailing cultivation practices can be seen on the river banks.



Photograph No. 2 - A view of the Tuirini watershed along with the forest.

Photo Plate 2

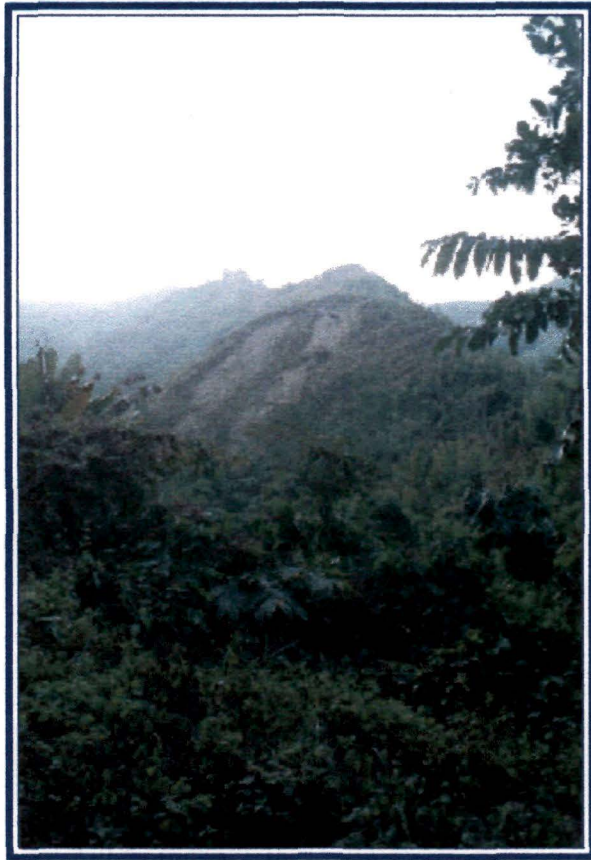


Photograph No. 3 - Forest occupy a major portion of the Tuirini watershed.



Photograph No. 4 - Bamboo dominated jhum area near Darlawng village.

Photo Plate 3



Photograph No. 5 - Tree dominated jhum area near Tlungvel village.



Photograph No. 6 - Darlawng village in the watershed.

Photo Plate 4

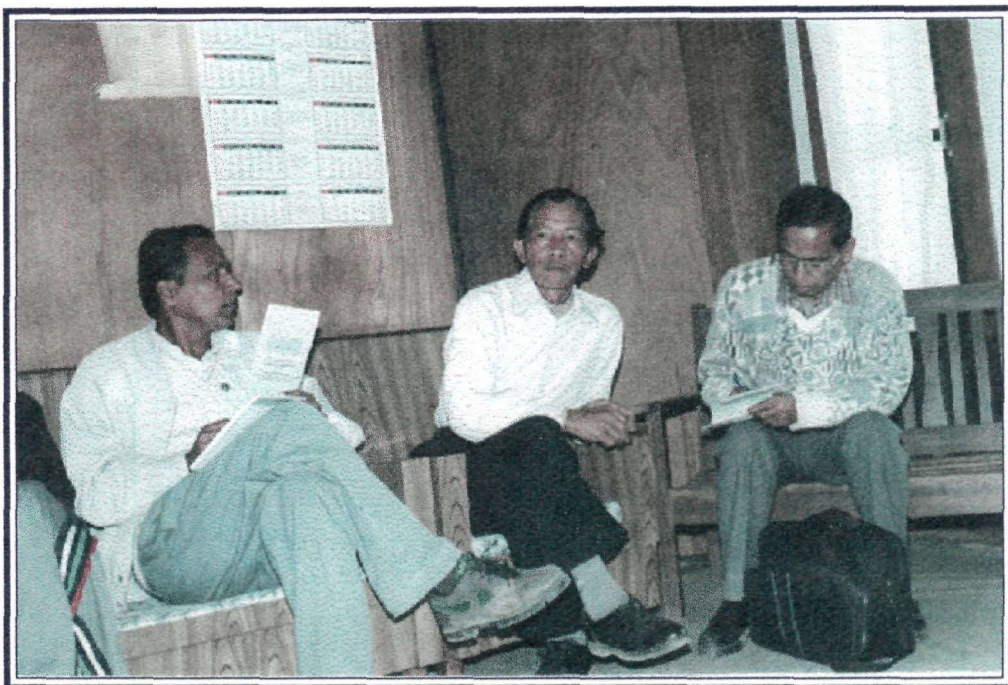


Photograph No. 7 -Tlungvel village in the watershed.



Photograph No. 8 - A part of Thingsulthliah village in the watershed.

Photo Plate 5

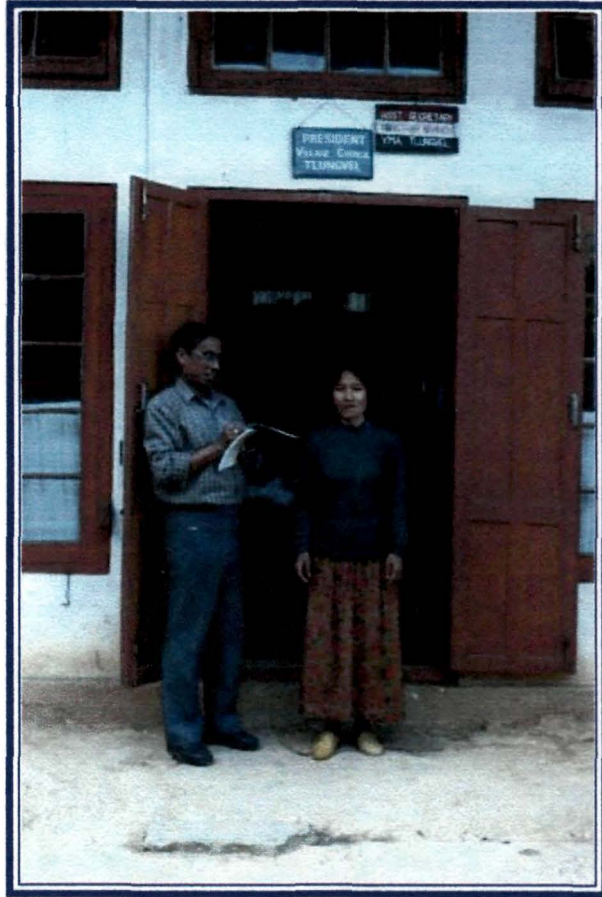


Photograph No. 9 -Survey to prepare resource inventory of economic plant species, existing cropping system and Socio-economic condition of inhabitants of the watershed.



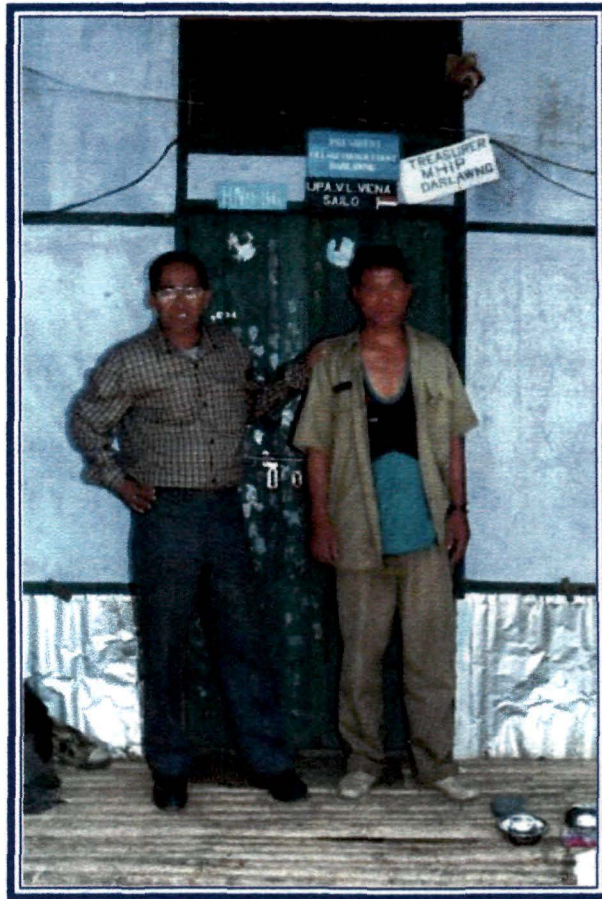
Photograph No. 10 - Market survey for documentation of availability of forest products in Seling market.

Photo Plate 6



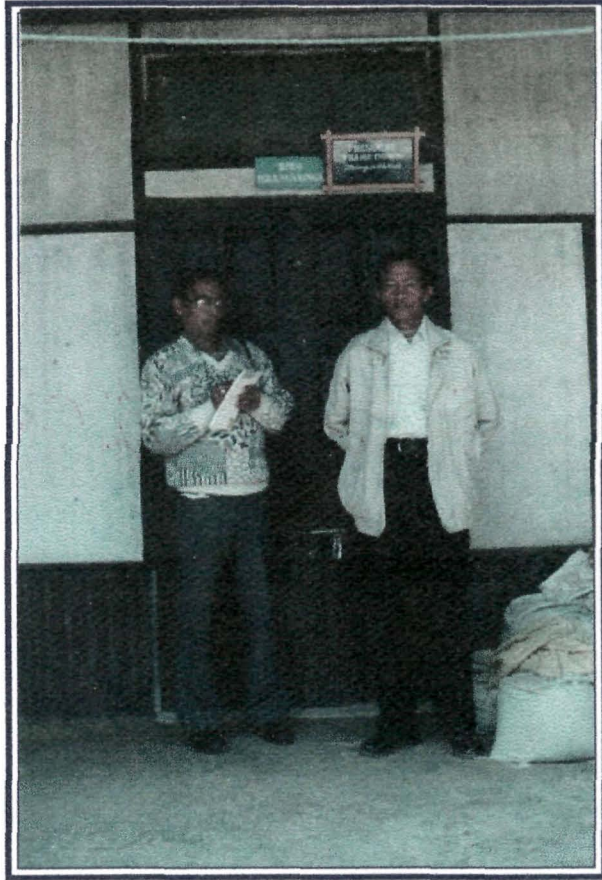
Photograph No. 11 - Resource inventory survey, scholar interviewing a village women of watershed area in Tlungvel village.

Photo Plate 7



Photograph No. 12 - Resource inventory survey, scholar with V.C.P. of Darlawng village.

Photo Plate 8

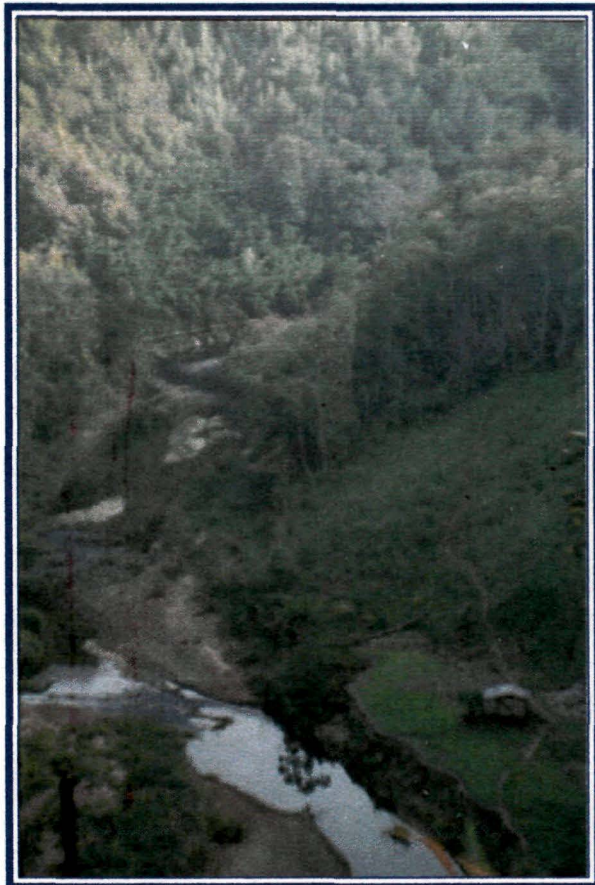


Photograph No. 13 - Resource inventory survey, scholar interviewing V.C.P. of Thingsulthiah village in the watershed.

Photo Plate 9



Photograph No. 14 - Loss of forest cover due to jhum cultivation with shortened jhum cycle, near Darlawng village.



Photograph No. 15 - Forest of watershed area near 10 km stone on Seling - Saitual road. Main stream is also seen.

Photo Plate 10

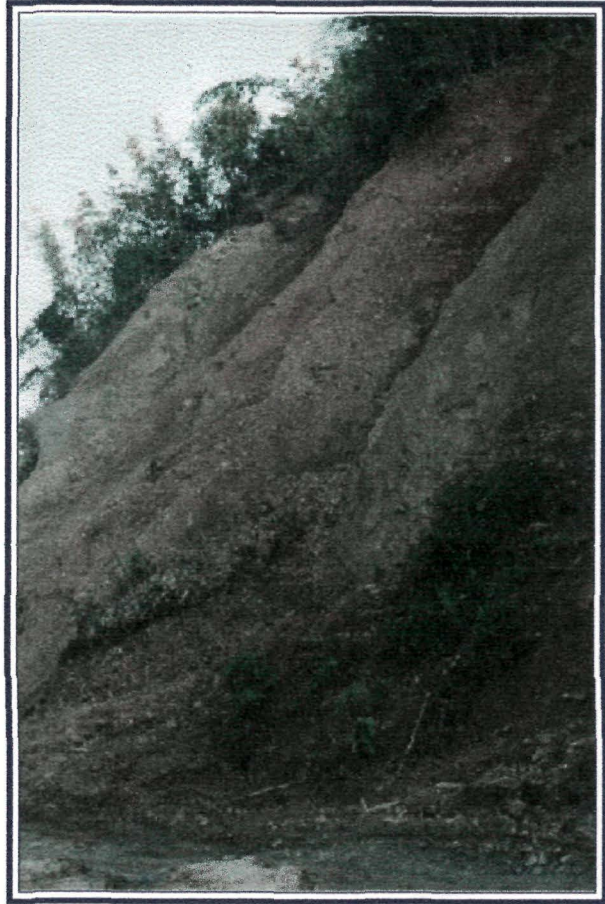


Photograph No. 16 - Forest of watershed area near Darlawng village.



Photograph No. 17 - Forest of watershed area near Seling village.

Photo Plate 11



Photograph No. 18 - Degradation of land due to faulty land use, near 8 km stone on Seling - Saitual road.

Photo Plate 12



Photograph No. 19 - Cropping system: Banana plantation near Thingsulthliah village.



Photograph No. 20 - Cropping system: Pineapple plantation near Thingsulthliah village.

Photo Plate 13



Photograph No. 21 - Cropping system: Orange plantation near Thingsulthliah village.



Photograph No. 22 - Cropping system: Vegetable farming in Tlungvel village.

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1. Resource and their spatial pattern in Mizoram. Proc. Sem. On Resource base and problem of regional development, NEHU, Shillong, 1977.
2. Morphometric analysis of Tuirin river watershed for judicious management of. Poster session, Int. Workshop Agroforestry & Forest Products, 2000, NEHU, MC, Aizawl.
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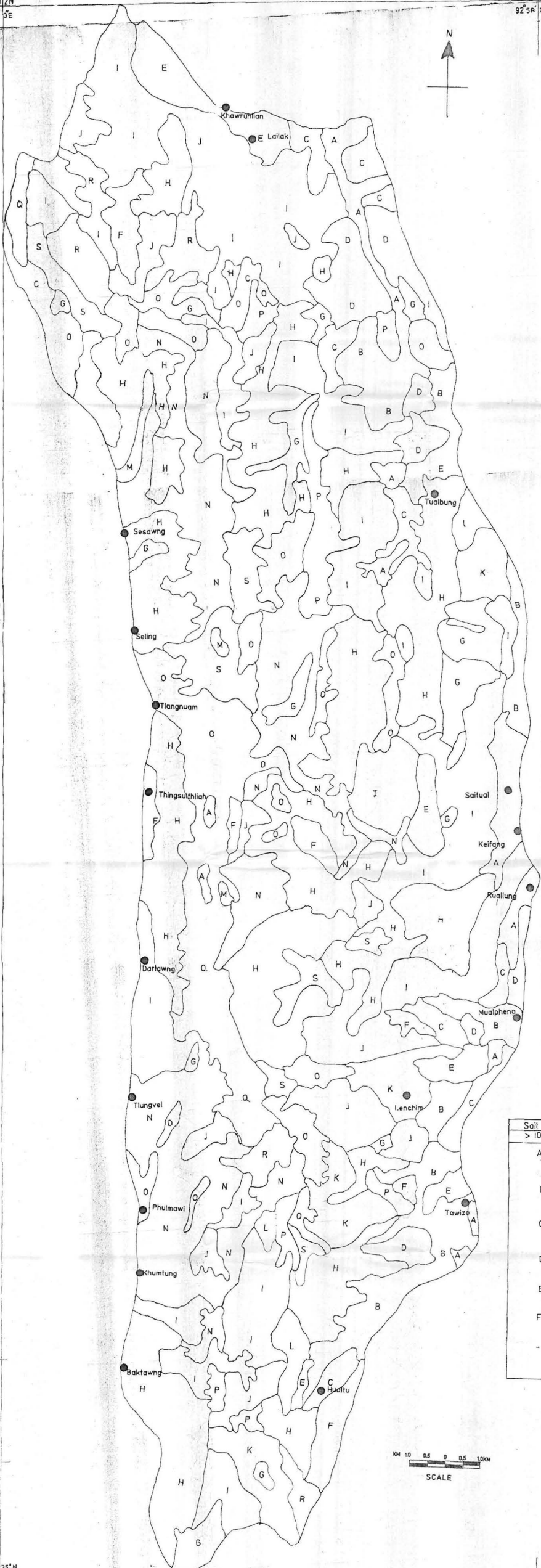
Fig. 4. 1A: Average Slope Map of Tuirini River, Mizoram



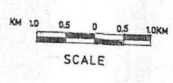
Fig. 4. 2A: Soil Map of Tuirini River Catchment, Mizoram.

23°52' 2N
92°49' 3E

23°53' 2N
92°50' 27E



Soil Mapping S	
> 1000M/500-ft	
A	G
B	H
C	I
D	J
E	K
F	L
-	-



23°28' 35"N
92°49' 3E

23°28' 35N
92°50' 27E

Fig. 4. 4A: Drainage Map of Tuirini River Showing Delineation of Micro-Watersheds

