# Carrying Capacity Study of Teesta Basin in Sikkim

*Volume-IV*
WATER ENVIRONMENT

*Commissioned by :*
**Ministry of Environment & Forests, Government of India**

*Sponsored by :*
**National Hydroelectric Power Corporation Ltd., Faridabad**

CENTRE FOR INTER-DISCIPLINARY STUDIES OF
MOUNTAIN & HILL ENVIRONMENT
CISMHE UNIVERSITY OF DELHI, DELHI

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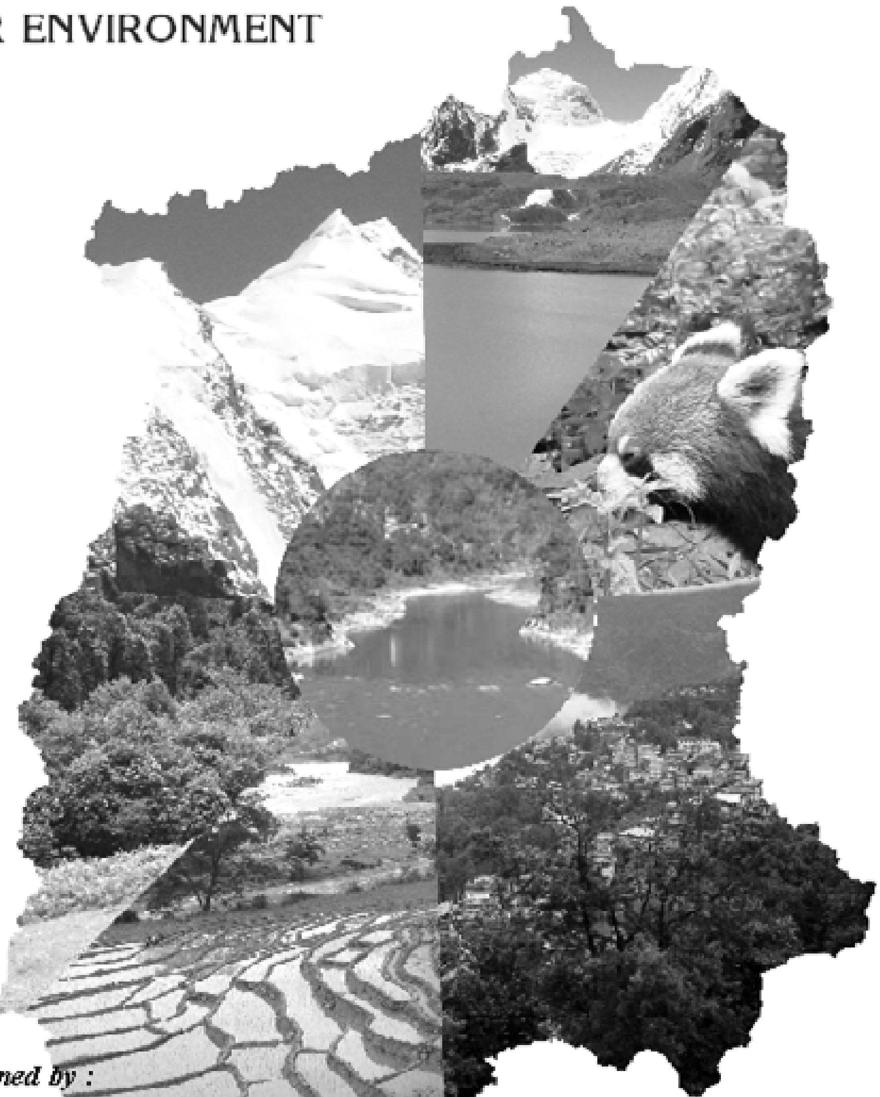

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&

**Water and Power Consultancy Services (India) Ltd., Gurgaon, Haryana**

# CARRYING CAPACITY STUDY
# OF
# TEESTA BASIN IN SIKKIM

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VOLUMES INDEX*



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# FACTS AT A GLANCE

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| | Total cultivable area | th ha | 108.89 |
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| | (b) Follow land | th ha | 34.65 |
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| | Average size per holding | ha | 2.01 |
| 4 | **Hydrology** | | |
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| | North District | mm | 2306.01 |
| | South District | mm | 2224.50 |
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| | Average for state | mm | 2544.40 |
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| | (i) Chungthang | Mcum | 4332 |
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| | (iii) Coronation Bridge | Mcum | 16221 |
| | (c) Sediment load | | |
| | (i) Average sediment load w.r.t. runoff | | |
| | Chungthang | % | 0.025 |
| | Sankalang | % | 0.087 |
| | Dikchu | % | 0.086 |
| | Sirwani | % | 0.068 |
| | Khanitar | % | 0.056 |
| | (ii) Average sediment monsoon load | | |
| | Chungthang | th cum/ sq.km | 0.29 |
| | Sankaland | th cum/ sq.km | 1.35 |
| | Dikchu | th cum/ sq.km | 1.51 |
| | Khanitar | th cum/ sq.km | 1.53 |

| | | | |
|---|---|---|---|
| | (iii) Average sediment rate | | |
| | Chungthang | mm/year | 0.32 |
| | Sankaland | mm/year | 0.65 |
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| | Net sown area | th ha | 63.25 |
| | Gross cropped area | th ha | 113.34 |
| | Cropping intensity | % of NSA | 179 |
| | Gross irrigated area | th ha | 22.95 |
| | Extent of irrigation | % of GCA | 20 |

| | | | | |
|---|---|---|---|---|
| | Food grain production | th ha | **1990-91** | **2001-02** |
| | | | 107.72 | 78.29 |
| **6.** | **Irrigation** | | **Major & medium** | **Minor** |
| | Potential | th ha | 20.00 | 50.00 |
| | Created upto March 2004 | th ha | - | 31.30 |
| | Minor irrigation schemes Constructed upto March 2003 | | | |
| | (i) Number | no. | 1176 | |
| | (ii) Channel length | km | 972.38 | |

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| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | **Water Resources** | | | | | |
| | Rainfall | mm | | | | 2544.4 |
| | Potential evapotranspiration | mm | | | | 1531 |
| | 100 years return year flood | | | | | |
| | (a) Khanitar | cumec | | | | 5779 |
| | (b) Coronation Bridge | cumec | | | | 5919 |
| 2 | **Agriculture** | | **1990-91** | **2025** | | |
| | Net sown area | th ha | 63.25 | 76.82 | | |
| | Grossed cropped area | th ha | 113.34 | 138.30 | | |
| | Grossed irrigated area | th ha | 22.95 | 70.00 | | |
| | Rainfed area | th ha | 90.39 | 68.30 | | |
| | Cropping intensity (GCA/NSA) | % | 179.00 | 180.00 | | |
| | Extent of irrigation (GIA/GCA) | % | 20.00 | 50.60 | | |
| | Cropped area under | | | | | |
| | (i) Kharif | th ha | | 73 | | |
| | (ii) Rabi | th ha | | 25 | | |
| | (iii) Perennial & others | th ha | | 40.3 | | |
| | Cropping pattern (as % of GCA) | th ha | | | | |
| | Paddy | | 10.10 | 10.80 | | |
| | Maize | | 35.50 | 28.90 | | |
| | Wheat | | 4.60 | 7.20 | | |
| | Total Cereals | | 55.90 | 50.60 | | |
| | Pulses | | 5.20 | 4.30 | | |
| | **Total food grains** | | 61.10 | 54.90 | | |
| | Total oilseeds | | 4.90 | 7.20 | | |
| | Cardamom | | | 18.10 | | |
| | Ginger | | 35.00 | 3.60 | | |
| | Vegetables & other crops | | | 16.10 | | |
| | **Crop yields (irrigated)** | | **1975-76** | **2000-01** | **2025** | **2050** |
| | Paddy | ton/ha | 0.88 | 1.40 | 2.50 | 3.00 |
| | Maize | ton/ha | 1.00 | 1.40 | 2.50 | 3.00 |
| | Wheat | ton/ha | 0.58 | 1.49 | 2.00 | 2.50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Pulses | ton/ha | 0.41 | 0.86 | 1.50 | 2.00 | |
| | Cardamom | ton/ha | 0.25 | 0.23 | 0.30 | 0.35 | |
| | **Production** | | | | | | |
| | Total cereals | th tonne | | 74.63 | 13.75 | | 173.75 |
| | Pulses | th tonne | | 3.66 | 7.50 | | 9.75 |
| | Total oilseeds | th tonne | | 4.04 | 7.75 | | 11.00 |
| | Cardamom | th tonne | | 4.06 | 6.00 | | 6.50 |
| **3** | **Water requirement** | | | | | | |
| | Domestic use | Mcum | | | 19.00 | | 34.00 |
| | Irrigation | Mcum | | | 328.00 | | 328.00 |
| **4** | **Per capita food availability** | | | | | | |
| | Total cereals | g/day | | 156.36 | 378.55 | | 336.65 |
| | Total pulses | g/day | | 21.00 | 21.23 | | 18.90 |
| | Total oilseeds | g/day | | 5.99 | 21.93 | | 21.31 |

# INTRODUCTION

# INTRODUCTION

## 1.1 OBJECTIVE OF THE STUDY

The concept of Carrying Capacity encompasses the need for improvement in the quality of life of human society and its sustenance. Sustainable development shall meet the needs of the present generation without compromising with the ability of future generations to meet their requirements and aspirations. It is a process in which the utilisation of resources, the investment made and institutional changes are consistent with future as well as present needs. Thus the concept of Carrying Capacity broadly implies improvement in the quality of life which is possible only when the pattern and levels of production and consumer activities are compatible with the capacities of natural environment as well as social preferences. In keeping with the said purpose, the present study aims to take stock of the existing quality of life, the perceived scenario and the aspired scenario so that the scope and limits of growth can be chalked out. It is to be kept in mind that Carrying Capacity can not be indefinitely elastic and a limit is indicated by the optimum level of generation/regeneration of any resource.

The role of water resources in the environment is paramount. It is recognised that water is a scarce and precious natural resource to be planned, developed and conserved in an integrated and environmentally sound basis. In doing so, the preservation of the quality of environment and the ecological balance are also of prime consideration. The adverse impact, if any, on the environment is minimised and is off-set by adequate compensatory measures.

As brought out earlier, planning of water resources is major component of the environment in which man occupies the center-stage. Apart from the need for sustenance of life i.e. for drinking etc., water is also required for producing food and fibre, municipal needs industrial, power and recreation requirements etc. These diverse requirements have brought into focus the fragility of environment associated with fulfillment of these needs and to guard against its over-utilisation. Further, although quantitative availability of water on an annual basis is more or less constant in nature, it varies substantially both temporally and spatially which creates a situation where there is acute mismatch between the demand and supply patterns. The demand is always on the increase not just because of increase in human population and their growing needs both quantitatively and qualitatively but also due to multiplication of all living beings at a fast rate. This state of affairs exerts tremendous pressure on water resource which tends to disturb the status of water in the overall environment. To meet these ever-increasing needs for sustainable development of water resource, realistic assessment of available and utilisable quantity of water, its present use and future requirement, status of development so far and the ultimate stage of development etc. are the issues which need to be adequately addressed. The objective of the instant study with regard to water resource development is enumerated below:

(1) Socio-economic profile

(2) Hydro-meteorological studies with respect to water resources assessment

  a) Assessment of water resources availability / spatial and temporal.

  b) Assessment of flood hydrology

(3) Studies on existing utilisation of water resources for irrigation, municipal use, industries etc.

(4) Agricultural studies, horticulture and other agriculture allied activities in the state in the light of agro-climatological and hydro-meteorological condition of the area and available water resources with respect to existing cropping pattern, existing irrigation facility, irrigation intensity, potential for proposed cropping pattern for better yield. Rainfall deficient area in the state would be treated separately on the basis of scope of development *vis-à-vis* techno-economically viable option.

(5) Possibility of additional minor irrigation schemes planning keeping in view the existing water resources project in the downstream.

(6) Power development status

(7) Land use survey, land improvement and management

(8) Land slides and flood management

(9) Watershed management strategies

(10) Strategic suggestions for water resource development in future

(11) Broad cost estimates and financing of various measures.

## 1.2 METHODOLOGY

Water resource is an important component in the environment management. However, this resource has some uniqueness i.e. it is always cyclic in nature. Though it's annual availability is more or less constant in nature, its use is growing day by day for various activities. The availability of this resource does not match with the demand pattern to the extent that about 75% of the rainfall is available in 3-4 monsoon months whereas the demand exists throughout the year although uneven. This situation entails the need of comprehensive and integrated planning of this resource for its development. Further, it is to point out that most of the development decisions in the present context are multi-objective in nature involving social, economic and environmental considerations. Hence this multi-disciplinary nature of water resource planning, and development which has become quite complex due to management considerations, requires co-ordination amongst various concerned sectors and governmental bodies dealing with water and need to minimise adverse environmental impacts due to water development activities. In this background utmost care is needed in such type of study for projecting a realistic scenario with regard to its availability and utilisation.

Planning for sustainable development of water necessarily involves appraisal of two basic resources i.e. water and land. The appraisal of water resources includes determining the source, extent and dependability of availability of water on which its future utilisation and management is planned. In determining the quantity of water it is important to ascertain not only the total quantity available but also its special and temporal distribution. Water though not strictly divided may broadly occur as surface and ground water. The appraisal of surface water resource generally includes estimation of (i) annual runoff and its monthly/ten daily distribution (ii) aerial distribution of water resource within the basin, (iii) flood flows (iii) low flows (v) return flows and (vi) sediment load. Similarly ground water involves identification of dependable aquifers and annual replenishable quantities therein.

Usually for a reliable appraisal of water resource, stream flow records for around 40 to 50 years are desirable or else in case of short records, temporal extrapolation may be required. In case where the length of stream flow data is not adequate but the length of precipitation data is available for sufficiently long period, a statistical co-relation is developed between precipitation and run-off using concurrent data. Using this relationship, long-term run-off is obtained from the available precipitation date. For flood studies, especially peak flows, flood frequency analysis is carried out. The rate of sedimentation is obtained from sediment-discharge observation which also takes into account the differences in sediment producing characteristics of different catchments in terms of soil conservation measures if any, undertaken in the catchment.

The appraisal of land resources includes assessment of existing land use pattern, areas suitable for irrigation, areas requiring drainage and areas that can be reclaimed and used for cultivation which would be determined by land use surveys, land classification survey and soil surveys etc.

Land and water form the two essential inputs for agriculture. Status of agriculture development in the basin, important problems faced by the sector and the trend of production and yield of various crops are important aspects which need to be studied. In this context, land under cultivation, crops grown, irrigation facilities available, crop yields, marketing facilities, rural population engaged in agriculture, alternate employment opportunities and willingness of the farmers to adopt improved methods and practices need to be dealt. Since the demand projections for agriculture products are dependent on population growth, pricing policies, personal income and supply of commodities, attempts would be made to estimate the range of demands developing in the future. With regard to irrigated agriculture, the area under irrigation through surface and ground water, state owned and privately owned, major, medium and minor irrigation schemes including lift irrigation would be assessed. Similarly water use by industries, power, domestic water supply etc will also be found out.

Over and above present population, its projection to the end of planning period is also of vital importance because the demands of water and agricultural activities etc. are primarily dependent on this aspect. This would be done on the basis of baseline population data of the state and attempting projection exercise taking into consideration the relevant parameters of the state affecting birth and death rates.

Subsequent to this, food and fiber requirements of projected population and shortfall in comparison to the present availability will be viewed.

With the above data / information and studies carried out, the next step would be to explore possibilities of new irrigation projects in the state in order to make up the intermediate and long term projecteddemands of the population. In this connection, agricultural produce would be considered to be scaled up to bridge the gap to the extent possible by intensive and extensive strategies. Improved cultivation practices for major crops will be suggested for achieving the optimum yield levels. However, the topography of the state not being very favourable to major and medium irrigation projects, minor irrigation development duly supported with region–specific treatments to conserve soil moisture in-site would be attempted.

Finally economics of all the above efforts alongwith a time schedule for their need based phase wise implementation would be suggested.

# CHAPTER - 2

# SALIENT CHARACTERISTICS OF SIKKIM

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## 2.1 LOCATION

Sikkim is a land locked territory. It is like a bowl with some of the World's highest ranges circumscribing it to the west, north, east and south-east. To the west, its border abuts Nepal along the nearly North-South ridges of the Khangchendzonga range with elevation varying from 8,598 m to 3,407 m. To the north and east, it is bordered by vast stretches of the Tibetean plateau. To the east, the watershed on the western shoulder of Chumbi valley rises to 7,128 m, with the lowest point at 3,738 m along which the passes which were famous trade routes to Tibet and Jelepla lie. The southern and south eastern boundary lies along India and for a short distance along Bhutan.

## 2.2 PHYSIOGRAPHY

The state, being part of the Inner Himalayan mountain ranges, has elevations ranging from 300 m to 8,600 m above Mean Sea Level (MSL). Nearly two thirds of its territory consists of very high mountains, which are perpetually covered with snow which form glaciers like Talung and Zemu. These mountains, including the third highest mountain in the world – Khangchendzonga (8,598 m) – are located in the north- west Sikkim.

In the context of the various exogenous and geo-complex factors, the system may be characterised as climate-soil-vegetation climax system which controls dynamic equilibrium of slope in the ecological sites. The frequency of extreme (catastrophic) meteorological events during monsoon season has been considered in view of its importance in the process of slope transformation accompanied with gravitation, slope wash and linear erosion under fluvial environment of this site. As a whole, the higher amount of rainfall (about 2300 mm) over the steeper slopes has created a suitable environment for initiation of run-off and subsequent soil erosion, slope failures, slides or sinking of land masses in the area.

Depending upon the nature of the terrain and the steepness of the slopes, the state can be broadly divided into following six (6) physiographic zones as per National Bureau of Soil Survey and Land Use Planning, ICAR, Nagpur as follows:

i) Summits and hill ridges

ii) Sides of hill slopes with varying steepness

iii) Narrow valleys

iv) Cliff and precipitous slopes

v) Zones of glacial drifts characterized by strewn boulders and moraines, and

vi) Zones with perpetual snow cover

District-wise physiographic features are described as follows:

### 2.2.1 North District

The North District with an area of 4,226 sq km is the largest of the four districts and has elevations ranging from 300 m near Dik Chhu to about 8,598 m at the famous Khangchendzonga peak. The northern and north western parts of the districts are covered by snow throughout the year. This area also has a number of glaciers of which Zemu and Changme Khangpu glaciers are the most important.

### 2.2.2 South District

South district with an area of 750 sq km is the smallest district and falls in the Lesser Himalayan Zone. A classic water divide along the Damthang-Rayong-Rabangla axis, with elevations ranging from 2,038 m to 2,379 m, separates the Teesta and Rangit river valleys. The highest peak in the district is Mount Narsingh (5,825 m). The northern part of the district is traversed by narrow steep valleys and gorges which provide potential dam sites for development of hydropower.

### 2.2.3 West District

The West district with an area of 1,166 sq km has a rectangular shape with North-South elongation. The elevations vary from 350 m at Jorethang in the south to 7,000 m near Pandim in the north. The district has only one glaciated basin known as the East Rathong basin located west of Teesta River. This basin has totals of 36 glaciers of different sizes covering an area of 57.8 sq km.

### 2.2.4 East District

The East district with an area of 954 sq km shares its borders with China and Bhutan. The topography is characterized by narrow crested ridges and deep ‘V’ shaped to broad valleys. The altitudes vary from as low as 350 m near Rangpo to as high as 5,278 m near Chumapu. The famous Nathula pass (4,728 m) lies in the district. The longitudinal chola range separates the district from China and Bhutan. The high altitude areas in the northern parts of the district are dotted with 42 snow-fed lakes. A major part of the district has good forest cover. At lower elevations, about 25 per cent of the hill slopes have agricultural lands.

## 2.3 TOPOGRAPHY

Sikkim state being a part of inner mountain ranges of Himalayas, is mostly hilly. As indicated in para 2.3 the altitude above mean sea level varies from 300 m in the south to about 8,600 m in the north and the hill slope generally ranges between 4% in the flat valleys to 90% and characterised by undertaking surface features. The habitable areas exist only upto the altitude of 2,100 m constituting only 20% of the total area of the state. The northern portion of the state which is deeply cut into escarpments is not populated except in Lachen and Lachung valley. The hill tops are in the North, East and West and covered with perpetual snow which feed the two major rivers, the Teesta and the Rangit traversing through the state from North to South. The highest portion of Sikkim lies in its North-West direction. The Khangchendzonga, the third highest peak in the world at an elevation of 8,600 m adorns the State with its beautiful range covered with shining snow. A number of glaciers descend from the eastern slopes of Khangchendzonga where show line is found above 5,300 m. The biggest amongst them is Zemu.

## 2.4 THE TEESTA & ITS TRIBUTARIES

Teesta river originates as Chhombo Chhu from a glacial lake Khangchung Chho at an elevation of 5,280 m in the northeastern corner of the state. The glacial lake lies at the snout of the Teesta Khangse glacier descending from Pauhunri peak (7,056 m) in north western direction. Teesta Khangse glacier and Chho Lhamo are also considered as the source of Teesta river by many authors. Along its traverse from its origin to the plains, the river receives drainage from a number of tributaries on either side of its course. The tributaries on the eastern flank are shorter in course but larger in number whereas the tributaries on the western flank are much longer with larger drainage areas, consequently contributing much more amount of discharge to the main Teesta river. Furthermore, right-bank tributaries drain heavily glaciated areas with large snow-fields. The left bank tributaries, on the other hand, originate from semi-permanent and much smaller snow-fields as compared to right bank tributaries. The major tributaries of Teesta river are listed in Table 2.1. For better understanding of Teesta river system, it has been divided into a number of river sub-systems which are described in the succeeding paragraphs. These sub-systems are: i) Chhombo Chhu/ Teesta river upstream of Zemu Chhu-Teesta confluence, ii) Zemu Chhu, iii) Teesta river between Lachen and Chungthang, iv) Lachung Chhu, v) Chungthang-Mangan and Chakung

Chhu sub-system, vi) Rangyong (Talung) Chhu, vii) Dik Chhu, viii) Teesta river between Mangan and Singtam, ix) Rani Khola, x) Teesta river between Teesta-Rani Khola confluence and Teesta-Rangpo Chhu confluence, xi) Rangpo Chhu, xii) Rangit River, and xiii) Jaldhaka River. A brief description of each of these sub-systems is given in the following paragraphs.

**Table 2.1 Major tributaries of Teesta river**

| S.No. | Tributaries | |
|---|---|---|
| | **Left-bank tributaries** | **Right-bank tributaries** |
| 1. | Lachung Chhu | Zemu Chhu |
| 2. | Chakung Chhu | Rangyong Chhu |
| 3. | Dik Chhu | Rangit River |
| 4. | Rani Khola | |
| 5. | Rangpo Chhu | |

After perambulating a distance of about 40 km from Melli in hilly terrain, the river enters into the plain of West Bengal at Sevoke near Siliguri. Further ahead, it fans out and attains the width of 4 to 5 km at places. In the Sub-Himalayan plains, it is again joined by a number of tributaries *viz*. Leesh, Geesh, Chel, Neora from the north-eastern end and the Karala from the north-western end. After traversing a length of about 414 km in India and Bangladesh, it meets the river Brahmaputra (Jamuna) in Bangladesh at an elevation of 23 m.

In the mountain gorges, the width of the river Teesta is not much. At Chungthang, the width of the river is 30 m and at Singtam 40 m during autumn. The average depths of water are 1.8 m and 4.5 m, respectively. From Chungthang to Singtam, the bed slope varies from approximately 35 m/ km to 17 m/ km. From Rongpo to Teesta Bazar, the average slope is approximately 3.8 m/ km. The velocity of flow in the hilly region is a high as 6 m per second while in the terai, the velocity is 2.4 to 3 m per second. The banks are alternately steep and sloping according to the position of main current.

The salient features of the river Teesta are given below.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. | Origin | : | In the glacier of North Sikkim at an altitude of 6,200 m. | | | |
| 2. | Outfall | : | River Teesta outfalls into river Brahmaputra near Raniganj Town of Rangpur District of Bangladesh. It belongs to the Brahmaputra system of rivers. | | | |
| 3. | Length (in km) | : | (i) | In Sikkim | : | 151 |
| | | | (ii) | Boundary between Sikkim and West Bengal | : | 19 |
| | | | (iii) | Upto Sevoke | : | 29 |
| | | | (iv) | Upto Indo-Bangladesh | | |
| | | | (v) | Border from Sevoke | : | 94 |
| | | | (v) | In Bangladesh | : | 121 |
| | | | | **Total** | **:** | **414** |
| 4. | **Longitudinal Slope of the River** | | | | | (in m/km) |
| | | | (i) | From Chhungthang to Singtam varying from | - | 34.9 to 16.5 |
| | | | (ii) | From Rangpo to Teesta Bazar | - | 3.8 |

| | | | |
|---|---|---|---|
| (iii) | At Jalpaiguri | - | 0.7 |

5. **Catchment Area** (in sq. km)

| | | | |
|---|---|---|---|
| (a) | Hilly Region | : | 8,051 |
| | (i) Sikkim | : | 6930 |
| | (ii) West Bengal | : | 1121 |
| | (b) In Plain | : | 4,108 |
| | (i) West Bengal | : | 2104 |
| | (ii) Bangladesh | : | 2004 |
| | **Total in India** | **:** | **0,155** |
| | **Total in Bangladesh** | **:** | **2,004** |
| | **Total** | **:** | **12,159** |

## 2.5 SOILS

Based on the soil survey conducted by 'National Bureau of Soil Survey of India & Land Use Planning (ICAR)', the state has been classified into three main groups *viz*.

| | | | |
|---|---|---|---|
| i) | Udalf | : | High base status soil of humid region |
| ii) | Orthants | : | Recent formed soil |
| iii) | Odhepts | : | Shallow blocks, brown and alluvial soil |

The characteristics of soil of the state vary from place to place due to topographical variations. The soil in general is loamy sand to silty clay loam with a depth of 30 cm to 100 cm and in some cases even more than 120 cm. It has less water holding capacity and is dry in nature. Chemically acidic soil abound resulting from the washing down of the salts in rain water and also on account of leaching effect. The pH value varies from 4.5 to 7.5. The soils are characterized by low to high organic matter (2-5 percent, in some places even more than 5 percent) with low action exchange capacity and high lime requirement. Notwithstanding the relatively high organic matter content, the nitrogen content in the soil is low.

Some of the plant nutrient like phosphate gets fixed in soils due to the high acidity and thus does not become available to the growing plants even on application. As such there is remarkable deficiency of micro-nutrients *viz*. zinc, boron, copper, calcium, magnesium, manganese etc in the soils.

There is a great deal of variation in the physical properties of the soils of the state. The soils may be classified into following 5 categories:

i) Soils on summit and ridge tops
ii) Soils on side slopes of hills
iii) Soils on valleys
iv) Soils on cliff and precipitous slopes
v) Soils on glacial drift moraines and boulders

## 2.6 DRAINAGE CHARACTERISTICS

Unique in its complex and diverse drainage characteristics, the antecedent river Teesta offers a fascinating study for Himalayan drainage basin evolutionary processes under fluvial environment in particular. Studies of the Teesta drainage characteristics particularly of the river channel changes including river deposits and fluvial or fluvio-glacial processes in the Sikkim Himalayan terrain have been in progress for more than a decade.

These landforms and drainage patterns include mainly the four tier terraces, canyons or gorge-valley at different altitudes, asymmetric valleys, polyprofilic U-shaped valleys and steps or troughs, lakes, alluvial cones, truncated ridge-spurs, soil profiles, terracettes (soil landscape systems), rectangular-barbed-parallel-trellised-radial –sub-dendritic, etc. drainage patterns, straight meandering braided etc, channels and others.

Huge amount of water enters into the Teesta catchment in the form of rain and snow which is drained off as the discharge of water by a system of drains of the Teesta and its tributary streams. Primarily the Teesta drainage basin is constituted by this system of drains or channels (straight, sinuous or meandering, braided etc.) both of natural and artificial, relating to the action of draining the higher mountains and piedmonts in Sikkim. In an interpretative sense, the Teesta drainage catchment is found to have been occupied by a complex hydrographic net works of branching streams in hierarchical order from its smallest tributary like Andherijhora etc. to the trunk stream Teesta, the main channel for drainage. This hierarchy and other characteristics of the hydrographic net works of the Teesta drainage may be expressed in terms of morphometric attributes (drainage texture, orders, bifurcation ratio, texture ratio index, stream length ratio etc.).

The Teesta basin includes (a) surface bodies like rivers or lakes, in the superjacent air, and (b) underground drainage of various types and origins. Hence, three types of surface drainage have been distinguished in the basin area. Primarily, surface drainage relates to (i) precipitation of moisture or rainfall and flowing in accordance with the varied topography (ii) drainage conspicuously confined along these streams specially during dry or non-dry periods and (iii) the static water bodies, lakes including glacial lakes stagnant pools of water etc. being typified by seasonal flow only during floods or extreme (catastrophic) meteorological events which are common in the Teesta drainage area. Rain water which contributes substantially to total runoff, flows according to the variations in slope of the hills and valley-side surfaces at different elevations. Here, the actual amount of rainfall diverted in various ways (surface runoff, interflow, ground water, soil moisture etc. are found to have varied greatly in the different sub-basins of the humid Teesta catchment area where the intensity of rainfall normally exceeds the infiltration rate even in the upper reaches at 3,000 m and more In most of the elevated watershed surfaces the higher intensity of falling rain which has determined largely the infiltration capacity and surface runoff, finds its way down the slopes along the distinct channels of flow of running water i.e. tributary streams, or river including ephemeral stream channels of lower drainage order within the Teesta basin. The infiltration capacity forming an important control of stream flow relating to drainage conditions is found to be associated with soil-landscape systems, a dynamic entity, and is dependent on seven factors like (i) soil texture, (ii) soil structure, (iii) vegetative cover, (iv) biologic structures in the soil including such features at rodent perforations and amount of humus and vegetal debris, (v) amount of moisture in the soil (antecedent soil moisture), (vi) condition of the soil surface as determined by whether it has been cultivated recently or is baked or sun cracked, and (vii) the temperature of the soil at different positions in the hills and valley slopes in the Teesta and its tributary or sub-basins.

The Teesta drainage has been resulted from both physical and cultural environments in the course of geoecological adjustment of those Himalayan geocomplex like climate, structure, vegetation, soil, topography or other terrain factors determining the rapidity of runoff. It relates to geomorphology including hydrology, and the flow characteristics in the Teesta and tributary streams especially after storms, human intervention over the mountain and piedmont plain. The human intervention mainly concerns with the utilization of water for irrigation, hydel power generation, fishery development, and the various arrangements which in turn obstruct the normal flow of water in terms of constructing embankments of canal and reservoir, human settlements, roads, railway and like. However, this drainage of different types especially of surface drainage with varying depth, surface spread, frequency or mobility at different seasons is closely associated with irrigation work.

The Teesta basin or catchment may be divided into sub-catchments of decreasing size on the basis of both quantitative and qualitative considering the interrelated factors like gradient, infiltration capacity, surface roughness etc. The higher mountainous terrain with varying topography has determined rapidity of runoff and character of flow maxima and minima in the upper Teesta and tributary streams particularly after severe (local) storms. Most of the upper granite gneiss surfaces mainly made of impermeable materials with few pondage pockets are typified by a steeply sloping topography. The relatively smooth-surface-segments being covered with little vegetation (relating to forest clearance) are found to have given rapid runoff and high sudden flow maxima during rainy seasons. On the contrary, long continuous flow with low and delayed maxima is a common feature in the moderately sloping hill-side and valley-sides with thick forest cover which are developed over the permeable materials downstream.

It has been evaluated that much of the Teesta terrain except the upper most segment at 5,000 m and above owes its actual morphology to stream-flow relating to disposition of form rainfall and runoff as mentioned above. Normally, the Teesta stream flow is composed of (a) rain falling both in the main and tributary channels, (b) excess rainfall or surface runoff in the basin, (c) interflow amount of water which infiltrates the soil and moves laterally toward the stream channels, (d) ground water etc. Theoretically, the amount of interflow with movement entirely above the ground water tube is increased by the existence of an impervious layer which limits percolation to the ground water table and forces the water to move laterally depending upon the soil structure and the depth to the level of groundwater. This stream flow is measured more exactly than evaporation, transpiration, rainfall or other forms of water in the hydrologic cycle.

## 2.7 DEVELOPMENT PROSPECTS

Sikkim is a thinly populated and hilly state with its unique environment and ecology. The population is concentrated around the capital Gangtok only and the rest of the area is occupied by forests with small villages and townships. The economy is largely agriculture and forest based with very little technologically advanced industrial base. The general economic conditions of the inhabitants of the State are below average. Due to the hilly terrain, the agricultural production is not sufficient even to the self consumption needs of the population but potential for agriculture development exists in the state due to high rainfall. Horticulture and floriculture and tourism also hold the promise in future, if appropriate strategy for furthering these sectors is adopted in right earnest.

Due to prevalent cold and moderate climatic conditions with very low ambient dust levels, the state presents an ideal opportunity for development of high tech industries like micro-electronics and ancillary products which impose fewer burdens on transportation facilities and earn rich dividends. However, for such developmental efforts, abundance of cheap and clean power is vital. The available hydel power in the state , if harnessed in a planned way , can not only meet the domestic requirements but can also feed the eastern sector which has large industrial base and hence requires sustained power. This would go a long way in boosting up the economic level of the region.

Energy needs of the region are chiefly met by petroleum products and wood based products. Availability of electric power will thus obviate the wasteful expenditure on transportation costs of petroleum products as well as degradation of environment due to deforestation. Cheap electrical power will help in reducing environmental pollution due to deforestation and use of petroleum products. The hydel power generation can become a source of revenue to the state with recurring benefits from such income.

Presently, the eastern region mainly relies on thermal power generation which cannot provide efficient peaking facilities. Hydel power generation in Teesta cascade development will fill up this much needed shortfall in respect of peaking capabilities and the power system in the region can acquire robustness.

# CHAPTER - 3

# HYDRO-METEOROLOGY

# HYDRO-METEOROLOGY

## 3.1 GENERAL

The river Teesta, fed by the snow and glaciers of Khangchendzonga and the Great Himalayas, originates in north Sikkim at an elevation of 8,500 m above mean seal level. It is a perennial river, and flows through the territories of Sikkim, West Bengal in India and Bangladesh. Most of its tributaries are flashy mountain rivers and carry boulders and considerable quantity of sediment. The flow is turbulent, characterised by high velocities. Throughout its course in Sikkim, the Teesta and its tributaries flow in very narrow and deep valleys having precipitous hill slopes, except where the tributaries join the main stream. The hill slopes are mostly friable and land slips are very common. Access to the river in these reaches is very difficult.

The entire precipitation on the territory of Sikkim travels towards the central north-south axis which is the course taken by the river Teesta. All the water courses in the country, such as Lhonak Chhu, Lachen Chhu, Lachung Chhu, Rongni Chhu and Rangpo Chhu flow into Teesta. The river Rangit also joins Teesta at a point south of Me1li bazaar. It can thus be said that every drop of water falling on Sikkimese territory as rain or snow leaves the territory only at one point, south of Melli Bazar at the confluence of Rangit and Teesta rivers. River Teesta is confined in a very narrow gorge from Chungthang up to Melli Bazar in

Sikkim and thereafter from Melli, Teesta Bazar to Sevoke in North Bengal. This narrow gorge widens only at a few points, which mark its confluence with other major streams, where the turbulence has scoured basins in which large silt deposits are left. Rangpo is one such side basin. The concentration of flow in the river is large and velocity of flow is high due to gorge constriction. The silt and timber charge carried due to hillside denudation is also high when the river having a width less than 200 m at Sevoke Road Bridge meets the plains of Jalpaiguri south of the railway bridge; it spills along a width of 4 to 6 km braiding itself into four well-defined streams separated by large silt fans.

For evaluation, planning and development of water resources in a basin, it is most important to have a detailed knowledge of hydro-meteorological characteristics of the basin. Hydro-meteorological parameters include rainfall, temperature, humidity, wind flow, evaporation and duration of sunshine which determine the climate of a region or basin. The hydro-meteorological parameters in turn are greatly influenced by the physical features and the climate of the area.

## 3.2 CLIMATE

The abrupt variation in altitude of 8,000 m high hills in less than 100 km which are enjoying alpine type, results in very wide and abrupt changes in climatic conditions of the State all throughout. Relief features such as high mountains act as a barrier for the movement of monsoon winds. Depending mainly upon the altitude of the location, the mid hills have a temperature zone while lower hills and valleys covered somewhat sub-tropical agro-climates prevailing. The temperature and rainfall almost follow the altitude intensity of rise and fall and the major determinant of the types of micro-climates of a place. The rainfall pattern is also unique in itself, the heavy rainfall occurring in the mid and the lowers hills while alpine, temperate and lower valleys get less rainfall. The rainfall in these hills is again influenced by the direction of the wind and the aspects of the hill slopes. It is generally observed that the valleys along Teesta river and its tributaries receives good amount of rainfall whereas the valleys of Rangit river and its tributaries receives lesser or scarce rainfall one possible reason for less rainfall or some times no rain in the region may be attributed to the Shadowing effect exerted by the adjoining Darjeeling hills in this past of the south and west districts.

Besides the above the monsoon rainfall is controlled also by north-south oscillations of the monsoon trough and other perturbations in the monsoon circulation such as the formation of depressions in the Bay of Bengal and “Breaks” in the monsoon.

As the monsoon depressions bring fresh surges of the monsoon air, they cause spurts in rainfall over the Himalayas in the longitudinal belt covered by the field of depressions. During ‘breaks’ in the monsoon, this part of the Lesser Himalayas (the Eastern Himalayas) gets heavy to heavy rains which cause occasional floods and landslides in the Teesta river basin. In such a peculiar situation, if the troughs in the upper westerlies move eastwards, they interact with the monsoonal circulation and cause very heavy rain in the mountainous terrain. Generally, the axis of sub-tropical jet is located along the southern slopes of the Himalayas in winter but suddenly shifts northwards with the advent of the monsoon accompanied by the tropical Easterly Jet.

The monsoon depressions as part of extreme (catastrophic) meteorological events do not generally reach the Himalayas, except occasionally, when they recurve northwards or north-eastwards after having moved initially, west-north-westwards from the Bay of Bengal. The extreme (catastrophic) meteorological events have played an important role in the evolution of slopes both in hill-side and valley-side areas. This movement occurs mostly in late August or in September. When the monsoon depressions break up in the Himalayas, they cause extensive and very heavy rain which decreases westwards. The occurrences of extremely high intensity particularly in terms of rapid down-pours, and connected with convection currents or the passage of cyclones, have brought about remarkable charges in landforms relating to the processes of mass-movements along with changes in the morphogenetic balance within this part of the Teesta basin. March, April and May are the transition months between the winter months and the summer monsoon, surface temperatures rise and thunderstorms increases, some of the thunderstorms being accompanied by hail. Convective activity is more marked on the south facing slopes of the ranges because of the greater insulation than on the other side. The upslope winds also help the air to rise-up, leading to convective activity if moisture is present.

In the hills, thunderstorms often develop rather rapidly and are sometimes accompanied with hail. The frequency of hail in the area is maximum in April and May. Any mitigation that may be achieved would be of great economic benefit to the fruit orchards of the Himalayan terrain.

The simplified account of the distribution of precipitation, while broadly true, is strongly influenced by local orographic effects. Actually, the Himalayan orography is of complex type and it is difficult to carryout any detailed study without having a dense net work of observatories which is rare in the Eastern Himalayas. It is necessary to establish a dense net work of meteorological stations as described in Chapter IV. A detailed analysis on the very important feature of variation in precipitation due to changes in elevation has not been feasible because of the absence of observatories at different elevation under comparable situations in the Teesta basin area in Sikkim.

The meteorology of the Teesta basin area in the Eastern Himalayas along with the effects on weather conditions of Sikkim, is of great scientific interest. It is necessary to record meteorological data regularly for further research work on geomorphological problems of this critical region. As mentioned earlier, the climatic conditions of the basin including the cold environments of the upper most reaches are quite important for the management of water resources and the socio-economic development of the basin area. The area of interest should not be merely the productive ecological sites with human settlements like Lachen etc. but right upto the northern marginal (glacierised) sectors (The great Himalayas) and distant morphogenetic zones within the basin.

On the basis of foregoing discussion on various weather and climatic peculiarities, climate has been divided amongst four principal season's *viz*. (i) Winter season from mid-November to mid April, (ii) Spring (summer equivalent) season from mid-April to mid-June, (iii) Monsoon season from mid-June to mid-September, and (iv) Autumn season from mid-September to mid-November.

## 3.3 WATER REGIME

The perhumid climate of the Teesta basin in Sikkim is characterised with enormous water surpluses. The prevalent monsoon climates have supported evergreen (broad leaf) rainforests including grasses which become dense and luxuriant in some parts of middle Teesta basin.

It is important to note that depending upon the terrain properties e.g. structure, rocks in different geological formations, surface cover, and slope, the water surplus takes its course either through surface run off or deep percolation to underground regions. This becomes available for exploitation as ground water. In certain years, due to strong monsoonal activity or frequent occurrence of depressions and local severe storms, the precipitation may be much greater than normal; local water surpluses do occur, for brief periods producing not only enormous surface flow resulting in severe floods but also significantly contribute to the ground water resources. The orographic influence of the Sikkim Himalayan terrain including their hill-side and valley-side-slopes is, however, responsible for the occurrence of wet climatic types throughout the upper and middle Teesta basin. Practically, per humid climatic types are found in the whole mountainous terrain according to the moisture regime which plays a decisive role in the water potentialities of various sectors within the basin. Obviously, the south-west monsoon season which is the principle rainy period for almost the entire Teesta basin is responsible for more than 80% of the total annual rainfall in these mountainous ecological sites, and significant in controlling the water balance.

## 3.4 RAINGAUGE NETWORK

### 3.4.1 Present Status of Rain Gauge Stations

At present there are 19 ordinary rain gauge stations in Teesta basin in Sikkim, the locations of which are shown in Fig. 3.1. The locations of these stations and period of data availability are given in Table 3.1. It is also understood that there are a number of self recording rain gauges in the catchment at places like Lachung, Chungthang, Gangtok, etc. The details of these self recording gauges, however, could not be available.

**Table 3.1 Details of Raingauge Stations in Teesta Basin in Sikkim**

| Sl No | Raingague Station | Co-ordinaries | | Period of availability of monthly rainfall |
|---|---|---|---|---|
| | | Lat. | Long. | |
| 1. | Dikchu | $27^o$ 24’ | $88^o$ 31’ | 1957 to 63, 1971-80 & 1992-99 |
| 2. | Singhik | $27^o$ 31’ | $88^o$ 30’ | 1957 to 63, 1971-80 & 1992-99 |
| 3. | Chhungthang | $27^o$ 36’ | $88^o$ 30’ | 1957-84 |
| 4. | LaChhung | $27^o$ 42’ | $88^o$ 45’ | 1957-63, 1971-79 and 1990-99 |
| 5. | Yumthang | $27^o$ 48’ | $88^o$ 42’ | 1957-63, 1971-80 and 1985, 1987 |
| 6. | Lachen | $27^o$ 43’ | $88^o$ 32’ | 1951-67, 1971,1972 7 1992-99 |
| 7. | Thangu | $27^o$ 53’ | $88^o$ 31’ | 1951-69 & 1980 |
| 8. | Damthang | $27^o$ 14’ | $88^o$ 23’ | 1957-63 |
| 9. | Yoksum | $27^o$ 27’ | $88^o$ 12’ | 1958-63,1971-80, 1991-99 |
| 10. | Dentam | $27^o$ 15’ | $88^o$ 09’ | 1958-63,1971-80, 1992-99 |
| 11. | Chhangu | $27^o$ 22’ | $88^o$ 40’ | 1958-63,1971-72 1978,1992 |
| 12. | Rongli | $27^o$ 12’ | $88^o$ 41’ | 1957-63, 1971-79, 1991-99 |
| 13. | Geyzing | $27^o$ 17’ | $88^o$ 16’ | 1957-78 |
| 14. | Gangtok | $27^o$ 30’ | $88^o$ 37’ | 1957-78, 1990-99 |
| 15. | Mangan | $27^o$ 30’ | $88^o$ 32’ | 1957 AND 1960-80 |
| 16. | Serrathang | - | - | 1958-63 & 1993 |
| 17. | Gnathang | - | - | 1974-79 |
| 18. | Khanitar | - | - | 1980-96 |
| 19. | Sankalang | - | - | 1992-98 |

### 3.4.2 Adequacy of Network

In general, one aims at an optimum density of rain gauges from which reasonably accurate information about the storm can be obtained. World Meteorological Organization (WMO) has recommended norms for defining the density of rain gauge stations in respect of following types of regions:

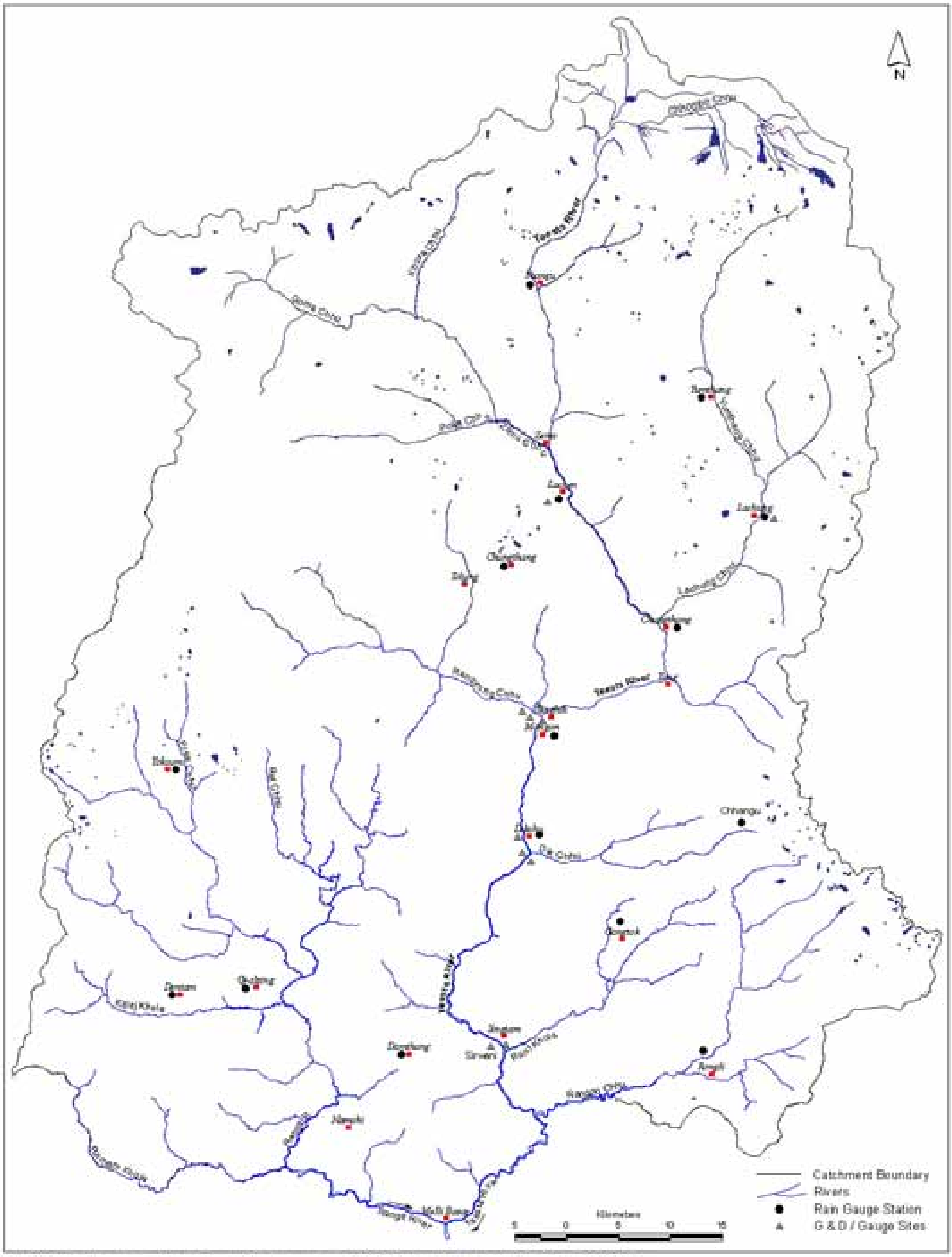



**Fig.3.1 Index map showing raingauge and G&D sites in Teesta basin in Sikkim**

(a) Flat region of Mediterranean and tropical zones

(b) Mountainous region of above zones

(c) Arid and polar regions

The minimum density of rain gauge network is given at Table 3.2.

**Table 3.2 Minimum density of Rain Gauge Network recommended by WMO**

| Sl. No. | Type of region | Ideal Network ($km^2$/station) | Network under difficult condition ($km^2$/station) |
|---|---|---|---|
| 1. | Flat region of temperate, Mediterranean and tropical zones | 600-900 | 900-3000 |
| 2. | Mountainous region of temperate, Mediterranean and tropical zones | 100-250 | 250-1000 |
| 3. | Arid and Polar region | 1500-2000 | 2000-10,000 |

As par the above guidelines, a network of one ordinary rain gauge for every 300 $km^2$ area would suffice in hilly regions. Considering the physiographical features of Sikkim state, it would be desirable to have about 21 rain gauges. According, it is suggested that additional four rain gauge stations should be installed in the valley at the following places for making the network satisfactory:

i) Donkung on the Lachen Chhu

ii) Namchi - South

iii) Rangpo - East

iv) Naya Bazar - West

About ten percent of the total rain gauges should be equipped with self-recording gauges to know the intensities of the rainfall. It is suggested that three additional self recording rain gauges may be installed at following locations:

i) Lachen
ii) Gyalzing
iii) Gangtok

In addition to these rain gauge stations, snow gauges are also required to be established for measurement of snowfall at the higher altitudes. The following locations are suggested for establishing snow gauge stations:

i) Thangu
ii) Yumthang Chhu
iii) Nathu La
iv) Jambong on Zemu Chhu
v) Lampharam

Above suggested locations for rain and snow gauges may also be consulted with Indian Meteorological Department and Central Water Commission who are already operating the existing raingauge network in the state.

He data from all the rain and snow gauges shall be collected regularly as per standards laid down by the IMD and the reported data should be checked for consistency before being utilized for any storm analysis or study.

## 3.5 RAINFALL FEATURES

In Teesta Basin in Sikkim, the southwest monsoon normally sets around mid-June and withdraws by end of September.

### 3.5.1 Normal Rainfall

Monthly and annual normals of rainfall are available for 15 stations in the basin. Station wise normal rainfalls are given in Annexure 3.1. Along with the corresponding monthly normal rainfall values for the state of Sikkim as a whole. Average annual normal rainfall in Sikkim is about 2534 mm. Monthwise details is given at Table 3.3.

**Table 3.3 Monthwise Normal Rainfall for Sikkim as a whole**

| **Month** | **Rainfall mm/month** |
|---|---|
| January | 37.0 |
| February | 53.0 |
| March | 104.1 |
| April | 151.7 |
| May | 287.6 |
| June | 442.7 |
| July | 480.1 |
| August | 440.1 |
| September | 331.8 |
| October | 156.0 |
| November | 30.7 |
| December | 19.1 |
| Total | **2533.9** |

The isohyetal maps of annual, monsoon and non-monsoon normal rainfall values are shown in Figs 3.2(a), (b) and (c) respectively. An examination of these figures reveals that the annual rainfall decreases towards North West direction, perhaps due to orographic effects. The isohyetal map for non-monsoon period reveals distinctly lesser rainfall towards south Sikkim, varying from 1343 mm in Gangtok to less than 500 mm towards Namchi. The same trend is also noticed in the north Sikkim above the snow line at Yumthang where the normal rainfall is of the order of 457 mm.

The analysis of normal rainfall shows that Gangtok station receives the highest annual rainfall (3804 mm), followed by Dik Chhu (3364 mm) and Rongli (3207 mm). Minimum annual rainfall of only 904 mm has been registered at Thangu in extreme North Sikkim. The annual, monsoon and non-monsoon normal rainfall values have also been plotted against altitude as shown in Fig. 3.3. It is observed from this figure that the rainfall has shown a declining trend above an altitude of 1,000 m.

Looking at the monthly variation of normal rainfall, it is seen that the month of July receives maximum rainfall of the order of 480 mm and minimum normal rainfall of 19 mm is recorded in the month of December for the Sikkim as a whole.

### 3.5.2 Variation in Rainfall

There is significant variation in rainfall in the basin, both temporally and spatially. The altitude of the station also influences the coefficient of variation ($C_V$). The coefficient of variation of various stations as computed are compiled at Table 3.4. The $C_V$ verses altitude of various stations has also been plotted and shown at Fig 3.4. The coefficient of variation is generally found to increase with higher altitude.

**Table 3.4 Altitude *vs*. Coefficient of Variation**

| Station | Altitude in m | CV |
|---|---|---|
| Dentam | 132 | 0.09 |
| Rongli | 823 | 0.18 |
| DikChhu | 869 | 0.12 |
| Mangan | 1310 | 0.49 |
| Singhik | 1402 | 0.35 |
| Gezing | 1524 | 0.42 |
| Chungthang | 1631 | 0.34 |
| Gangtok | 1756 | 0.24 |
| Yoksum | 1780 | 0.21 |
| Damthang | 1981 | 0.58 |
| Lachung | 2633 | 0.18 |
| Lachen | 2697 | 0.34 |
| Yumthang | 3673 | 0.16 |
| Thangu | 3834 | 0.44 |
| Chhangu | 3841 | 0.41 |

### 3.5.3 Number of Rainy Days

Statistics of average number of rainy days for each month of the year along with their seasonal and annual totals in respect of all the 15 stations are presented in Annexure 3.2.

In the monsoon season from June to September, the station Chhangu is seen to experience the rainiest weather with 100.9 average numbers of rainy days followed by Gangtok (99.1), Rongli (98.1) and Yumthung (96.2).

Total number of rainy days are maximum for Singhik station at 172.7 days while these are minimum for Gyalzing station at 124 days. Average number of rainy days are 148.3 for the Sikkim state as a whole for the whole year.

### 3.5.4 Monthly Rainfall

Monthly rainfall values for the 19 rain gauge stations in the state of Sikkim was obtained from IMD for varying time periods. The same are given in Annexure 3.3 (a) to 3.3 (q). Certain gaps are observed in the reported data which are depicted in Annexure 3.3(r). The short gaps in the data have been filled up through standard statistical practices based on station normal and actual rainfall of neighboring stations. The long gaps which are for a continuous spell of years together have not been considered appropriate to be filled up by statistical methods as these are likely to result in great variation from actual figures.

The missing rainfall Px at the station is given by the equation:

$$P_x = \frac{N_x}{n}\left[\frac{P_1}{N_1} + \frac{P_2}{N_2} + - - - - \frac{P_n}{N_n}\right]$$

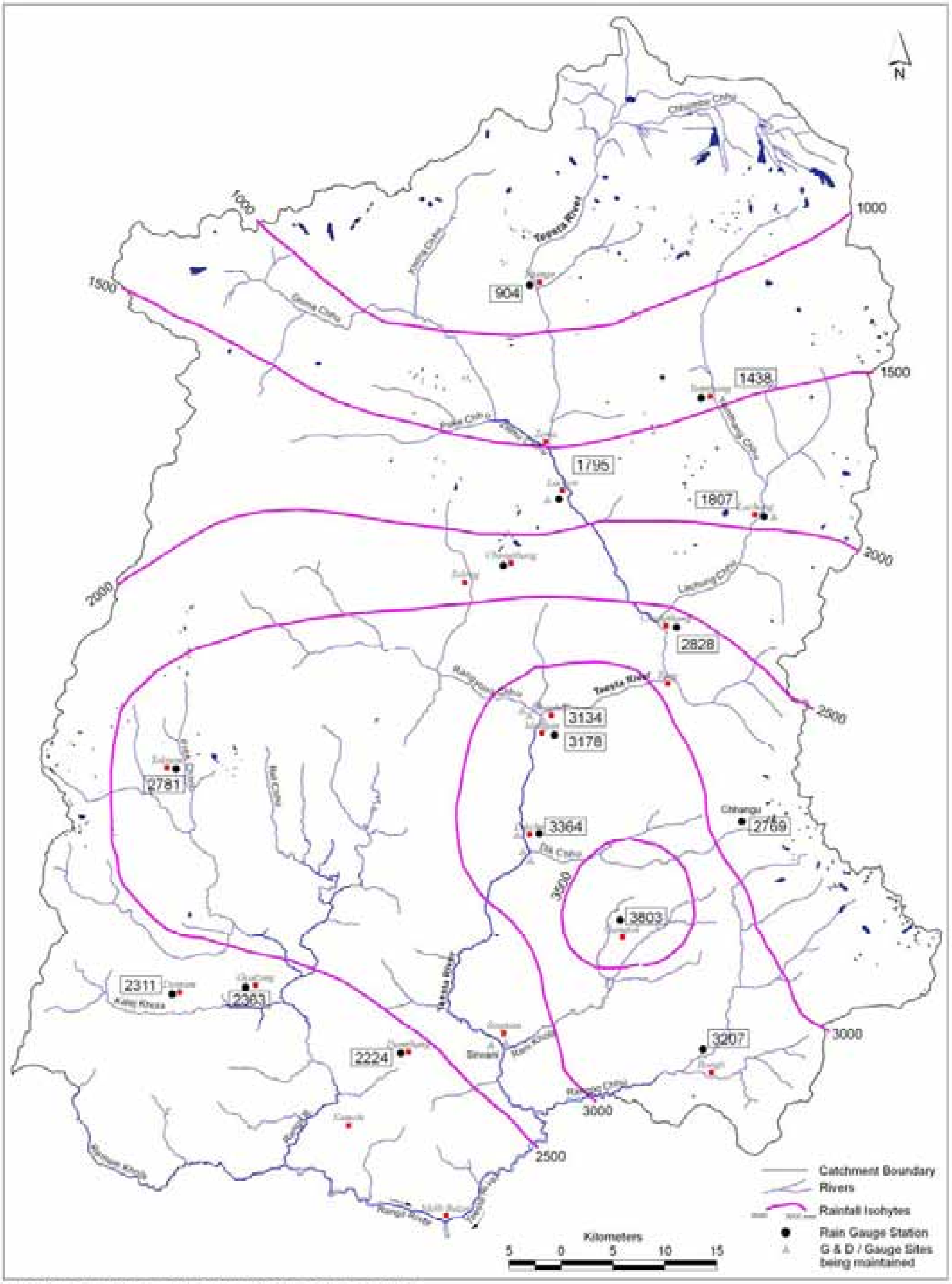



Fig.3.2(a) Annual Normal Rainfall in Teesta basin in Sikkim

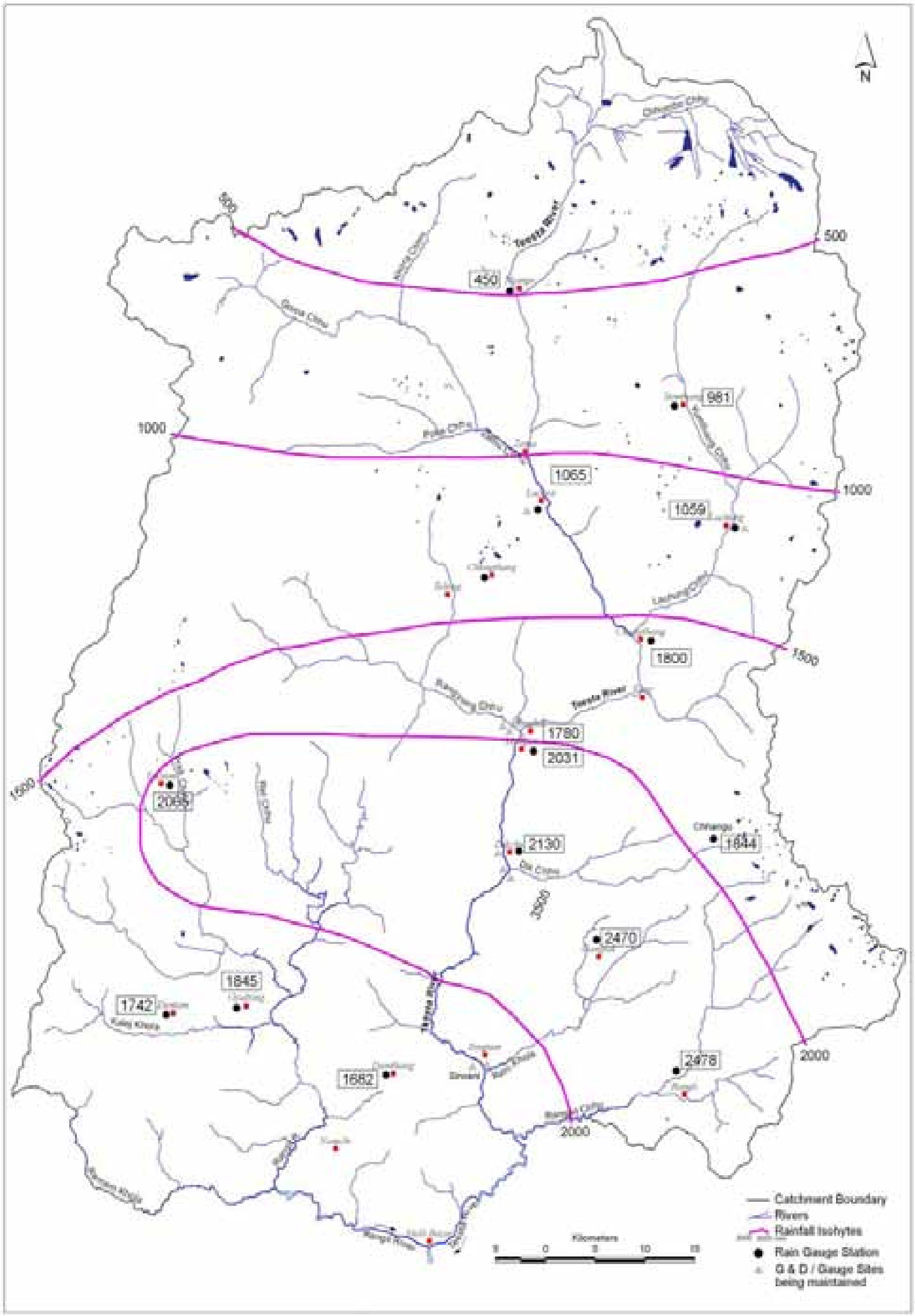



Fig.3.2(b) Monsoon Normal Rainfall in Teesta basin in Sikkim

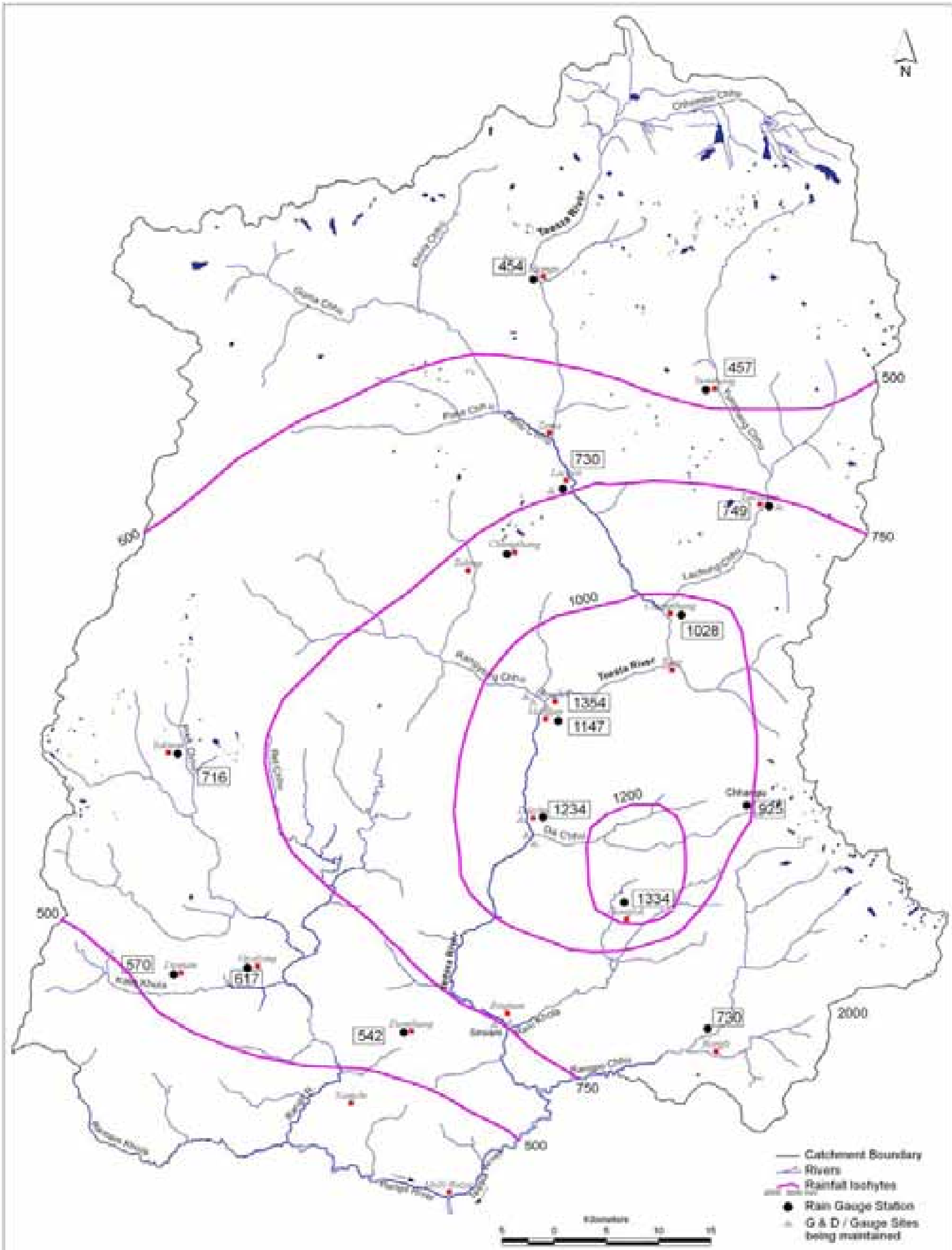



Fig.3.2(c) Non-Monsoon Normal Rainfall in Teesta basin in Sikkim

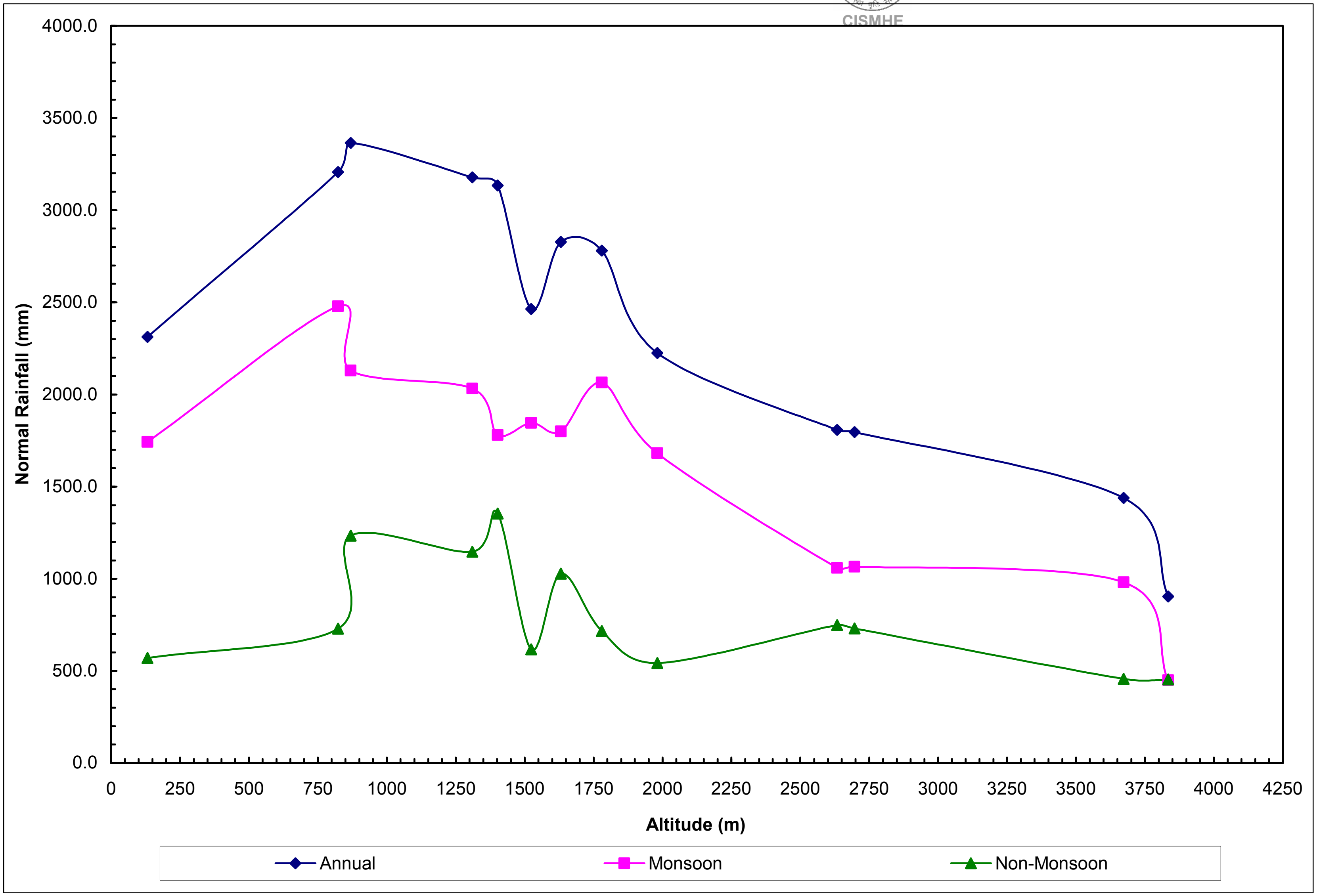



**Fig. 3.3 Altitude vs. normal rainfall**

Where $N_i$ is normal rainfall

$P_i$ is the actual rainfall

n- no. of stations considered for the analysis

The filled rainfall data for all the stations have been compiled at Annexure 3.4(a) to 3.4(q). The filled up data has been used to work out average rainfall for the whole basin on monthly basis for each year using Thiesson polygon method. The Thiesson polygon are plotted at Fig.3.5(a) to Fig.3.5(e). The computed Thiesson weights are given at Annexure 3.5. The computed average monthly and annual rainfall for each year are compiled at Annexure 3.6. The 75 percent dependable rainfall in the basin in Sikkim works out to 2478 mm. These weighted average rainfall values can conveniently be used to derive the yield series of the basin or suitably extend the yield series arrived from observed discharge measurement through development of appropriate rainfall-runoff models.

## 3.6 CLIMATOLOGICAL CHARACTERSTICS

Monthly mean values of the maximum and minimum temperatures, mean monthly relative humidity, monthly sunshine hours and monthly mean wind speed are available at Gangtok station and have been compiled in Table 7.10 to Table 7.13 in Chapter VII. These climatological figures are being taken as representative of the Teesta Basin in Sikkim.

### 3.6.1 Temperature Distribution

Mean daily maximum temperature in the sub-basin varies from about 26.8$^o$ C in September to 20.7$^o$ C in the month of January. Mean daily minimum temperatures are around 7.5$^o$ C in January, 10.7$^o$ C in April, 14.5$^o$ C in July and 13.3$^o$ C in October. The districtwise monthly mean temperatures are given at Table 3.5.

### 3.6.2 Relative Humidity (RH)

Mean daily Relative Humidity varies from 63.8 percent to 88.7 percent over the basin. The mean daily RH is 68.3 percent in January, 66.2 percent in April, 88.7 in July and 68.0 in October. The district-wise monthly Mean daily Relative Humidity are included in Table 4.5 above.

### 3.6.3 Wind Speed

The mean monthly wind speed varies from as low as 43.2 km/day from July to September to high of 98.4 km/day in the month of April. Month wise details are given at Table 3.6.

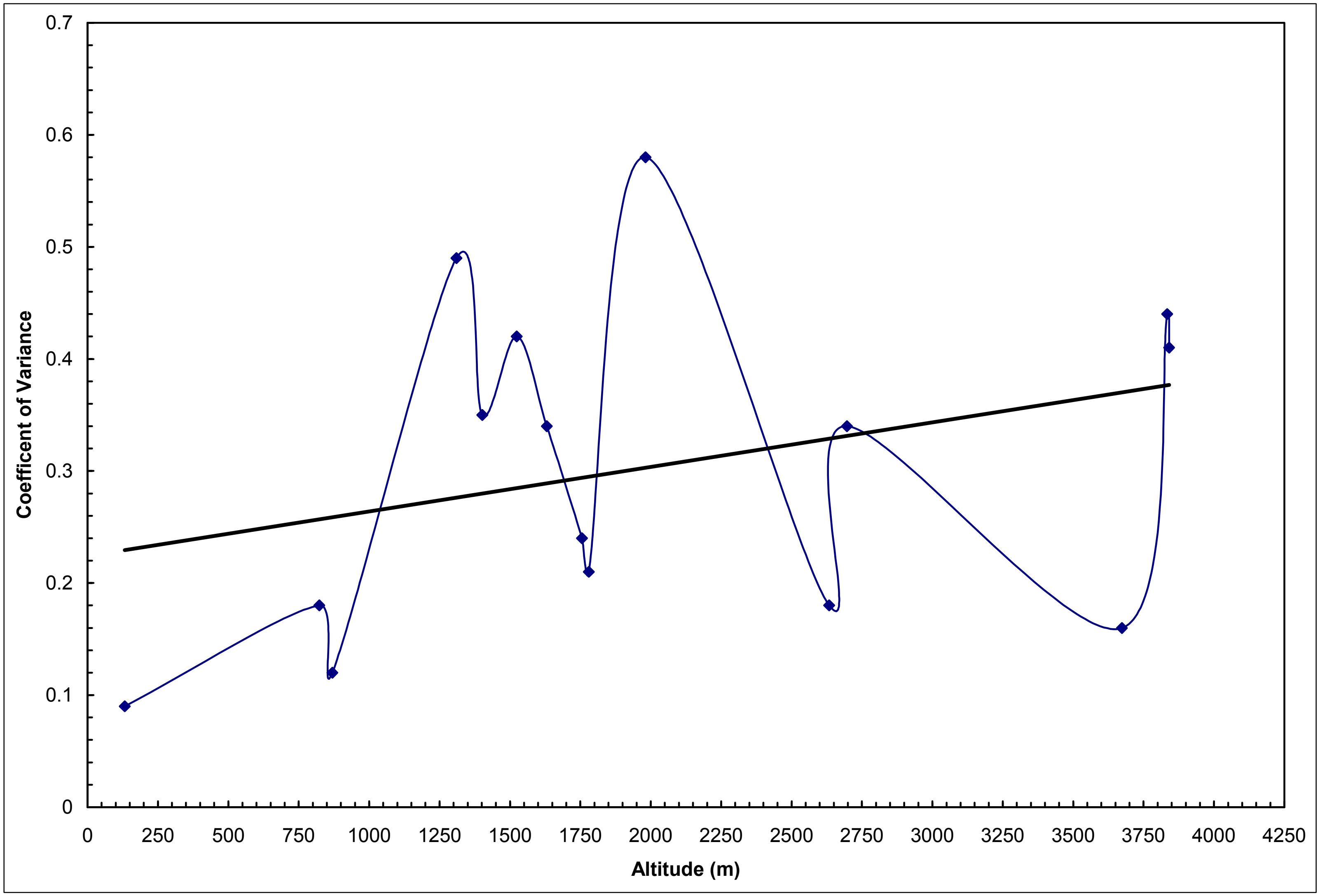
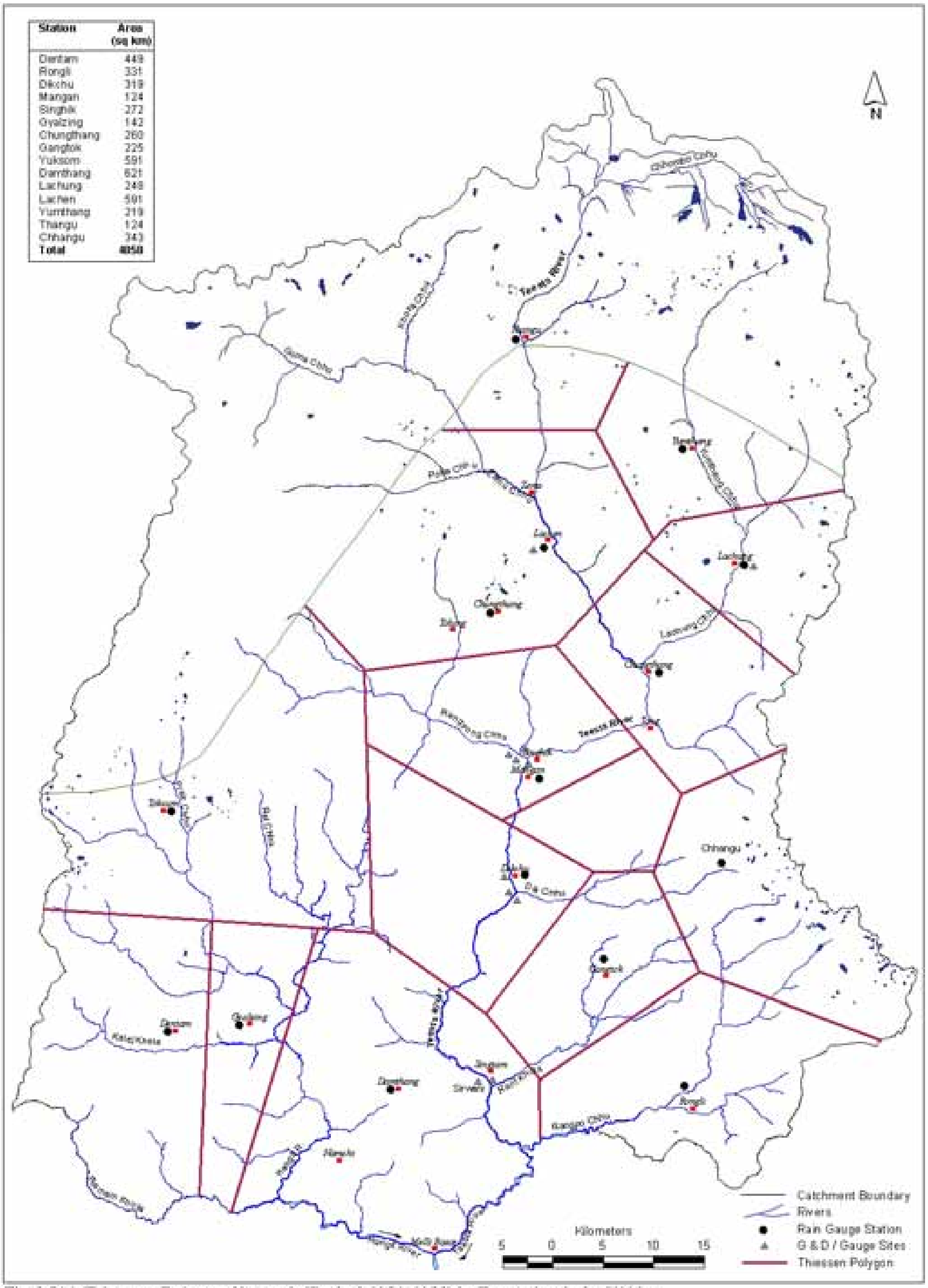



**Fig. 3.4 Altitude vs. coefficient of variance**




| Station | Area (sq km) |
|---|---|
| Dentam | 449 |
| Rongli | 331 |
| Dikchu | 319 |
| Mangan | 124 |
| Singhik | 272 |
| Gyalzing | 142 |
| Chungthang | 260 |
| Gangtok | 225 |
| Yuksom | 591 |
| Damthang | 621 |
| Lachung | 249 |
| Lachen | 591 |
| Yumthang | 319 |
| Thangu | 124 |
| Chhangu | 343 |
| **Total** | **4950** |

**Fig.3.5(a) Thiessen Polygon Network (Period 1951-1956) in Teesta basin in Sikkim**

| Station | Area (sq km) |
|---|---|
| Chungthang | 3050 |
| Lachen | 1619 |
| Thangu | 189 |
| **Total** | **4858** |

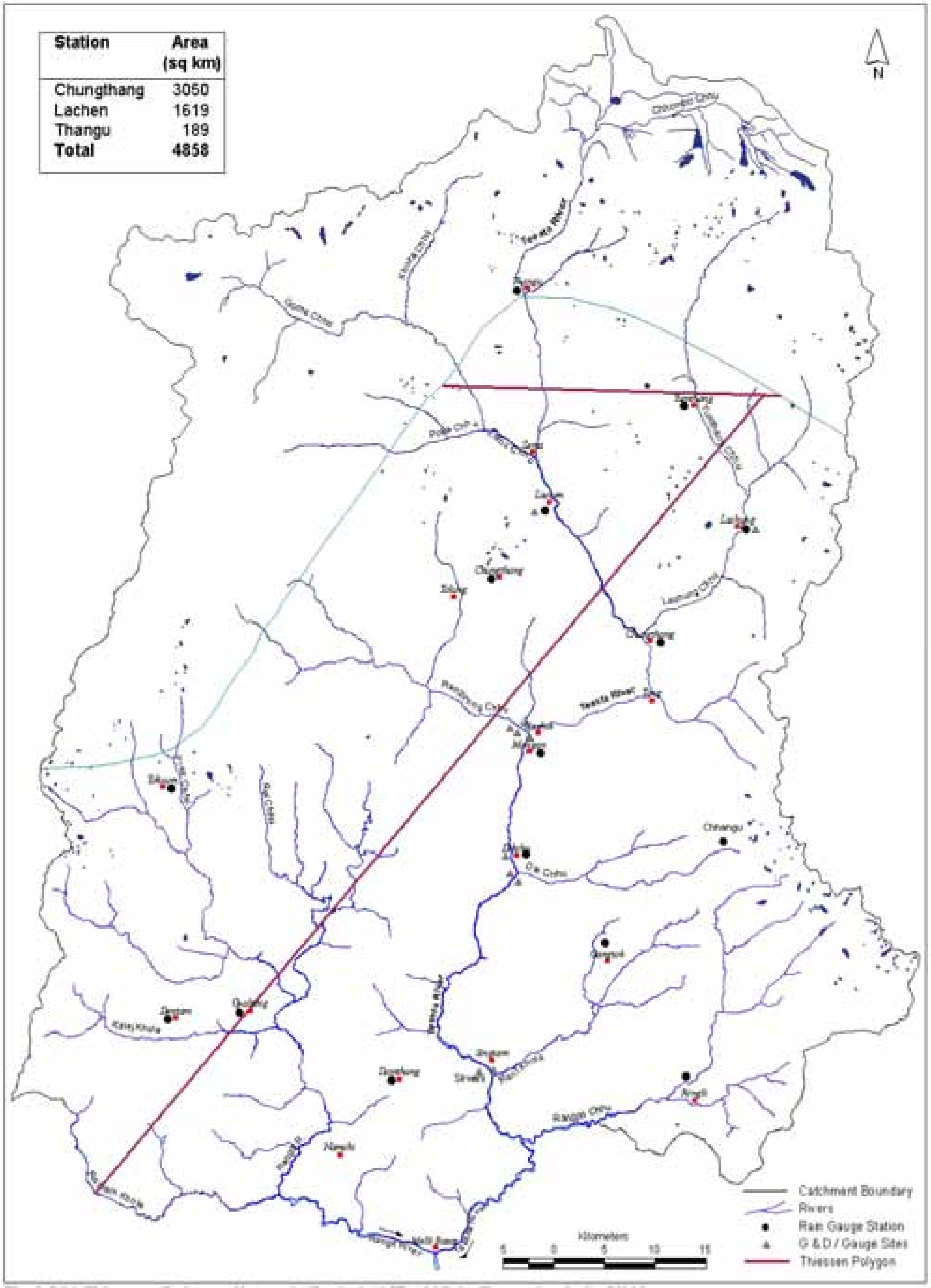
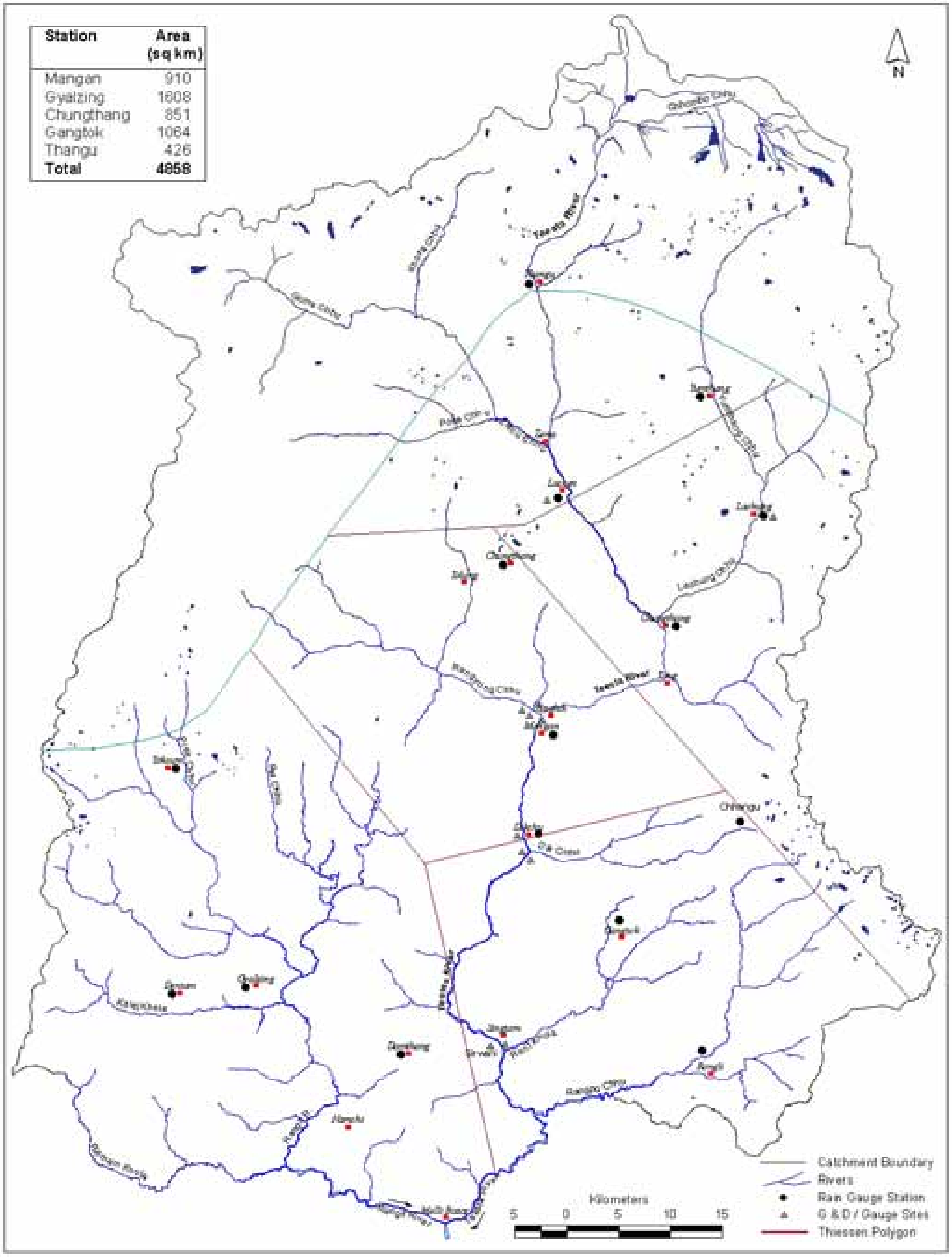



**Fig.3.5(b) Thiessen Polygon Network (Period 1957-1963) in Teesta basin in Sikkim**



| Station | Area (sq km) |
|---|---|
| Mangan | 910 |
| Gyalzing | 1608 |
| Chungthang | 851 |
| Gangtok | 1064 |
| Thangu | 426 |
| **Total** | **4858** |



**Fig.3.5(c) Thiessen Polygon Network (Period 1964-1970) in Teesta basin in Sikkim**

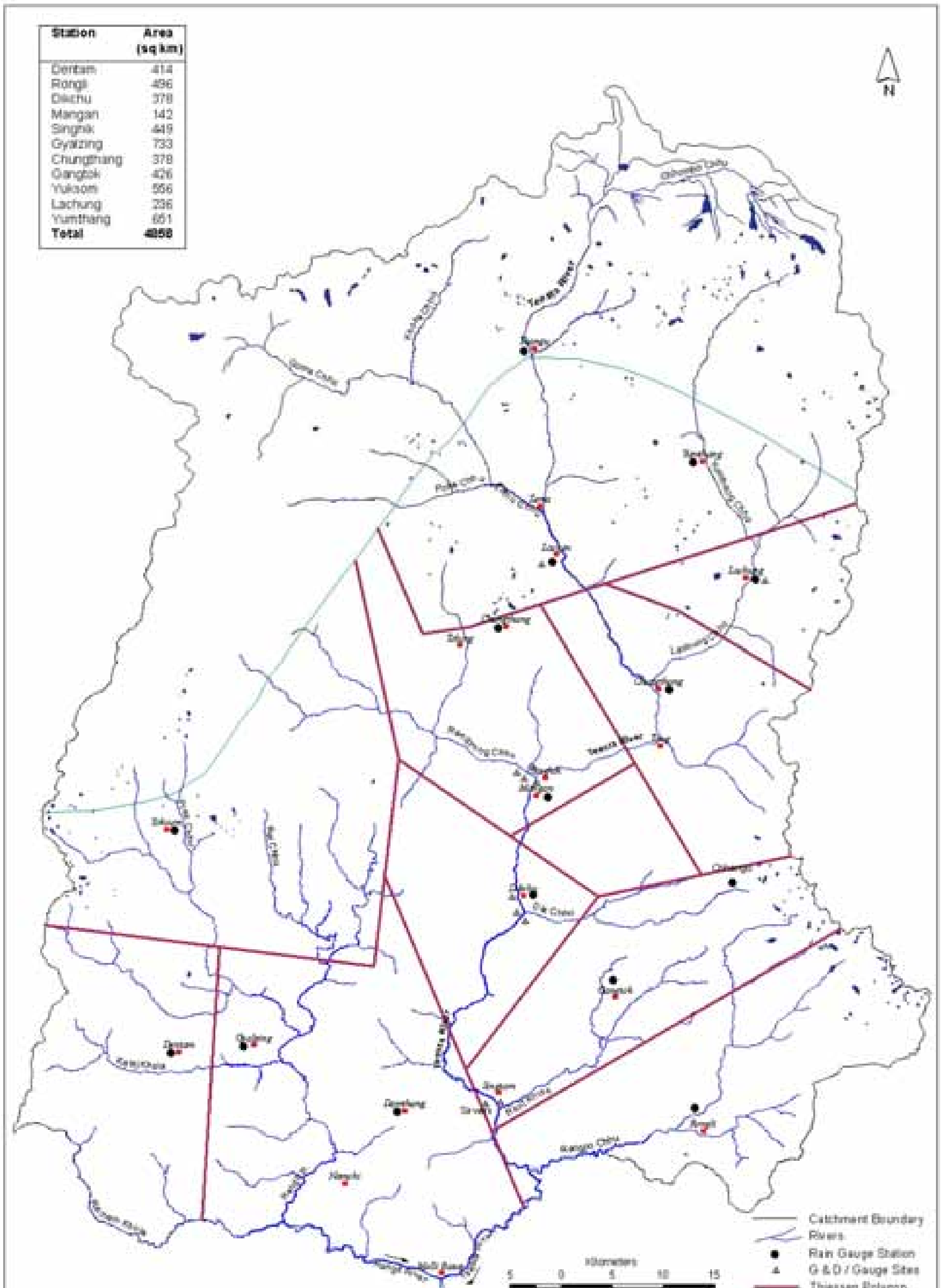
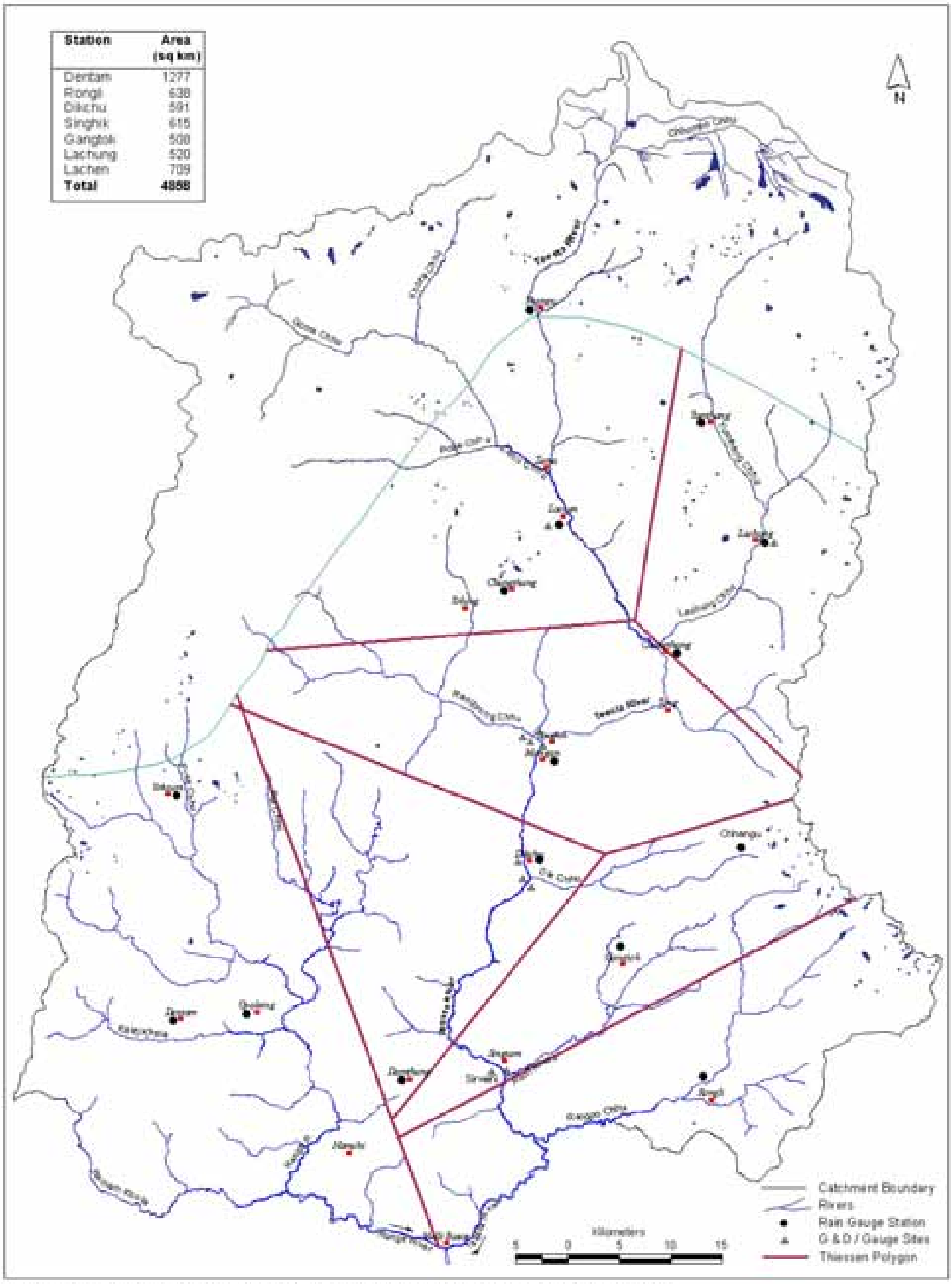



**Fig.3.5(d) Thiessen Polygon Network (Period 1971-1979) in Teesta basin in Sikkim**




| Station | Area (sq km) |
|---|---|
| Dentam | 1277 |
| Rongli | 638 |
| Dikchu | 591 |
| Singhik | 615 |
| Gangtok | 508 |
| Lachung | 520 |
| Lachen | 709 |
| **Total** | **4858** |

**Fig.3.5(e) Thiessen Polygon Network (Period 1992-1999) in Teesta basin in Sikkim**

**Table 3.5 Districtwise Monthly Mean Temperature & Relative Humidity (%)**

| District | Temp/RH | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max | | | | | | | | | | | | |
| NORTH | Min | Data Not Available | | | | | | | | | | | |
| | RH | | | | | | | | | | | | |
| | Max | 14.7 | 16.1 | 19.4 | 21.8 | 23.8 | 24.8 | 24.1 | 24.6 | 23.8 | 22.5 | 19.5 | 16.6 |
| EAST | Min | 4.6 | 5.0 | 8.0 | 11.0 | 13.4 | 15.9 | 16.7 | 16.1 | 15.5 | 11.8 | 8.0 | 6.0 |
| | RH | 74.4 | 75.3 | 72.6 | 73.9 | 79.6 | 85.1 | 88.2 | 81.7 | 85.5 | 78.9 | 73.8 | 71.5 |
| | Max | 27.4 | 27.4 | 26.1 | 26.6 | 23 | 23.3 | 24.0 | 26.1 | 27.6 | 27.8 | 27.2 | 28.7 |
| WEST | Min | 8.4 | 7.3 | 11.6 | 8.7 | 8 | 9.1 | 7.1 | 8.2 | 8.6 | 9.9 | 8.5 | 4.9 |
| | RH | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | Max | 20.1 | 20.3 | 20.8 | 25.3 | 28.4 | 29.2 | 27.9 | 29.6 | 29.2 | 27.5 | 24.4 | 23.3 |
| SOUTH | Min | 9.5 | 10.1 | 11.4 | 12.4 | 16.4 | 19.1 | 19.8 | 20.1 | 20 | 18.2 | 13.1 | 10.2 |
| | RH | 62.1 | 52.2 | 58.3 | 58.5 | 68.1 | 82.9 | 89.1 | 80 | 65.4 | 57.1 | 65.3 | 56.2 |
| | Max | **20.7** | **21.3** | **22.1** | **24.6** | **25.1** | **25.8** | **25.3** | **26.8** | **26.9** | **25.9** | **23.7** | **22.9** |
| | Min | **7.5** | **7.5** | **10.3** | **10.7** | **12.6** | **14.7** | **14.5** | **14.8** | **14.7** | **13.3** | **9.9** | **7.0** |
| | RH | **68.3** | **63.8** | **65.5** | **66.2** | **73.9** | **84.0** | **88.7** | **80.9** | **75.5** | **68.0** | **69.6** | **63.9** |

## Table 3.6 Monthly Mean Wind Speed

| Month | Mean (km/day) |
|---|---|
| January | 52.8 |
| February | 62.4 |
| March | 91.2 |
| April | 98.4 |
| May | 81.6 |
| June | 50.4 |
| July | 43.2 |
| August | 43.2 |
| September | 43.2 |
| October | 64.8 |
| November | 55.2 |
| December | 45.6 |

# CHAPTER - 4
# HYDROLOGY

## 4.1 GENERAL

Assessment of surface water resources of a basin is an important component for planning and development of water resources for various uses. The state of Sikkim is characterised with enormous water resources available through various rivers and hill streams. However, the same could not been put to utilisation because of the land availability constraints.

Teesta is a perennial river with substantial flows even in lean season. The river flows generally in North South direction bisecting the State of Sikkim. It is the single major river in the State draining 95 % of the total area of the State. Enormous fall of the order of 3,300 m over a river stretch of 175 km. makes this river an ideal and reliable source of hydropower. This necessitates the establishment of a hydro-meteorological network for collecting the gauge, discharge and precipitation data to estimate the water availability in the Teesta valley for development of power. The collection of discharge data during the lean as well as monsoon seasons is equally important. The former is required for assessing the firm power draft while the later is required for the design of hydraulic structures for hydro power projects.

## 4.2 CATCHMENT AREA

The catchment area of Teesta basin is studded with quite a few glaciers in its upper reaches, the largest of which is the Zemu glacier in the western part of the catchment. Upper portion of the catchment area is reported to be snow covered. Precise details of the snow covered area or the amount of snowfall etc are not available. However, in view of the fact that the hill slopes are generally very steep, it is felt that limited areas in the upper reaches and that too near the river section might have permanent snow cover. This is also evident from the presence of a few glacier ranges. As per the toposheets (Survey of India, 1943), the snow line varies from 4,572 m (15,000 ft) to 6,096 m (20,000 ft). For the limited purpose of the hydrological studies, the contour line of 4,572 m has been considered to be the snow line. Although the catchment above 15,000 ft may have some rainfall, but it can be considered to be insignificant for all practical purposes.

Based on the information, the total catchment area and the snow-covered area upto various stages of Teesta hydel project have been worked out and given in Table 4.1.

**Table 4.1 Details of snow-covered and rainfed area**

| Stage | Location | Catchment area (sq km) | | | Snow-covered area as % of total area |
|---|---|---|---|---|---|
| | | Snow-covered | Rainfed | Total | |
| III | Chhungthang | 1598 | 1189 | 2287 | 57 |
| IV | Sankalang | 1939 | 1900 | 3839 | 51 |
| V | DikChhu | 2240 | 2020 | 4260 | 53 |

CISMHE

| | | | | | |
|---|---|---|---|---|---|
| VI | Khanitar | 2240 | 2634 | 4874 | 46 |

## 4.3 ASSESSMENT OF SURFACE WATER RESOURCES

### 4.3.1 Gauge and Discharge (G&D) Network

At present, there are 11 gauge and discharge observation sites being maintained by the Central Water Commission over the river Teesta up to Tarkhola, a village between Melli and Rangpo. The Fig. 3.1 shows the locations of hydro meteorological network where gauge and discharge observations are being taken at regular interval. The discharge observations are being taken in the morning at 0800 A.M. and gauge observations are being taken at 8.00. The location and date of opening of these sites is given in Table 4.2.

**Table 4.2 Details of G&D Sites in Teesta Basin in Sikkim**

| Sl. No. | Site | River | Location | Opened on |
|---|---|---|---|---|
| 1. | Lachen | Lachen Chhu Lachen Chhu | Suspension bridge of | 1.10.88 |
| 2. | Lachung | Lachung Chhu | d/s of LaChhung bridge (reopened) | 6.6.88 |
| 3. | Chungthang | Teesta | d/s of confluence of Lachen | 4.1.75 |
| 4. | Sangklang | Talung Chhu | u/s of confluence of Talung Chhu & Ree Chhu | 1.9.85 (reopened) |
| 5. | Sangklang | Talung Chhu | d/s of confluence of Talung Chhu & Ree Chhu | 1.9.85 (reopened) |
| 6. | Sangklang | Teesta | About 100 m d/s of confluence of Teesta & Talung Chhu | 3.11.89 |
| 7. | DikChhu | Teesta | At confluence of Teesta | 14.5.91 |

| | | | | |
|---|---|---|---|---|
| | | | Deadkhola | |
| 8. | DikChhu | Teesta | At 14th mile suspension bridge | 1.1.90 |
| 9. | DikChhu | Teesta | More than 2 km d/s of DikChhu Bazar | 21.12.83 |
| 10. | Dipndara / Balutar | Teesta | d/s of Dipudara | 11.3.85 |
| 11. | Sirwani R.C.C. bridge | Teesta | Sirwani RCC bridge | 12.3.84 |

### 4.3.2 Methodology for Measurement of Flow

The flow during monsoon season as well as in lean season in the river Teesta and its tributaries is very turbulent due to high velocity of water, bouldary bed, steep gradient interspaced by rapid falls and floating bodies like wooden logs etc. It is difficult to carry out discharge observations in this river by conventional means like current meter. Therefore, the surface float method is, presently, being employed for measurement of discharge at all the Gauge & Discharge sites. The detailed methodology for observation of discharge and selection of suitable sites is given at Annexure 4.1.

### 4.3.3 Adequacy of Network

In view of its varied terrain and flashy character of various hill streams joining the river Teesta, the above network of G&D sites appears inadequate. Hence, the following additional set up for key hydrological stations is suggested after taking into consideration the terrain conditions and the availability of suitable places for locating the headquarter for the positioning to staff for taking the observations.

i) On Lhonak Chhu before its confluence with Lachen Chhu.
ii) On Lachen Chhu below the confluence of Lhonak Chhu and Lachen Chhu.
iii) On LaChhung Chhu above its confluence with tributary on its left.
iv) On LaChhung Chhu below its confluence with tributary on the left.
v) On the main Teesta at Mangan.
vi) On Rangpo Chhu before its confluence with the Teesta.
vii) On the main Teesta at Singtam.

### 4.3.4 Water Availability

The observed monthly discharge data of river Teesta are available different G &D sites at Chhungthang, Sankalang, Dikchu and Khanitar for varying periods from 1976 to 1995. It may be observed that very limited data is available for the concurrent period at different sites. Therefore, a precise comparison of average annual flows observed at various stations may not be possible. The average annual runoff at different sites is given in Table 4.3.

**Table 4.3 Average annual runoff of Teesta river at various sites**

| Sl. No. | Site | Period of data availability | Mcm | Mm |
|---|---|---|---|---|
| 1 | Chungthang | !976-95 | 4332 | 1554 |
| 2 | Sanklang | 1989-95 | 7860 | 2047 |

| | | | | |
|---|---|---|---|---|
| 3 | DikChhu | 1984-93 | 9580 | 2249 |
| 4 | Khanitar | 1980-94 | 11569 | 2374 |

The observed discharge data is also available at Coronation bridge which is in West Bengal. Since the upstream abstractions are very nominal in the state of Sikkim, the same can be considered as total availability for the state of Sikkim as a whole. The average annual runoff at coronation bridge is 16221 Mcm. This series for the period 1978 to 1994 is given at Annexure 4.2.

## 4.4 FLOOD HYDROLOGY

Flood frequency analysis has been performed to estimate the flood of various return period at coronation bridge. The objective of frequency analysis in the context of present study is to get an estimate of periodicity of flooding likely in the downstream regions. Once a return period - flood magnitude relationship is fitted to a data set, flood magnitude may be worked out for any return period.

### 4.4.1 Choice of Flow Series for Flood Estimation

Frequency analysis techniques attempt to extract the information contained in a data to construct a flood magnitude – exceedance probability relationship and is used to interpolate and extrapolate flood magnitude for a specified exceedance probability or vice-versa. Therefore, frequency techniques are totally data dependent. The results are affected by the length of the data series and by the inaccuracies contained in the data series. There are two methods for abstracting the flood frequency information from observed data series. The Annual Maximum

(AM) method and the Peak Over Threshold (POT) method. POT method is also called Partial Duration method.

In AM method, a data series is built picking out the maximum instantaneous flow for each year, hence it is called Annual Maximum series. The criticism against this method is that it picks one and only one event from each year, totally ignoring others. It is possible that in some years, the second or third largest flood was larger in magnitude than the largest flood in some other years. The occurrence of these floods contributes to the flood frequency information contained in the data. Yet this information is neglected because the event is not the largest within the year.

This disadvantage is remedied in POT method. The POT series is constructed by fixing some threshold magnitude and selecting all events that exceed this threshold. Some years may contribute more than one event to the POT series while some years may not contribute any event.

There is another variation of POT method in which the number of floods per year, and not the threshold, that is fixed a-priory. If the total number of years in the data series is N and the number of floods events exceeding the threshold, fixed a-priory, are M, then the average number of floods selected from each year is M/N. This number is not necessarily an integer. Conversely, if it is decided to select K floods per year, (K need not be integer), then a total of N*K flood are to be selected. The entire data series is arranged in descending order and top N*K flood events are picked up from the partial duration series.

**Table 4.4 Comparison of Recurrence Interval for AM and POT series**

| Recurrence Interval in Years | |
|---|---|
| **POT series** | **AM series** |
| 0.5 | 1.16 |
| 1.0 | 1.58 |
| 1.44 | 2.0 |
| 2 | 2.54 |
| 5 | 2.52 |
| 10 | 10.5 |
| 20 | 20.5 |
| 50 | 50.2 |
| 100 | 100.5 |

Chow investigated the theoretical relationship between the two methods. Table 4.3 attributed to Dalrymple, compares the recurrence intervals of two types of series. It is seen that the distinction is of importance only for the flows of very low return period, of the order of one year or less. Therefore, only the AM method has been used in this study.

### 4.4.2 Data Availability

The population for the AM series is annual maximum floods for all the years, starting with historical years when the data collection was yet to commence and upto the future year which are yet to occur for as long as the catchment and the river will exist in their present forms. Obviously, data for the entire population cannot be available. What is available is only a sample from the population. This sample has to be examined using the procedures for obtaining unbiased estimates of population parameters from a sample.

The frequency analysis by AM series is not a time series analysis in the sense that it does not take into account the stochasticity. Therefore, a break in the data series does not affect the sample and the AM series analysis can proceed even if the data for some years is missing.

Therefore, flood frequency analysis is conducted using the annual flood peaks, extracted from the observed daily discharge data on river Teesta at Kanitar and Coronation Bridge. Annual flood series (AFS) hydrograph plots for the Kanitar site and Coronation Bridge are given at Figs 4.1 and 4.2 respectively. The detailed calculations are given at Tables 4.5 (a) and 4.5 (b) respectively.

## Table 4.5(a) Details of Annual Flood Series at Kanitar Site

| S. No | Year | Max. Flood X (cumec) | X-X | (X-X)2 | (X-X)3 | Z= log X | Z-Z | (Z-Z)2 | (Z-Z)3 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1970 | 2356.0 | -175.9 | 30937 | -5441560 | 3.372 | -0.008 | 0.000 | 0.000 |
| 2 | 1971 | 1932.0 | -599.9 | 359868 | -215881222 | 3.286 | -0.094 | 0.009 | -0.001 |
| 3 | 1972 | 2846.0 | 314.1 | 98665 | 30991692 | 3.454 | 0.074 | 0.006 | 0.000 |
| 4 | 1973 | 4890.0 | 2358.1 | 5560683 | 13112701652 | 3.689 | 0.309 | 0.096 | 0.030 |
| 5 | 1974 | 4149.0 | 1617.1 | 2615045 | 4228815019 | 3.618 | 0.238 | 0.057 | 0.013 |
| 6 | 1975 | 2356.0 | -175.9 | 30937 | -5441560 | 3.372 | -0.008 | 0.000 | 0.000 |
| 7 | 1976 | 2861.0 | 329.1 | 108313 | 35647020 | 3.457 | 0.077 | 0.006 | 0.000 |
| 8 | 1977 | 4169.0 | 1637.1 | 2680129 | 4387666236 | 3.620 | 0.240 | 0.058 | 0.014 |
| 9 | 1978 | 3915.0 | 1383.1 | 1912993 | 2645880125 | 3.593 | 0.213 | 0.045 | 0.010 |
| 10 | 1979 | 3460.0 | 928.1 | 861388 | 799462976 | 3.539 | 0.159 | 0.025 | 0.004 |
| 11 | 1980 | 2369.0 | -162.9 | 26533 | -4321985 | 3.375 | -0.005 | 0.000 | 0.000 |
| 12 | 1981 | 1530.0 | -1001.9 | 1003784 | -1005680723 | 3.185 | -0.195 | 0.038 | -0.007 |
| 13 | 1982 | 1955.0 | -576.9 | 332802 | -191990187 | 3.291 | -0.089 | 0.008 | -0.001 |
| 14 | 1983 | 2516.0 | -15.9 | 252 | -4012 | 3.401 | 0.021 | 0.000 | 0.000 |
| 15 | 1984 | 2070.0 | -461.9 | 213342 | -98540708 | 3.316 | -0.064 | 0.004 | 0.000 |
| 16 | 1985 | 2191.0 | -340.9 | 116206 | -39613461 | 3.341 | -0.039 | 0.002 | 0.000 |
| 17 | 1986 | 1955.0 | -576.9 | 332802 | -191990187 | 3.291 | -0.089 | 0.008 | -0.001 |

| S. No | Year | Max. Flood X | X-X | (X-X)2 | (X-X)3 | Z= log X | Z-Z | (Z-Z)2 | (Z-Z)3 |
|---|---|---|---|---|---|---|---|---|---|
| 18 | 1987 | 2727.0 | 195.1 | 38068 | 7427430 | 3.436 | 0.056 | 0.003 | 0.000 |
| 19 | 1988 | 1899.0 | -632.9 | 400550 | -253503933 | 3.279 | -0.101 | 0.010 | -0.001 |
| 20 | 1989 | 1955.0 | -576.9 | 332802 | -191990187 | 3.291 | -0.089 | 0.008 | -0.001 |
| 21 | 1990 | 1955.0 | -576.9 | 332802 | -191990187 | 3.291 | -0.089 | 0.008 | -0.001 |
| 22 | 1991 | 2727.0 | 195.1 | 38068 | 7427430 | 3.436 | 0.056 | 0.003 | 0.000 |
| 23 | 1992 | 1540.0 | -991.9 | 983846 | -975866783 | 3.188 | -0.192 | 0.037 | -0.007 |
| 24 | 1993 | 2235.0 | -296.9 | 88144 | -26168975 | 3.349 | -0.031 | 0.001 | 0.000 |
| 25 | 1994 | 1359.0 | -1172.9 | 1375671 | -1613510703 | 3.133 | -0.247 | 0.061 | -0.015 |
| 26 | 1995 | 2253.0 | -278.9 | 77780 | -21691962 | 3.353 | -0.027 | 0.001 | 0.000 |
| 27 | 1996 | 2191.0 | -340.9 | 116206 | -39613461 | 3.341 | -0.039 | 0.002 | 0.000 |
| **TOTAL** | | **68361** | **-0.03** | **20068617** | **20182777785** | **91.295** | **0.035** | **0.494** | **0.037** |
| **Average** | | **2532** | **24.79** | **794985.24** | **809763328.27** | **3.384** | **0.004** | **0.020** | **0.001** |

## Table 4.5(b) Details of Annual Flood Series at Coronation Bridge

| Sl. No | Year | Max. Flood (cumec) X | X-X | $(X-X)^2$ | $(X-X)^3$ | Z=log X | Z-Z | $(Z-Z)^2$ | $(Z-Z)^3$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1972 | 2696.00 | -72.92 | 5317.33 | -387739.44 | 3.431 | 0.011 | 0.000 | 0.000 |
| 2 | 1973 | 5090.00 | 2321.08 | 5387412.37 | 12504615095.40 | 3.707 | 0.287 | 0.082 | 0.024 |
| 3 | 1974 | 3647.00 | 878.08 | 771024.49 | 677021181.02 | 3.562 | 0.142 | 0.020 | 0.003 |
| 4 | 1975 | 2067.00 | -701.92 | 492691.69 | -345830148.52 | 3.315 | -0.105 | 0.011 | -0.001 |
| 5 | 1976 | 2191.00 | -577.92 | 333991.53 | -193020382.94 | 3.341 | -0.079 | 0.006 | 0.000 |
| 6 | 1977 | 2459.00 | -309.92 | 96050.41 | -29767941.95 | 3.391 | -0.029 | 0.001 | 0.000 |
| 7 | 1978 | 3236.00 | 467.08 | 218163.73 | 101899913.33 | 3.510 | 0.090 | 0.008 | 0.001 |
| 8 | 1979 | 2751.00 | -17.92 | 321.13 | -5754.59 | 3.439 | 0.019 | 0.000 | 0.000 |
| 9 | 1980 | 2192.00 | -576.92 | 332836.69 | -192020141.12 | 3.341 | -0.079 | 0.006 | 0.000 |
| 10 | 1981 | 2110.00 | -658.92 | 434175.57 | -286086964.21 | 3.324 | -0.096 | 0.009 | -0.001 |
| 11 | 1982 | 3758.00 | 989.08 | 978279.25 | 967596437.03 | 3.575 | 0.155 | 0.024 | 0.004 |
| 12 | 1983 | 2264.00 | -504.92 | 254944.21 | -128726428.70 | 3.355 | -0.065 | 0.004 | 0.000 |
| 13 | 1984 | 1751.00 | -1017.92 | 1036161.13 | -1054729133.79 | 3.243 | -0.177 | 0.031 | -0.006 |
| 14 | 1985 | 2967.00 | 198.08 | 39235.69 | 7771804.76 | 3.472 | 0.052 | 0.003 | 0.000 |
| 15 | 1986 | 1899.00 | -869.92 | 756760.81 | -658321360.70 | 3.279 | -0.141 | 0.020 | -0.003 |
| 16 | 1987 | 1866.00 | -902.92 | 815264.53 | -736118646.18 | 3.271 | -0.149 | 0.022 | -0.003 |
| 17 | 1988 | 2370.00 | -398.92 | 159137.17 | -63482998.42 | 3.375 | -0.045 | 0.002 | 0.000 |
| 18 | 1989 | 3243.00 | 474.08 | 224751.85 | 106550355.34 | 3.511 | 0.091 | 0.008 | 0.001 |

| Sl. No | Year | Max. Flood (cumec) X | X-X | $(X-X)^2$ | $(X-X)^3$ | Z=log X | Z-Z | $(Z-Z)^2$ | $(Z-Z)^3$ |
|---|---|---|---|---|---|---|---|---|---|
| 19 | 1990 | 4044.00 | 1275.08 | 1625829.01 | 2073062049.48 | 3.607 | 0.187 | 0.035 | 0.007 |
| 20 | 1991 | 4069.00 | 1300.08 | 1690208.01 | 2197405624.96 | 3.609 | 0.189 | 0.036 | 0.007 |
| 21 | 1992 | 2122.00 | -646.92 | 418505.49 | -270739569.26 | 3.327 | -0.093 | 0.009 | -0.001 |
| 22 | 1993 | 2496.00 | -272.92 | 74485.33 | -20328535.28 | 3.397 | -0.023 | 0.001 | 0.000 |
| 23 | 1994 | 2043.00 | -725.92 | 526959.85 | -382530691.70 | 3.310 | -0.110 | 0.012 | -0.001 |
| 24 | 1999 | 3395.00 | 626.08 | 391976.17 | 245408438.26 | 3.531 | 0.111 | 0.012 | 0.001 |
| 25 | 2000 | 2497.00 | -271.92 | 73940.49 | -20105897.06 | 3.397 | -0.023 | 0.001 | 0.000 |
| **Total** | | **69223.000** | **0.000** | **17138423.840** | **14499128565.734** | **85.620** | **0.120** | **0.364** | **0.029** |
| **Average** | | **2768.92** | **0.00** | **685536.95** | **579965142.63** | **3.42** | **0.00** | **0.01** | **0.00** |

$\overline{X}$ = average of X values

$\overline{Z}$ = average of Z values

### 4.4.3 Computation of Statistical Parameters

For working out various statistical parameters of the AFS, following formula have been used for original and its log transformed series.

i) Mean $\overline{X} = \frac{1}{N} \sum_{i=1}^{N} x_i$

ii) Standard deviation $\sigma_{n-1} = \left[ \frac{1}{N-1} \sum_{i=1}^{N} (x_i - \overline{x})^2 \right]^{1/2}$

iii) Coefficient of variance, $C_v = \frac{\sigma_{n-1}}{\overline{X}}$

iv) Skewness co-efficient (unbiased), $C_s = \frac{N \sum_{i-1}^{N} \left(x_i - \overline{x}\right)^3}{(N-1)(N-2)\sigma^3_{n-1}}$

Values of above parameters are given in Table 4.6 (a) and (b) for the Kanitar site and Coronation Bridge respectively.

**Table 4.6(a) Values of Statistical Parameters at Kanitar site**

| Parameters | Original Series | Log Transformed Series |
|---|---|---|
| $\overline{X}$ | 2531.89 | 3.38 |
| $\sigma_{n-1}$ | 878.561 | 0.138 |
| $C_v$ | 0.347 | 0.041 |
| $C_s$ | 1.236 | 0.587 |

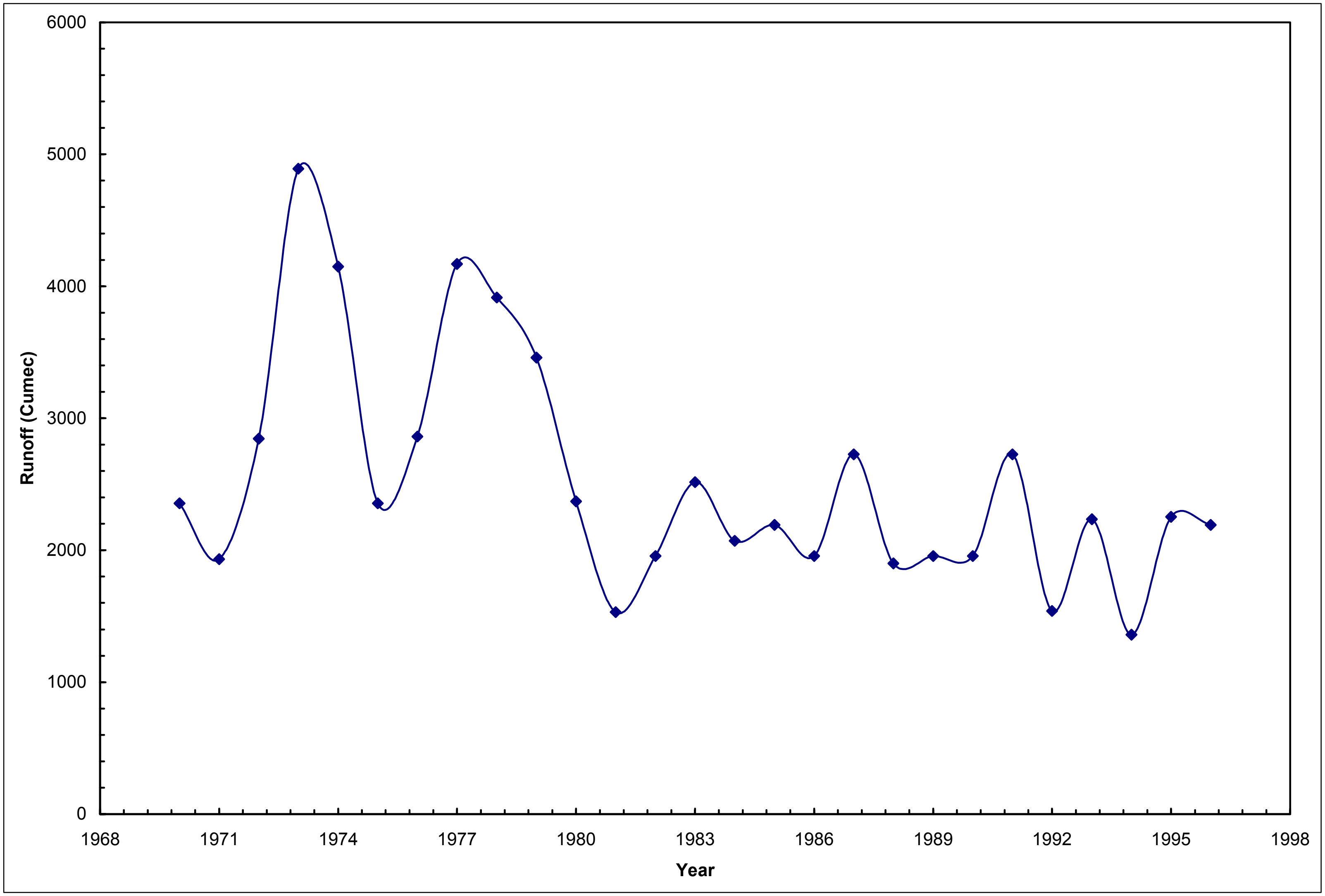



**Fig.4.1 Annual flood hydrograph on river Teesta at Khanitar site**

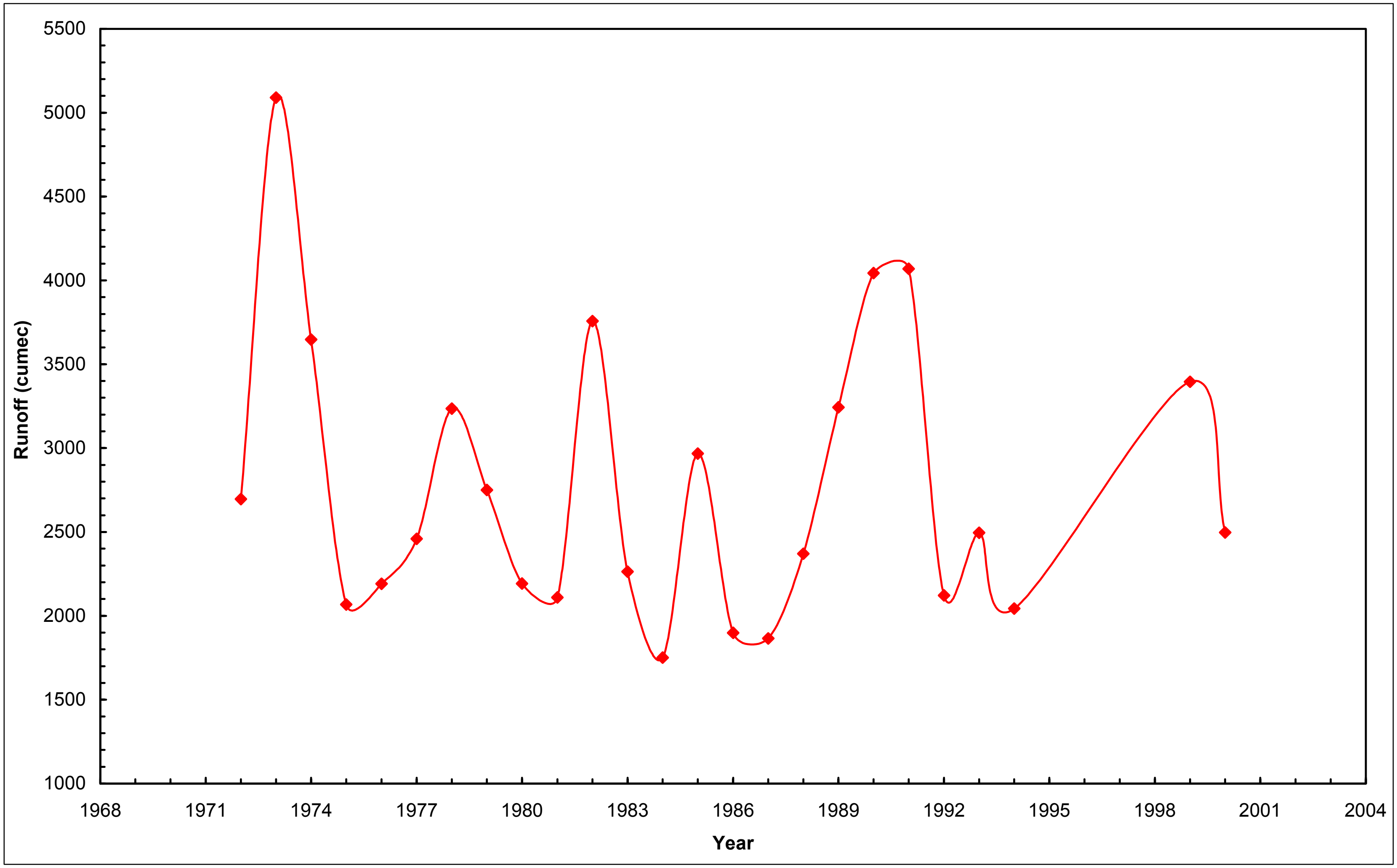



**Fig.4.2 Annual flood hydrograph on river Teesta at Coronation bridge**

**Table 4.6(b) Values of Statistical Parameters at Coronation bridge**

| Parameters | Original Series | Log Transformed Series |
|---|---|---|
| $\overline{X}$ | 2768.92 | 3.42 |
| $\sigma_{n-1}$ | 845.04 | 0.123 |
| $C_v$ | 0.305 | 0.036 |
| $C_s$ | 1.08 | 0.71 |

### 4.4.4 Checking the Data

The observed data in respect of annual maximum flood must be relevant, adequate and accurate. Flood frequency analysis assumes randomness and stationarity of data which must be checked for qualifying the data before subjecting it to frequency analysis. The data has been checked only for Coronation Bridge in succeeding paragraphs.

#### 4.4.4.1 *Randomness Check*

Random series is one in which the next discrete value is not known. Turning Point Test has been applied to check the randomness of the series. In this test, randomness of the series has been checked at significance level of 5%.

Significance level is decided depending upon the importance of the project. However, it is an established practice to check the hydrological parameters at 5% significance level in most of the cases. The parameter ⌡ is defined as follows:

$$⌡ = \frac{P - E(p)}{\sqrt{\text{var}(p)}}$$

where p = number of turning points in the AMS.

= number of peaks + number of troughs

E(p) = $\frac{2}{3}$ (N-2)

Var(p) = $\frac{16N - 29}{90}$

Where N = No. of data points in a series.

If [⌡] < 1.96, series is random at 5% significance level In the instant case, the value of [⌡] works out to 0.498 as calculated below:

P = 7 + 7 = 14 (Ref: Fig. 4.1)

Ep = 15.33

Var (p) = 4.12

⌡ = - 0.65 < 1.96

Hence, the series is random at significance level of 5%.

### 4.4.4.2 *Stationarity Check*

This check is applied to the annual series to ascertain the rising or falling trend in the values. Kandall''s Rank correlation test is generally used which defines a parameter ⌡ such as:

$$⌡ = \frac{T}{\sqrt{\text{var}(T)}}$$

where (T) = $\frac{4P}{N(N-1)}$ - 1

and Var (T) = $\frac{2(2N+5)}{9N(N-1)}$

where P = total numbers, any discrete observation in the series which is exceeded by subsequent observations.

If |⌡| < - 1.96 there is a falling trend in data at 5% signification level.

|⌡| > 1.96 there is a rising trend in data at 5% significance level.

|⌡| < 1.96 there is no trend in data at 5% significance level.

Here, P = 146

N = 25

$\therefore$ T = - 0.026

and var (T) = 0.020

Since ⌡ is less than 1.96, there is no trend in data at 5% significance level.

### 4.4.5 Choice of Distribution

One of the most common problems faced in flood hydrology is that of estimation of the magnitude of a flood of high return period from a fairly short record of stream flows. Probabilities of exceedance, and thereby return periods, can be assigned to each event in an AM series by different formulae. Computation of flood magnitude for design return period, therefore, involves extrapolation which is done by ‘fitting’ a frequency distribution to the observed data. A probability distribution is a function representing the probability of occurrence of a random variable. Most of the observed data will be located in the region of the distribution

curve while the design return period may lie in the tail of the distribution curve. Many distributions have similar shapes in their central region but have widely different tail shapes. Not only that, for any distribution, there are several methods for estimation of distribution parameters, i.e. for fitting the distribution. It is, therefore, possible to fit several distributions to the observed data by several different methods and thereby obtain several estimates of T year return period flood.

Digital computers have simplified the process of computations and therefore, it is common to come across a whole matrix of T-year return period floods computed by fitting different distributions and by different methods of parameter estimation. Confronted with such a wide selection of T-year return period floods, there is a tendency to select the largest value. This is nothing but maximizing the T-year return period flood.

There is no general agreement amongst hydrologists as to which of the various theoretical distributions available should be used. No standards have been established for design purposes. The decision becomes particularly difficult when the length of data series is short.

Extreme Value-I distribution, also called Gumbel distribution, and Log Pearson Type-III distribution are the most common distributions which have been used in this study.

### 4.4.6 Estimation of Flood at Various Return Periods

#### 4.4.6.1 *Gumbel Distribution*

This extreme value distribution introduced by Gumbel (1941) defines the value of variate x (flood) with a recurrence interval T as follows:

$$X_T = \overline{X} + k\ \sigma_{n-1}$$

Where $X_T$ = flood of T year frequency

$\bar{X}$ = mean of the series of size N

K = frequency factor = $\dfrac{Y_T - \bar{y}^n}{S_n}$

$\sigma_{n-1}$ = standard deviation of the series

$Y_T$ is the reduced variate, a function of T and is given by

$$Y_T = -\left[\ln\ln\left(\tfrac{T}{T-1}\right)\right]$$

Where $\bar{y}_n$ = reduced mean – a function of size of the series, for

$$N \rightarrow \propto,\ \bar{y}_n \rightarrow 0.577$$

$S_n$ = reduced standard deviation – a function of size of the series, for

$N \rightarrow \propto$, $S_n \rightarrow 1.2825$

Based on the above, flood of various return periods has been calculated and given in Table 4.7 (a) and (b) for Kanitar site and Coronation Bridge respectively.

### Table 4.7(a) Return Period Flood by Gumbels Method at Kanitar site

For N = 27, $\bar{y}_n$ = 0.5332 and $S_n$ = 1.1004

| Sl. No. | Return Period (T) | $Y_T$=-ln ln $\left(\frac{T}{T-1}\right)$ | k= $\frac{Y_T - \bar{Y}_n}{S_n}$ | $x_T = \bar{x} + k\sigma_{n-1}$ =2531.89 + K x 878.56 |
|---|---|---|---|---|
| 1 | 2 | 0.367 | -0.151 | 2398.81 |
| 2 | 10 | 2.250 | 1.560 | 3902.88 |
| 3 | 25 | 3.199 | 2.422 | 4659.90 |
| 4 | 50 | 3.902 | 3.061 | 5221.50 |
| 5 | 100 | 4.600 | 3.696 | 5778.95 |
| 6 | 1000 | 6.907 | 5.792 | 7620.95 |

### Table 4.7(b) Return Period Flood by Gumbels Method at Coronation Bridge

For N = 25, $\bar{y}_n$ = 0.5309 and $S_n$ = 1.0915

| Sl. No. | Return Period (T) | $Y_T$=-ln ln $\left(\frac{T}{T-1}\right)$ | k= $\frac{Y_T - \bar{Y}_n}{S_n}$ | $x_T = \bar{x} + k\sigma_{n-1}$ = 2768.92 + K x 845.04 |
|---|---|---|---|---|
| 1 | 2 | 0.367 | -0.155 | 2642.14 |
| 2 | 10 | 2.250 | 1.57 | 4095.63 |
| 3 | 25 | 3.198 | 2.44 | 4830.81 |
| 4 | 50 | 3.902 | 3.088 | 5378.40 |
| 5 | 100 | 4.600 | 3.727 | 5918.38 |
| 6 | 1000 | 6.907 | 5.841 | 7704.79 |

#### 4.4.6.2 *Log-Pearson Type III Distribution*

In this distribution, the variate is first transformed into logarithmic form and the transformed data is analysed. If Z is the log of variate x of a random series, the variate of $Z_T$ of T year recurrence interval is given by

$Z_T = \overline{Z} + k_z\sigma_z$

Where $\overline{Z}$ = mean of the series of Z variate where

Z = log X

$k_Z$ = frequency factor which is a function of recurrence interval T and coefficient of skew $C_s$

$\sigma_Z$= standard deviation of the Z variate series

$$= \sqrt{\frac{\Sigma(Z - \overline{Z})^2}{N-1}}$$

and Cs = coefficient of skew of variate Z

$$= \frac{N\Sigma(Z - \overline{Z})^2}{(N-1)(N-2)(\sigma_z)^3}$$

The floods of various return periods by Log Pearson type III distribution have been worked out for Kanitar site and Coronation Bridge and given in Table 4.8 (a) and (b) respectively.

**Table 4.8(a) Return Period Flood by Log Pearson Type-III Distribution at Kanitar site**

| Sl. No. | Return Period (T) | $K_Z$ | $Z_T = \bar{Z} + K_z\sigma_z$ = 3.38 + $K_Z$ x 0.1379 | $X_T$ = Antilog ($Z_T$) |
|---|---|---|---|---|
| 1 | 2 | -0.0974 | 3.371 | 2347.59 |
| 2 | 10 | 1.3275 | 3.567 | 3690.54 |
| 3 | 25 | 1.9361 | 3.651 | 4477.19 |
| 4 | 50 | 2.3542 | 3.709 | 5112.75 |
| 5 | 100 | 2.7481 | 3.763 | 5793.84 |
| 6 | 1000 | 3.9455 | 3.928 | 8473.59 |

**Table 4.8(b) Return Period Flood by Log Pearson type III Distribution at Coronation Bridge**

| Sl. No. | Return Period (T) | $K_Z$ | $Z_T = \bar{Z} + K_z \sigma_z$ = 3.42 + $K_Z$ x 0.123 | $X_T$ = Antilog ($Z_T$) |
|---|---|---|---|---|
| 1 | 2 | -0.118 | 3.405 | 2540.97 |
| 2 | 10 | 1.333 | 3.583 | 3828.25 |
| 3 | 25 | 1.967 | 3.661 | 4581.42 |
| 4 | 50 | 2.411 | 3.716 | 5199.96 |
| 5 | 100 | 2.830 | 3.768 | 5861.38 |
| 6 | 1000 | 4.119 | 3.926 | 8433.35 |

The return floods of 25 years, 50 years and 100 years by both the methods have been compared in Table 4.9 (a) and (b).

**Table 4.9(a) Comparison of Various Return Year Floods at Kanitar site**

| Return Period Distribution | Gumbel's Distribution | Pearson Type III |
|---|---|---|
| 25 | 4660 | 4477 |
| 50 | 5222 | 5113 |
| 100 | 5779 | 5794 |

**Table 4.9(b) Comparison of Various Return Year Floods at Coranation Bridge**

| Return Period Distribution | Gumbel's Distribution | Pearson Type III |
|---|---|---|
| 25 | 4831 | 4581 |
| 50 | 5378 | 5200 |
| 100 | 5918 | 5861 |

## 4.5 SEDIMENT LOAD

### 4.5.1 Availability of Silt Data

Central Water Commission carries out the silt observations at various key sites along river Teesta. Presently, silt observations are being carried out at five sites *viz*. Chhungthang, Sankalang, DikChhu, Sirwani and Khanitar. Chhungthang site is located at the confluence of river Lachen Chhu and LaChhung Chhu; Sankalang site is located at downstream of confluence of the rivers Talung Chhu whereas DikChhu site is located at down stream of confluence of DikChhu river with Teesta. Sediment load of the river Teesta are therefore greatly influenced by these rivers in addition to many small and medium size hilly streams with steep bed slopes. The location and period of availability of silt data at these sites is indicated in Table 4.10 below :

**Table 4.10 Availabi1ity of silt data of river Teesta at various sites**

| Sl.No. | Name of Site | Period |
|---|---|---|
| 1. | Chhungthang | 1983 - 97 |
| 2. | Sankalang | 1992 - 97 |
| 3. | DikChhu | 1986 - 97 |
| 4. | Sirwani | 1986 - 97 |
| 5. | Khanitar | 1995 - 97 |

The daily silt load is classified in three categories namely 'Coarse', 'Medium', and 'Fine' and it is evaluated by analysing the water samples collected at these sites.

## 4.5.2 Method of Observation and Collection of Samples

### 4.5.2.1 *Collection of Samples*

At a time five litre of water sample is collected in an enameled bucket from the flowing river with the help of one litre capacity bottle. The bottle is lowered at 0.6 d (depth of river) approximately for collection of sample. The samples are collected from middle of stream wherever bridge exists. Otherwise, the samples are collected from the bank of the river.

### 4.5.2.2 *Analysis of Samples*

The samples are analysed for three grades of sediment namely, coarse (particle size 0.2 mm and above), medium (size of particle between 0.2 mm and 0.075 mm) and fine (size of' particle below 0.075 mm). For separating coarse and medium grade of sediments, BS Sieve 200 and, BS Sieve 100 are used.

The sample of river water is passed through the sieves. The coarse particles are retained on Sieve No.200 while the medium size particles are retained on Sieve No.100. The fine silt particles pass through both the sieves and remain in suspension in the water sample.

The coarse and medium silt particles retained on the Sieves are collected in silt measuring tubes by washing the sieves thoroughly. The volumes of coarse and medium silt particles are measured with the help of silt measuring tube and their volume noted after tapping on the rubber pad and expressed in cubic-centimeter per liter (c.c. per liter).

The sample of water passing through the coarse and medium sieves, which still contains the finer particles in suspended state is allowed to settle overnight after adding 2 to 3 c.c. of 5% Alum Solution to it. The alum solution help in flocculation. The flocculation makes fine silt particles to combine and form a conglomeration which fasten the settlement process. The fine silt particles settle in 24 hours due to flocculation. Therefore, the sample is left undisturbed for such time. The clear water is siphoned off after 24 hours and the residue is passed through a pre-weighted filter paper. The filter paper is then dried in an oven and cooled in a dissector after which its weight is measured with the help of physical balances. The weight of the blank filter paper is deducted from the total weight observed to obtain actual quantity of fine grade of sediment retained on the filter paper. The respective volume of the coarse and medium sediment fractions in c.c. per litre needs to be multiplied by a factor of 1.4 in case the weight in grams of each of these fractions is required.

### 4.5.3 Analysis of Sediment Data

The sediment data for the monsoon months i.e. from May to October for the periods as indicated in Table 4.10 above was analyzed with respect to the corresponding runoff figures. Maximum percentage of 0.2295 was observed at DikChhu during 1993. The average percentage increases from upstream up to DikChhu and then starts reducing in downstream reaches. The yearwise variation in sediment load in also depicted in Fig 4.3.

**Table 4.11 Yearwise percentage sediment load with respect to runoff**

| Year | Chungthang | Sankalang | DikChhu | Sirwani | Khanitar |
|---|---|---|---|---|---|
| 1983 | 0.0296 | | | | |
| 1984 | 0.0203 | | | | |
| 1985 | 0.0461 | | | | |
| 1986 | 0.0168 | | 0.0181 | 0.0552 | |
| 1987 | 0.0269 | | 0.0837 | 0.1202 | |
| 1988 | 0.0137 | | 0.0746 | 0.0948 | |
| 1989 | 0.0080 | | 0.0416 | 0.0580 | |
| 1990 | 0.0181 | | 0.0559 | 0.0562 | |
| 1991 | 0.0120 | | 0.0890 | 0.0649 | |
| 1992 | 0.0139 | 0.0439 | 0.1189 | 0.0394 | |
| 1993 | 0.0324 | 0.0999 | **0.2295** | 0.0407 | |
| 1994 | 0.0269 | 0.0709 | 0.0716 | 0.0334 | |
| 1995 | 0.0439 | **0.1287** | 0.0745 | 0.0542 | 0.0675 |
| 1996 | 0.0270 | 0.0771 | 0.0851 | 0.0972 | **0.0854** |
| 1997 | 0.0342 | 0.1038 | 0.0916 | 0.1014 | 0.0152 |
| **Average** | **0.025** | **0.087** | **0.086** | **0.068** | **0.056** |

Monthwise details are given at Annexure 4.3(a) to 4.3(e) for the above sites respectively. The monthwise distribution was also studied for each site and is given at Table 4.12. It is observed that maximum silt load is carried in the month of July at four site while at Chungthang only, maximum silt was observed in the month of June, perhaps due to early rains in the upstream catchment. Minimum silt is observed in October at all the sites. The mothwise variation at all the sites are depicted at Fig. 4.4.

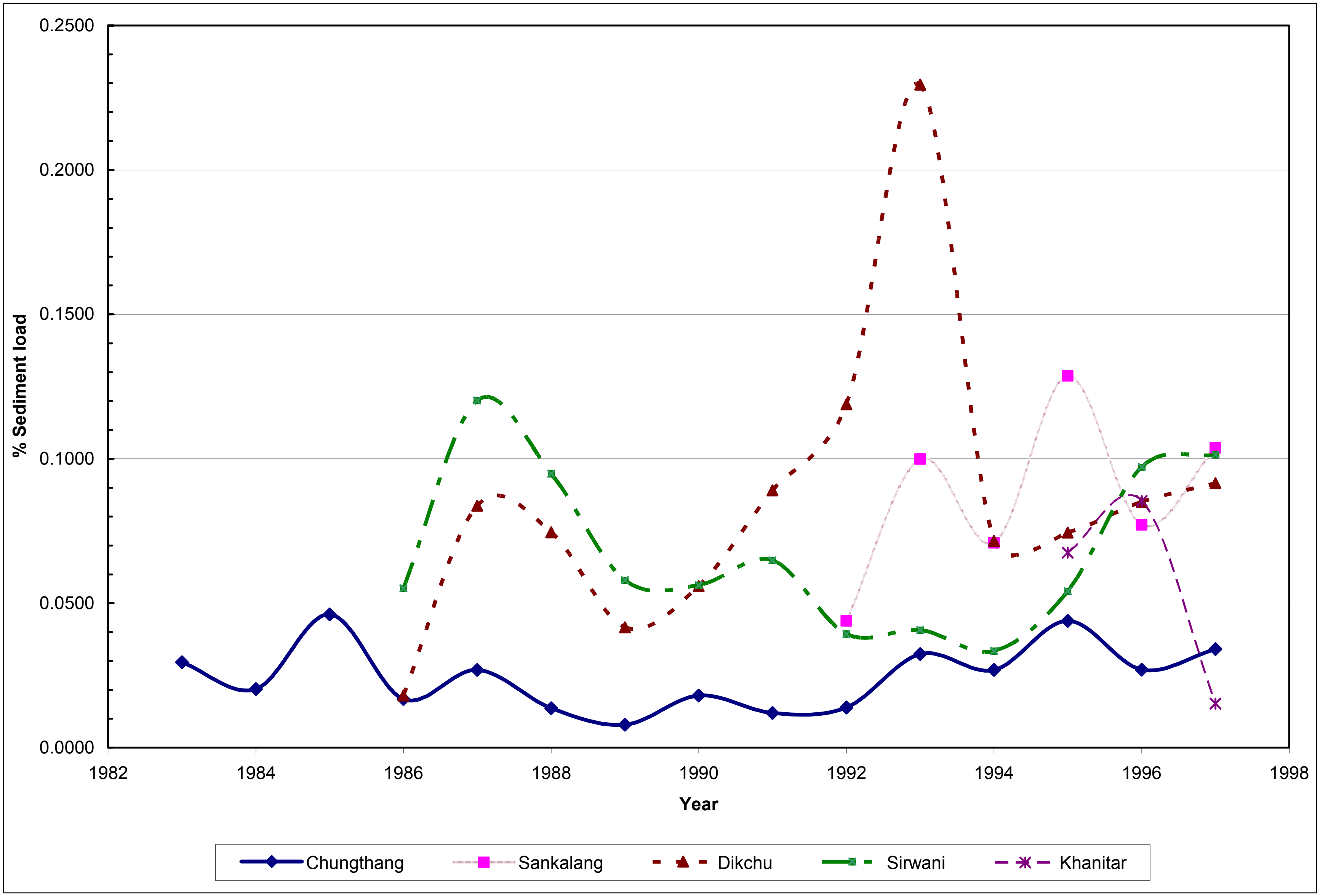



**Fig.4.3 Percentage of sediment load with respect to runoff during monsoon**

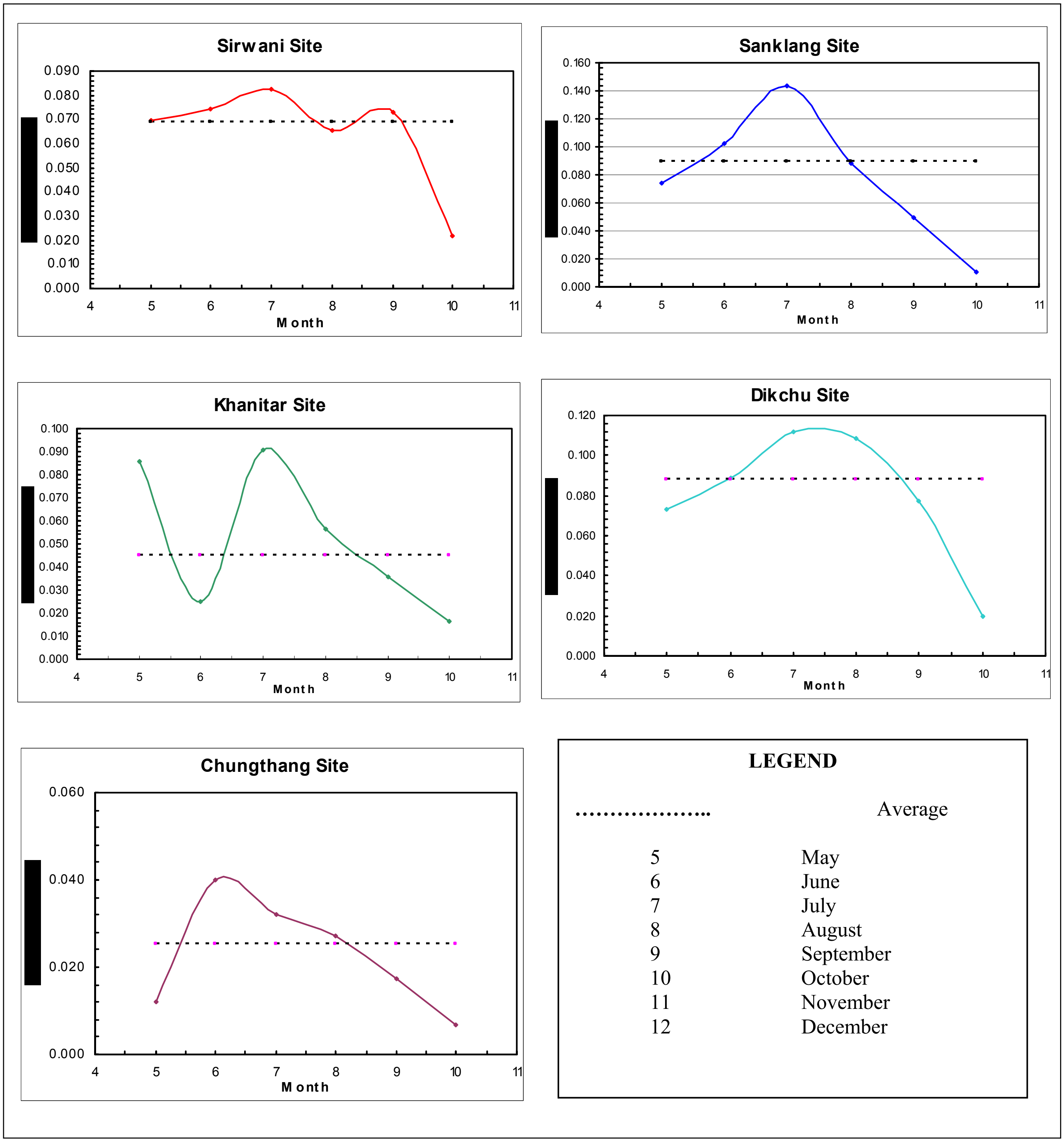



**Fig.4.4 Monthwise average percentage of sediment load with respect to runoff**

**Table 4.12 Monthwise Average percentage of sediment load with respect to runoff**

| Month | Chhungthang | Sankalang | DikChhu | Sirwani | Khanitar |
|---|---|---|---|---|---|
| May | 0.012 | 0.074 | 0.073 | 0.070 | 0.086 |
| June | 0.040 | 0.102 | 0.089 | 0.074 | 0.025 |
| July | 0.032 | 0.144 | 0.112 | 0.082 | 0.091 |
| Aug | 0.027 | 0.088 | 0.109 | 0.066 | 0.057 |
| Sept | 0.017 | 0.050 | 0.077 | 0.073 | 0.036 |
| Oct | 0.007 | 0.011 | 0.020 | 0.022 | 0.016 |

The sediment load was also analyzed with respect to catchment area up to various sites. As is evident from the Table 4.13, average sediment load increases from the upstream to the downstream sites from 0.29 to 1.53 Th cum / sq km. The contribution from Chungthang to Sankalang was maximum of the order of 1.06 Th cum / sq km while the same was very meager from DikChhu to Khanitar, of the order of only 0.02 Th cum / sq km only.

**Table 4.13 Average monsoon sediment load and runoff per sq km of catchment area**

| Sl. No. | Site | Catchment area (sq km) | Average monsoon sediment load | | Average runoff | |
|---|---|---|---|---|---|---|
| | | | Th cum | Th cum/ sq km | M cum | M cum/ sq km |
| 1. | Chhungthang | 2787 | 821.70 | 0.29 | 3241 | 1.16 |
| 2. | Sankalang | 3839 | 5184.60 | 1.35 | 5826 | 1.52 |
| 3. | DikChhu | 4260 | 6433.50 | 1.51 | 7322 | 1.72 |
| 4. | Khanitar | 4874 | 7478.10 | 1.53 | 16719 | 3.43 |

The annual silt load distribution among Coarse, Medium and Fine in terms of percentage of total silt load at all the silt observation sites was analyzed for the years 1995, 1996 and 1997. It is observed that most of the silt load is carried by the river during the monsoon period i.e. from May to October which is of the order of about 97% to 98% of annual silt load. The fine silt load is more in comparison to coarse and medium silt load for Khanitar and Sirwani silt stations. On the other hand, the silt particle distribution scenario reverses in the upper reaches of river. At these stations, the quantity of coarse silt load is generally more in comparison to medium and fine silt load. This may be due to heavy rainfall and occurrence of frequent land slides in the upstream of the river.

The Table 4.14 below gives the % of coarse, medium and fine silt load at various GD&S stations for three years i.e. 1995 to 1997.

**Table 4.14 Distribution of Coarse, Medium & Fine Sediment Load in various years at different GD&S Stations**

| Site Name | Year | Coarse Silt | Medium Silt | Fine Silt |
|---|---|---|---|---|
| Khanitar | 1995 | 24% | 23% | 53% |
| | 1996 | 32% | 24% | 44% |
| | 1997 | 14% | 24% | 62% |
| | **Average** | **23** | **24** | **53** |
| Sirwani | 1995 | 23% | 30% | 47% |
| | 1996 | 42% | 25% | 33% |
| | 1997 | 38% | 24% | 38% |

| | | | | |
|---|---|---|---|---|
| | **Average** | **34** | **26** | **39** |
| 14th Mile, | 1995 | 51% | 27% | 22% |
| Dikchu | 1996 | 44% | 31% | 25% |
| | 1997 | 47% | 28% | 25% |
| | **Average** | **47** | **29** | **24** |
| Sankalang | 1995 | 34% | 24% | 42%- |
| | 1996 | 42% | 31% | 27% |
| | 1997 | 51% | 32% | 17% |
| | **Average** | **42** | **29** | **29** |
| Chungthang | 1995 | 35% | 25% | 40% |
| | 1996 | 45% | 20% | 35% |
| | 1997 | 38% | 25% | 37% |
| | **Average** | **39** | **23** | **37** |

From the observed sediment data as indicated in Table 4.10, rate of sedimentation has been assessed at different locations and the results are summarized in Table 4.15.

**Table 4.15 Sediment Rate at various sites**

| Sl. No. | Site | Period for which data is used | No. of years | Average annual suspended silt rate (mm/year) |
|---|---|---|---|---|
| 1. | Chhungthang | 1983-92 | 10 | 0.32 |
| 2. | Sankalang | 1990-92 | 3 | 0.65 |
| 3. | DikChhu | 1992 | 1 | 0.95 |
| 4. | Sirwani | 1986-91 | 6 | 0.51 |
| 5. | Khanitar | 1995-96 | 2 | 0.42 |

The analysis of sediment data as observed at various sites in different time horizons indicates marked variation in rate of sedimentation from site to site. No specific correlation between the data at different sites could, however, be established.

In view of the above, efforts have been made to collect the silt rate as adopted in the nearby projects / rivers. The silt rate as recommended for some of the projects in the region is as given in Table 4.16.

**Table 4.16 Silt Rate recommended for nearby Projects**

| Sl. No. | Project / river | Silt rate (inclusive of bed load) in mm / year |
|---|---|---|
| 1. | Subansiri | 1.13 |
| 2. | Lohit | 1.20 |
| 3. | Puthimari | 1.40 |
| 4. | Pagladiya | 1.60 |
| 5. | Sankosh | 0.90 |
| 6. | Wang Chhu | 1.60 |

In view of the above discussion, it is considered appropriate to adopt long term average sediment rate of 1 mm/year (inclusive of bed load of about 15% of the suspended silt load) for preliminary planning purpose of Teesta hydel schemes, especially Stage-IV, V and VI.

# CHAPTER - 5
# IRRIGATION

# IRRIGATION

## 5.1 GENERAL

Sikkim falls within the high rainfall zone of the country and during the monsoon which lasts from the beginning of June to almost end of September, the state witnesses a very high precipitation practically in all its parts. While this phenomenon assures availability of water for agricultural purposes the necessity for providing water for agricultural purposes during the winter season and the need for providing water in the drier southern part of the state, underlines the urgency of having to pay specific attention to creation of irrigation potential in the state.

In the arid and semi-arid lands, the rainfall is characterised by scanty and low intensity of rainfall and at the same time of erratic distribution. Invariably these areas are frequently disturbed by the occurrence of drought. These regions have usually low humidity, high wind velocity, high light intensity and temperatures causing loss of moisture. The minimum rainfall in dry region for crop prescribed is 250 mm to 350 mm during winter and 500 mm in summer. In dry region the drier the climate greater is the variability of rainfall so much so that years of scanty rain would be followed by seasons of heavy rainfall.

The irrigation in crops other than paddy, vegetable and cardamom is limited mainly due to the danger of soil erosion. The crops like maize, wheat, barley, millets, etc. are grown in soil which are untreated, partly terraced or unleveled terrace and irrigation can not be done without the risk of soil erosion. The danger of soil erosion is limited in paddy cultivation due to well terraced bunded fields, in cardamom, due to ample vegetation including trees to arrest soil erosion and in vegetables due to small area under the crop and also irrigation is done mostly by pipes/sprinklers/manual maneuvering.

The state has large number of small streams through which water flows down the hills. In the early days maximum focus was laid down for paddy cultivation with the usage of surface water by diverting in traditional channels with the help of bamboo and *kachcha* channels. Subsequently efforts were made to improve on these by constructing *pucca* channels with appropriate technology to suit the hilly terrain to enable these to be sustainable in the long run. While this strategy has helped the creation of a number of minor surface irrigation schemes and increase in availability of water, these have not been uniformly successful as several of them have tended to make water available only during the rainy season.

As mentioned above, all the existing irrigation schemes in the state fall in the category of surface water minor irrigation diversion schemes as terrain being hilly the CCA under individual schemes are far too less than 2,000 ha which is also the minimum coverage to be achieved under medium irrigation schemes as per the national norm. Even if as per assessment, irrigation potential through major and medium schemes exist in the state so far not a single such project has been taken up for implementation. Again the status of ground water is to be assessed as yet although the general topography of the state indicates its limited scope.

## 5.2 ULTIMATE AND CREATED IRRIGATION POTENTIAL

Ultimate Irrigation Potential (UIP) through major / medium and minor irrigation schemes and the details of potential created upto VIII$^{th}$ Plan (1992-97) are given in Table 5.1.

**Table 5.1 Ultimate Irrigation Potential and Potential Created and utilized up to VIII$^{th}$ Plan (1992-97)**

| Sl. No. | Item | Major & Medium Schemes | Minor Irrigation (Surface Water) |
|---|---|---|---|
| 1. | Ultimate irrigation potential | 20 | 50 |
| 2. | Potential created up to VIII$^{th}$ Plan (1992-97) | - | 26.987 |
| 3. | Potential utilised up to VIII$^{th}$ Plan (1992-97) | - | 20.580 |

The target of irrigation potential through minor irrigation during IX Plan (1997-2002) and actual achievement during various years is given in Table 5.2.

**Table 5.2 Target of minor irrigation potential and actual achievement during IX and X Plans period**

| S. No. | Item | Irrigation Potential | |
|---|---|---|---|
| | | Creation | Utilisation |
| **1** | **Target for IX$^{th}$ Plan (1971-2002)** | **10.000** | **8.000** |
| **2.** | **Anticipated Achievement for IX$^{th}$ Plan** | | |
| | 1997-98 | 1.125 | 0.962 |

| | | | |
|---|---|---|---|
| | 1998-99 | 0.300 | 0.250 |
| | 1999-00 | 0.250 | 0.200 |
| | 2000-01 | 2.000 | 1.800 |
| | 2001-02 | 0.825 | 0.788 |
| | **Total** | **4.500** | **4.000** |
| **3.** | **Actual Achievement** | **4.308** | **3.102** |
| **4.** | **Target for X$^{th}$ Plan (2002-07)** | **4.500** | **4.000** |
| **5.** | **Anticipated Achievement** | | |
| | 2002-03 | 0.400 | 0.375 |
| | 2003-04 | 0.400 | 0.600 |

Source: Five year Plan & Annual Plan Documents of I&FC Deptt. , Govt. of Sikkim

From the Table 5.2, it may be seen that although the target for creation of potential from minor irrigation schemes was planned as 10 th ha during ninth FYP (1997- 2002), the actual achievement was only 4.30 th ha i.e. less than 50% of the target. The year wise anticipated creation of potential during Ninth FYP varies from 0.25 th ha to 2.00 th ha i.e. variation of eight times. The achievement of 2 th ha of potential in an year is significant which reflects the infrastructure capability of Irrigation Department engaged in implementation of such schemes.

It is seen from Table 5.1 that 26.987 th ha of potential was created upto 1997. During IX$^{th}$ plan (1997-2002), additional potential of 4.308 th ha was created while the anticipated potential created during 2002-03 and 2003-04 is of the order of 0.80 th ha. Thus, it is anticipated that potential of 32.10 th ha has been created up to March, 2004.

The district-wise break-up of target for X$^{th}$ FYP is also given in Table 5.3 as follows:

**Table 5.3 Districtwise break-up of target of Irrigation Potential during $X^{th}$ FYP**

(Unit: ha)

| District | Potential Creation | Potential Utilisation |
|---|---|---|
| East | 25% | 950 |
| | 1150 | |
| West | 27% | 1200 |
| | 1200 | |
| South | 28% | 1050 |
| | 1250 | |
| North | 20% | 800 |
| | 900 | |
| **Total** | **4500** | **4000** |

Source: Tenth Five Year Plan (2002-07) and Annual Plan (2003-04) I&FC Deptt. Govt. of Sikkim, Gangtok

## 5.3 FINANCIAL PERFORMANCE OF I&CAD SECTOR

The expenditure during $VIII^{th}$ and $IX^{th}$ FYP in minor irrigation, command area development (CAD) and flood control sub-sectors is given in Table 5.4.

**Table 5.4 Financial Progress upto end of Ninth FYP (1997-2002)**

**(Rs. in crore)**

| Sl. No. | Item | M.I. | CAD | Flood control | Total I & CAD |
|---|---|---|---|---|---|
| 1. | Expenditure during $VIII^{th}$ Plan | 11.17 | 0.20 | 3.07 | 14.44 |
| 2. | Approved outlay for $IX^{th}$ Plan | 10.00 | 1.00 | 30.00 | 41.00 |

| | | | | | |
|---|---|---|---|---|---|
| 3. | Antpd. exp. during IX$^{th}$ plan | | | | |
| (i) | 1997-98 | 1.55 | - | 1.09 | 2.64 |
| (ii) | 1998-99 | 0.28 | 0.02 | 3.97 | 4.27 |
| (iii) | 1999-00 | 4.94 | 0.02 | 3.00 | 7.96 |
| (iv) | 2000-01 | 3.12 | 0.05 | 4.05 | 7.22 |
| (v) | 2001-02 | 2.46 | 0.20 | 2.24 | 4.90 |
| | **Total** | **12.35** | **0.29** | **14.35** | **26.99** |

Source: Tenth Five Year Plan (2002-07) and Annual Plan (2003-04) I&FC Deptt. Govt. of Sikkim, Gangtok

Table 5.4 indicates that year-wise anticipated expenditure under M.I. sub-sector varies from Rs.0.28 crore to Rs.4.94 crore. The expenditure of Rs.4.94 crore in an year may be indicative of the capacity of I&FC Department to absorb fund into minor irrigation sub-sector. The above figure, if read in conjunction with the benefit figures in Table 5.2 indicates that the benefits from the investment in AP 1999-2000 have not accrued in same year but in the next year i.e. in AP 2000-01. Also the cost of creation of potential per ha during ninth FYP is about Rs.28,000/- which is very moderate as compared to some other North –Eastern states.

The financial targets for the Tenth FYP and its two Annual Plans are given in Table 5.5.

**Table 5.5 Financial Targets for X$^{th}$ FYP & APs**

**(Rs. in crore)**

| **Sl. No.** | **Item** | **M.I.** | **CAD** | **Flood Control** | **Total I&CAD** |
|---|---|---|---|---|---|
| 1 | X$^{th}$ FYP approved outlay | 22.97 | 0.18 | 15.64 | 38.79 |
| 2(i) | Agreed outlay for AP 2002-03 | 4.92 | 0.07 | 4.72 | 9.71 |

| | | | | | |
|---|---|---|---|---|---|
| (ii) | Antpd exp. for AP 2002-03 | 4.00 | 0.05 | 5.10 | 9.15 |
| 3 | Proposed outlay for AP 2003-04 | 4.64 | 0.20 | 6.00 | 10.84 |

Physical achievement of potential creation of about 4 to 4.5 th ha during five year plan period through minor surface irrigation indicates that with this rate of progress, the state may take above five FYPs to achieve the ultimate stage of creation of potential.

As per the available information, the state has implemented one scheme of lift and sprinkler system on pilot basis at Maming Rangpo and the people are taking advantage from the same to grow vegetable, maize and ginger. Scheme after completion was handed over to the local Panchayat for its operation and maintenance. In some dry areas, the concept of water harvesting has been introduced by providing tanks. In Bermiok Tokal area, such scheme is in operation bringing good results in cultivation of vegetables. Scheme for CADP has been introduced in Manpur, South Sikkim and others are in advanced stage of Planning & Investigation. It is suggested that more impetus may be given to such schemes involving lift and water harvesting with people's participation to expedite the development of irrigation potential.

## 5.4 CENSUS OF MINOR IRRIGATION (1995-96)

According to the norm introduced by the Planning Commission in the Year 1978-79, surface irrigation schemes, having culturable command area (CCA) upto 2000 hectare and all ground water schemes, are classified as minor irrigation schemes. According to an analysis conducted in the Planning Commission for the year 1992-94, cost of creation of irrigation potential through minor irrigation schemes is Rs.12,730 per ha only, against the cost per hectare through major and medium irrigation schemes being as high as Rs.78,630. The minor irrigation schemes being less capital intensive have less gestation period and give higher irrigation efficiency due to smaller conveyance and distribution system as compared to major and medium irrigation schemes.

Minor irrigation schemes include surface flow irrigated schemes, lift irrigation schemes, ground water irrigation schemes, small storage schemes. Storage schemes include tanks and reservoirs which impound water of streams and rivers for various uses. Small storage tanks which are called ponds or *bundhis* are also covered in minor irrigation.

Sikkim being a hilly state has mainly got only the surface flow minor irrigation schemes. Apart from this, there are few lift irrigation schemes also in the state where water is available to serve the intended purpose. There is no scope of deep wells, private shallow tube wells and public wells etc. in the state. Also no major and medium irrigation schemes have been planned or executed in the state so far.

Construction of various new schemes and renovation works are being taken up in each Five Year Plan period through several agencies/ co-operatives/ individuals either through plan financing, own saving, loans, Govt. subsidy and loans etc. The potential created and utilised by the concerned private channels were not fully accounted for earlier. Hence, Govt. of India during seventh plan initiated a fully funded centrally sponsored scheme for census of all types of MI Schemes by concerned departments in the states by cent percent enumeration on ground and their due accounting. This census covers various aspects related to all MI schemes in the state like, ownership of scheme, land holding size of farmers, social status, year of commissioning, type of schemes, status of its use, source of finance, CCA, gross potential created and area irrigated, etc.

As far as state level figures are concerned, there are total of 854 number of schemes, out of which 766 are fully operational covering a CCA of 17,017 ha. The total length of existing channels is 658.4 km. About 10% schemes are not in use at the state level. East district has maximum number of MI schemes numbering 348 with a gross potential created of 8383 ha followed by south district with 239 schemes and gross potential creation of 5,449 ha. A consolidated statement indicating the status of schemes showing the position at the state level and in four districts is given in Table 5.6.

**Table - 5.6 Status of M.I. schemes with some salient details - Census (1995-96)**

| Sr. No. | Item | Sikkim State | North District | East District | South District | West District |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **A** | **Total no. of Scheme (Nos)** | | | | | |
| | 1. Govt. owned | 615 | 51 | 334 | 78 | 152 |
| | 2. Co operative owned | 0 | 0 | 0 | 0 | 0 |
| | 3. Panchayat owned | 1 | 0 | 0 | 1 | 0 |
| | 4. Group of Farmers | 235 | 0 | 14 | 158 | 63 |
| | 5. Individual Farmers | 0 | 0 | 0 | 0 | 0 |
| | 6. Others | 3 | 0 | 0 | 2 | 1 |
| | **Total** | **854** | **51** | **348** | **239** | **216** |
| **B** | **Size of ownership (Nos)** | | | | | |
| | 1. Marginal Farmers | 227 | 0 | 6 | 47 | 174 |
| | 2. Small Farmers | 198 | 6 | 54 | 122 | 16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3. Medium Farmers | 216 | 35 | 133 | 47 | 1 |
| | 4. Big Farmers | 213 | 10 | 155 | 23 | 25 |
| | **Total** | **854** | 51 | **348** | **239** | **216** |
| **C** | **Social Status (Nos)** | | | | | |
| | 1. Scheduled Cast | 176 | 0 | 99 | 1 | 76 |
| | 2. Scheduled Tribes | 311 | 47 | 135 | 30 | 99 |
| | 3. Others | 367 | 4 | 114 | 208 | 41 |
| | **Total** | **854** | **51** | **348** | **239** | **216** |
| **D** | **Status of Scheme (Nos)** | | | | | |
| | 1. In Use | 766 | 48 | 333 | 211 | 174 |
| | 2. Not in Use | 79 | 3 | 12 | 25 | 39 |
| | 3. Permanently | 2 | 0 | 0 | 0 | 2 |
| | 4. Permanently dried up | 0 | 0 | 0 | 0 | 0 |
| | 5. Destroyed beyond repair | 4 | 0 | 2 | 2 | 0 |
| | 6. Permanently Destroyed | 3 | 0 | 1 | 1 | 1 |
| | **Total** | **854** | **51** | **348** | **239** | **216** |
| **E** | **Type of Scheme (Nos)** | | | | | |
| | 1. Storage Scheme | 34 | 0 | 31 | 0 | 3 |
| | 2. Permanent Diversion | 390 | 49 | 282 | 47 | 12 |
| | 3. Temporary Diversion | 430 | 2 | 35 | 192 | 201 |
| | 4. Conserv/Ground Water | 0 | 0 | 0 | 0 | 0 |
| | **Total** | **854** | **51** | **348** | **239** | **216** |
| **F** | **Source of Finance (Nos)** | | | | | |
| | 1. Govt. Funds | 613 | 51 | 334 | 82 | 146 |
| | 2. Own savings | 198 | 0 | 13 | 116 | 69 |
| | 3. Loan & saving | 0 | 0 | 0 | 0 | 0 |
| | 4. Govt.Subsidy & Loan | 5 | 0 | 1 | 3 | 1 |
| | 5. Govt.Subsidy only | 0 | 0 | 0 | 0 | 0 |
| | 6. Others | 38 | 0 | 0 | 38 | 0 |
| | **Total** | **854** | **51** | **348** | **239** | **216** |
| **G** | **Culturable Command Area (ha)** | **17106** | **1361** | **7727.29** | **4371.25** | **3647.58** |
| **H** | **Length of Channels (km)** | | | | | |
| | 1. Pucca | 380.77 | 45.55 | 121.2 | 88.92 | 125.1 |
| | 2. Kuccha | 222.49 | 5.13 | 33.28 | 118.61 | 65.47 |
| | 3. Underground | 58.12 | 5.86 | 23.74 | 1.7 | 21.82 |
| | **Total** | **661.38** | **56.54** | **178.22** | **209.23** | **212.39** |
| **I** | **Constraints (Nos)** | | | | | |
| | 1. Storage not filled up fully | 0 | 0 | 0 | 0 | 0 |
| | 2. Siltation of storage tank | 9 | 0 | 9 | 0 | 0 |
| | 3. Break down of Channels | 407 | 48 | 256 | 97 | 6 |
| | 4. Others | 438 | 3 | 83 | 142 | 210 |
| | **Total** | | **51** | **348** | **239** | **216** |
| **J** | **Gross potential created (ha)** | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 1. Kharif | 11541 | 980 | 4713 | 3354 | 2493 |
| | 2. Rabi | 5826 | 560 | 2332 | 1617 | 1318 |
| | 3. Perenial | 1795 | 132 | 828 | 293 | 542 |
| | 4. Others | 848 | 54 | 510 | 185 | 99 |
| | **Total** | **20010** | **1726** | **8383** | **5449** | **4452** |
| **K** | **Area Irrigated During 1993-94(ha)** | | | | | |
| | 1. Kharif | 7109 | 434 | 3606 | 1918 | 1152 |
| | 2. Rabi | 3641 | 236 | 1706 | 1017 | 682 |
| | 3. Perenial | 1227 | 70 | 647 | 223 | 287 |
| | 4. Others | 516 | 55 | 299 | 115 | 48 |
| | **Total** | **12493** | **795** | **6258** | **3272** | **2168** |

## 5.5 MASTER PLAN FOR IRRIGATION DEVELOPMENT IN SIKKIM

Agriculture although crucial to the economy of the state has primarily remained rainfed and mono-cropped so far with the cultivable area being only about 15%, of the geographical area and that too with difficult hilly terrain with no plain land and diverse agro-climate conditions. Land resource already is a serious handicap. On the other hand, the average annual rainfall is relatively high varying from 2300 mm to 3500 mm but quite substantial part of it is available from June to September and the remaining part of the year is more or less dry. Due to the above lopsided rainfall condition, only one season crops during kharif are grown. Even kharif crops face moisture stress in critical growth stages in several parts of the state due to lack of facilities for harnessing the available water resources. The state is yet to achieve self-sufficiency in food production. This situation makes imperative intervention in water resources availability regime to augment agriculture production. With this back drop, the Irrigation and PHE Department of the state entrusted the task of preparation of 'Master Plan for Irrigation Development' to the

Agriculture Finance Corporation Ltd., New Delhi which had submitted its report in the year 1995.

This Master Plan envisages following components for implementation at an estimated cost of Rs.8,300 lakh in a time span of 10 years. It includes 436 new MI schemes involving CCA of 24,549 ha, 419 schemes of rehabilitation and renovation covering 12112 ha and 30 sprinkler and drip irrigation schemes under lift irrigation programme with 600 ha CCA, i.e. a total of 885 schemes with 37261 ha of CCA. Details of these schemes are given in Table 5.7

**Table 5.7 Details of new M.I. schemes and schemes needing restoration/ improvement as per Master Plan 1995**

| Sl No | Item | No | Command ( ha) | Estimated Cost (Rs. in lakhs) |
|---|---|---|---|---|
| 1. | Construction of new MI schemes | 436 | 24549 | 5834.00 |
| 2. | Improvement of existing schemes | 50 | 1000 | 145.47 |
| 3. | Rehabilitation of Defunct schemes | 119 | 4408 | 608.51 |
| 4. | Rehabilitation of partially functioning schemes | 105 | 2454* | 80.00 |
| 5. | Special repair to fully functioning schemes | 145 | 4250 | 168.00 |
| 6. | Sprinkler & drip irrigation under Lift Irrigation Programme | 30 | 600 | 270.00 |
| | **Total** | **885** | **37261** | **7105.98** |

Note: Additional benefit to the tune of only half of the total CCA i.e. 2454 ha is envisaged

District-wise break up of above schemes is given in Table 5.8.

**Table 5.8 District-wise break-up of schemes in the Master Plan**

| Sl. No. | District | New schemes | | Defunct schemes | | Partially funding schemes | | Special repair | | Improve-ment | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No | ha | No | ha | no | ha | no | ha | no | ha |
| 1. | East | 113 | 5145 | 61 | 2117 | 44 | 1917 | | | 24 | |
| 2. | North | 120 | 5094 | | | 24 | 936 | | | 5 | |
| 3. | South | 62 | 6695 | 18 | 997 | 9 | 804 | | | 7 | |
| 4. | West | 141 | 7615 | 40 | 1294 | 28 | 1251 | | | 14 | |
| | **Sub-total** | **436** | **24549** | **119** | **4408** | **105** | **4908*** | **145** | **4250** | **50** | **1000** |
| Sprinkler & drip | | 30 | 600 | | | | | | | | |
| | **Total** | **466** | **25149** | **119** | **4408** | **105** | **4908** | **145** | **4250** | **50** | **1000** |

The cost of schemes included in the Master Plan has been assessed on pro-rata basis by actually investigating and designing some sample schemes in each district. The cost varies from Rs.20,000 per ha in East and West districts to Rs.25,000 per ha in North and Rs.30,000 per ha in the South district.

Thus this Master Plan is only indicative in nature and does not project the realistic scenario likely to emerge in the state. In this situation, for water resource development of the state in an integrated manner, detailed survey and investigation of viable schemes and their techno-economic appraisal has to be done and Detailed Project Report (DPR) of each and every scheme has to be prepared before these may be taken for implementation.

## 5.6 PRESENT STATUS OF MINOR IRRIGATION SCHEMES

Subsequent to the census of minor irrigation in 1995-96 which include the status only upto 1993-94, a number of additional schemes have been considered during subsequent years. The number and cost of these schemes is given in Table 5.9.

**Table 5.9 Number of minor irrigation schemes**

| Year | No. of Schemes | Length of Channels (km) | Cost (Rs. Lakh) |
|---|---|---|---|
| Upto 1993-94 | 854 | 856.37 | NA |
| 1994-95 | 1 | 1.50 | NA |
| 1995-96 | 7 | 12.00 | NA |
| 1996-97 | 25 | 32.00 | 105 |
| 1997-98 | 21 | 11.78 | 214 |
| 1998-99 | 4 | 3.22 | 150 |
| 1999-2000 | 14 | 10.23 | 590 |
| 2000-01 | 150 | 20.15 | 360 |
| 2001-02 | 38 | 9.38 | 390 |
| 2002-03 | 62 | 15.75 | 150 |
| **Total** | **1176** | **972.38** | |

It is seen from the above Table that a total of 1176 schemes have been constructed up to 2003 with a total length of channels as 972.38 km.

The status of 1044 schemes as per the records available with Irrigation Department is abstracted in Table 5.10.

**Table 5.10 Status of minor irrigation Schemes**

| Sl. No. | District/Division | No. of Functional schemes | No. of defunct schemes | Total |
|---|---|---|---|---|
| 1. | North | 62 | 21 | 83 |
| 2. | East | 381 | 40 | 421 |
| 3. | South | 185 | 92 | 277 |
| 4. | Soreng and Gaylsing Sub-division | 173 | 90 | 263 |
| | **Total** | **801** | **243** | **1044** |

It is seen from the above Table that only 801 schemes (77%) out of 1044 are functioning and the rest of the schemes (23%) are defunct for one reason or the other. East district has maximum number of functional schemes (90%). The district/ division-wise details of above schemes are given at Annexures 5.1 to 5.4 for north, east, south districts and Soreng and Gyalsing sub-division respectively.

Out of the above, 53 schemes in north-east division and 47 schemes under south-west division have been proposed to be taken up under centrally sponsored Accelerated Irrigation Benefit Programme (AIBP) for the year 2003-04 for the amount of Rs.85.60 lakh and Rs.114.40 lakh respectively. The details of these schemes are given in Annexures 5.5 and 5.6 respectively.

## 5.7 ORGANISATIONAL STRUCTURE

Specific attention to development of irrigation sector was given only from 1976 when a separate Department of Irrigation was created as an attachment to Department of Power. This was done keeping in view the organisational requirement for constructing multi-purpose irrigation schemes. Though the minor irrigation development was the responsibility of the Panchayat and Rural Works Department till 1986, the Department of Irrigation was given specific mandate of looking after minor irrigation. Subsequently, the Department of Irrigation and Flood Control was entrusted with the responsibilities as per allocation of Business Rule 1994 with the objective to shoulder following responsibilities:

- Development of water resources
- Construction of irrigation works
- Maintenance of Govt. irrigation works
- Water management and water conservation as a nodal department for clearance of schemes relating to river or reservoir.
- Assessment of irrigation and irrigation development
- Flood control and anti-erosion works including management and control of drainage and *Jhora* training.

The organisational set-up of I&FC Deptt. showing the disposition of technical manpower is given at Annexure 5.7.

From this it is seen that the I&FC department has one officer of the Chief Engineer level, one Additional Chief Engineer, two Superintending Engineers with four working Divisions, and nine sub-Divisions. The establishment cost of the Department had been about Rs.200.00 lakh annually.

# CHAPTER - 6

# LAND RESOURCE MANAGEMENT

# LAND RESOURCE MANAGEMENT

## 6.1 GENERAL

The importance of land resource for the State has already been described in earlier Chapters. It is an enduring asset since it is passed from generation to generation in a family/society. This asset to some extent, is also considered as a measure of economy and social stability in the society. Even if all types of diversification are taking place rural areas have predominantly agrarian economy and hence land resource apart from water need due management. In this context, it is also natural, therefore, that the availability of land, and its use pattern in agriculture would remain issue of extreme importance to the policy planners in the state.

It the context of land resource, it is also to be kept in mind that degraded land and "waste land" may not be mixed up with each other, although in true sense it is difficult to clearly distinguish between the two types in a given area. Accordingly to a general estimate, about half of the total available land area in the country is suffering from degradation of some form or the other in the hills which may hold good for the state of Sikkim also. Even if this is an over estimate for the state it could be regarded as flagging the seriousness of the issue since the topography of the state is entirely hilly with no plain land and only about 3% of the land of capability-II. Going by specific agrarian features of the state including declining land-man ratio, rural poverty and highly iniquitous land distribution, the land degradation problem assumes serious dimensions. However in this chapter, the given land use classification as given in Table 6.1 is being considered in detail and implication of inter-changeability of some of the categories would the discussed.

## 6.2 LAND USE PATTERN

Land resources being scarce in the state, land use pattern of the available resource is of utmost importance. The land use classification of the state of Sikkim as in 1995-96 is given in Table 6.1.

**Table 6.1 Land Utilisation Statistics (1995 – 96)**

| Sl. No. | Type of Land | Area in th ha |
|---|---|---|
| 1. | Geographical area | 709.60 |
| 2. | Reporting area for land utilisation statistics | 172.09 |
| 3. | Forest | 50.71 |
| 4. | Area not available for cultivation | 12.49 |
| 5. | Other uncultivated land excluding fallow land | 12.20 |
| 6. | Total fallow land | 34.65 |
| 7. | Net area sown (2-3-4-5-6) | 62.04 |
| 8. | Total cultivable area (2-3-4) | 108.89 |

*Source: Land utilisation statistics of Sikkim, Govt. of Sikkim, Tadong (Feb, 1996*)

Sikkim being located in Eastern Himalayan has a major chunk of its area under the snowy mountain ranges, including dense forests, the National Parks and the restricted area for defense purpose. Hence out of total geographical area of 709.60 th ha, nearly 75% of the area - around 46% under the snow-clad ranges and about 29% under the dense forests - has not been taken in the survey of land utilization. Reporting area for land utilisation statistics has been of the order of 172.09 th ha i.e. 24.58% of the total geographical area of Sikkim. The total arable land (the net sown area plus the current fallow and other fallow) is estimated to be 96.69 th ha i.e. 56.2% of the total reporting area. Around 50.71 th ha is under forests constituting 29.46% of the reporting area. Land put to non-agriculture uses is 2.61 th ha or 1.53%, barren and uncultivable land 9.89 th ha i.e. 5.75%, permanent pastures and other grazing land 4.37 th ha i.e. 2.54%, Land under miscellaneous tree crops and groves constitute 5.67 th ha or 3.30% and cultivable waste land is 2.39 th ha or 1.39% of the total reporting area.

From the Table 6.1, it is also observed that net sown area presently in the state is only 62.04 th ha which is 8.74 percent of the geographical area and 36 percent of the reporting area. The net sown area so arrived is total reporting area minus the area under forests, area not available for cultivation, other uncultivated land excluding fallow land and total fallow land. Total cultivable land is total reporting area minus forest and area not available for cultivation.

The details of total cultivable area in 1980-81, 1990-91 and 1995-96 are given in Table 6.2.

**Table 6.2 Cultivable Area in 1980-81, 1990-91 and 1995-96**

**Unit : th ha**

| **Sl. No.** | **Particulars** | **1980-81** | **1990-91** | **1995-96** |
|---|---|---|---|---|
| 1. | Net sown area | 78.38 | 63.25 | 62.04 |
| 2. | Fallow Land | | | |
| | (i) current fallow | 4.43 | 3.91 | 5.08 |
| | (ii) other than current fallow | 9.47 | 9.20 | 29.57 |
| | **Total fallow land** | 13.90 | 13.11 | 34.65 |

| | | | | |
|---|---|---|---|---|
| 3. | Other uncultivated area excluding fallow land | 4.56 | 10.83 | 12.20** |
| 4. | Cultivable wasteland | 0.68 | 9.81 | 2.39@ |
| 5. | **Total cultivable area** | **97.52** | **97.00** | **108.89** |
| 6. | Land not available for cultivation | 11.60 | 14.30 | 12.49 |
| 7. | **Total operated land** | **109.12** | **111.30** | **121.38** |

** includes cultivable waste land of 2.39 ha
@ included in 'other uncultivated area

Source for 1995-96 figure: Land utilisation statistics of Sikkim Department of Agriculture, February, 1996 (P/3)

Source for other figures: Sikkim Human Development Report 2001, Govt. of Sikkim in Table 3.1.

**Note:**
1) 'Other uncultivated area excluding fallow land' includes permanent pastures and other grazing land plus land under miscellaneous tree crops and groves, not included in net sown area and cultivable wasteland.

2) 'Land not available for cultivation' includes area under non-agriculture uses plus barren and uncultivable land.

The above Table shows that due to increase in 'cultivable wasteland' and 'land not available for cultivation', the net area sown has gone down from 78.38 th ha to 63.25 th ha within ten years from 1980-81 to 1990-91. In the year 1995-96, there appears to be abnormal increase in the 'fallow land other than current fallow'.

The cultivation is done in sloping topography with or without proper bench terracing. As per an estimate, except the paddy fields, more than 50% of other lands are either improperly terraced or unterraced. Per capita availability of net cultivable area has also recorded a sharp decline from 0.31 ha in 1971 to 0.27 ha in 1981 and 0.17 ha in 1991.

The status of districtwise cultivable area during 1995-96 is given in the Table 6.3.

**Table 6.3 District-wise cultivable area (1995-96)**

| District | Geographical area (GA) (th ha) | Cultivable area (CA) (th ha) | % of GA | % share in CA |
|---|---|---|---|---|
| North | 422.60 | 17.49 | 4.14 | 16.00 |
| East | 95.40 | 28.99 | 30.38 | 26.62 |
| South | 75.00 | 29.92 | 39.90 | 27.50 |
| West | 116.60 | 32.49 | 27.89 | 29.88 |
| **Total** | **709.60** | **108.89** | **15.34** | **100.00** |

Source : Land Utilisation Statistics of Sikkim ( Feb,1996 )

The above Table in respect of 1995-96 shows that cultivable area in the state is limited to 15.34% of the geographical area with only 4.14% in the North district. Less than 3 % of the land has been classified as the land of capability Class-II in the state.

## 6.3 TEMPORAL TREND OF LAND USE IN THE STATE

Like other states in the country, agriculture in the state of Sikkim has developed over time as a mixture of “land extensive” and “land intensive” process of production, although data in support of this is not available. Probably, after merger of this state in the Union of India in 1975, the net sown area might have been stretched to a reasonable limit till 1980-81. After this, it appears that fresh area could hardly be brought under cultivation. Thus an objective look to all other categories of land use appears pertinent in this regard. “Areas not available for cultivation” consists of (i) barren and uncultivable land and (ii) land put to non-agricultural uses. Absolutely barren and uncultivable land like mountains etc can not be brought under agriculture and if at all it is possible, the cost may be prohibitive. Land covered by buildings, roads, water bodies etc or otherwise appropriated for non-agricultural uses makes up (ii) above. Although long range temporal variation figure for the state is not available but as a general trend in other states, barren and uncultivable land decline marginally while land put to non-agricultural uses go up steadily over time. Even the area under category (i) is partly utilized by category and (ii) which is quite natural for provision of socio-economic infrastructure in an expanding economy.

Permanent pastures and other grazing lands and lands under miscellaneous tree crops and groves normally witness decline, the reason being that trees are cut and groves cleared to meet the immediate fuel and fodder needs of the rural poor as also to satisfy the commercial interests of forests lessees etc. But the land cover under t6tree crops and groves is an important component of agricultural health of rural areas which need to be kept in view, if it has declining trend.

The data is respect to ‘cultural waste land’ over a period of time does not show any relation with each other. As indicated in Table 6.2, it varies from 0.68 th ha in 1980-81 to 9.80 th ha in 1990-91 and again it gets reduced to 2.39 th ha in 1995-96. If it is considered *vis-a-vis* total fallow land in the state, it is quite sizable.

Total fallow land in the state is reported to be 34.65 th ha during 1995-96,out of which 5.08 th ha is under current fallow and 29.57 th ha is other fallow land. The figures in Table 6.2 reveal that other fallow land of the order of 29.57 th ha in 1995-96, i.e. 47.67% of the NSA, is quite high. The share of this category has drastically increased from 9.47 th ha (12% of NSA) in 1980-81 to 29.57 th ha (48% of NSA).This is the land which was taken up for cultivation but is temporarily out of cultivation for a period not less that one year and not more than five years.. The reasons for this state of affairs may be poverty, inadequate supply of water, unfavorable climate including spread of malaria, damage of irrigation channels and unremunerative nature of farming etc. In this situation, it can only be said at this stage that the above figure of ‘other fallow land’ is abnormally high especially when majority of the above reasons are manageable. However, the status may be amply clear, if detailed verification of the area and specific contributory reasons are identified which itself may entail the management strategy to be followed for this category of land. But one thing is clear that total fallow land may be a target area for the state.

## 6.4 DISTRICT-WISE STATUS OF FALLOW LAND

Table 6.4 depicts a district-wise land use status.

**Table 6.4 District-wise distribution of fallow land (1995-96)**

| Districts | North | East | West | South | State Total |
|---|---|---|---|---|---|
| Cultivable Area | 17.49 | 28.99 | 32.49 | 29.92 | 108.89 |
| Net sown area (NSA) | 9.74 | 18.12 | 16.63 | 17.55 | 62.04 |

| | | | | | |
|---|---|---|---|---|---|
| Total Fallow land | 5.60 (57.5% of NSA) | 7.85 (43.3%) | 12.24 (73.6%) | 8.96 (51%) | 34.65 (55.8%) |
| Current fallow | 1.70 | 0.31 | 2.14 | 0.92 | 5.07 |
| Fallow lands Other than Current fallow | 3.89 | 7.54 | 10.09 | 8.05 | 29.57 |

Source: Land utilisation statistics of Sikkim (Feb, 1996)

The district-wise data as above shows that west district has total fallow land as high as 73.6% of NSA which is alarmingly high. Two more district i.e. north and south also have over 50% of total fallow land which also is quite substantial.

## 6.5 LAND RESOURCE MANAGEMENT STRATEGY

Generally two types of wasteland i.e. culturable waste land (CWL) and barren and un-culturable land (BUL) are found - either unproductive or partially productive in the present day context. If both these categories of land dealt as per their potential end use and fallow land clubbed with CWL, probably this may bring out a revealing figure. As is known, decline in CWL may add to area already under plough (NSA) or to potentially ploughable area (NSA+fallows). The decline in BUL may not serve the same purpose. At best, it may promote some afforestation effort including social forestry or may pave the way for some kind of non-agricultural uses etc. Hence NSA alone or in combination with fallows is the natural choice for CWL while forest area and land under non-agricultural uses are the end uses for any part of reclaimed land against the existing BUL.

CWL is a fairly big proportion of NSA if seen in the above perspective and thus it may be interpreted that a substantially high proportion of cultivable area is still lost of agriculture which may be helpful in boosting land-man ratios, in equitable land distribution, absence of buoyant avenues of non-agricultural employment and earnings etc. This loss of land to agriculture is a loss of the most precious State Resource. Even if the state is able to meet even partly say half of the total land (34.65 th ha of total follows land + 9.89 th ha of barren and unculturable land + 2.39 th ha of culturable waste land =46.93 th ha) i.e. say 23.50 th ha and make it culturable, then this would be able to raise the NSA by over one third of the existing value.

The possible use of CWL may be net sown area (NSA), fallow lands (FA) and land devoted to miscellaneous tree crops and groves, perhaps for all the districts of the State in that order. Similarly the possible uses for BUL could be area under forests (FA), area under non-agricultural uses (NAV) and permanent pastures and other grazing lands. This may not be uniformly applicable to all the districts but definitely expansion of forest area and non-agricultural activities would assume higher significance than increase in pastures and grazing lands.

In regard to the land classification data, it is to point out that the above classification is available on year-to-year basis according to village papers and is based on returns of the area prepared by village staff for revenue purpose in the districts. According to this classification, the total area reported in village papers is split into the following four major categories:

(i) Land not available for cultivation, comprising area under forests, land put to non-agricultural uses and barren and uncultivated lands.

(ii) Other uncultivated land, consisting of permanent pastures and other grazing lands, lands under miscellaneous tree crops and groves and culturable waste land.

(iii) Fallow lands not included in (ii) above comprising current fallows and other fallows, and

(iv) Net sown area.

The revenue records at the village level have their own shortcomings and can not always be relied upon especially in areas of land holding structures, cropping pattern and common village lands etc. Sometimes possibility of interchangeability between “old fallows” and “cultivable Waste Land” can not be ruled out. Same is the case with “Permanent pastures” and “land under “tree crops and groves”, at least in some areas at some point of time may also be a possibility. Also there is no scientific rationale explicitly distinguishing “Waste Land” out of total land available “Culturable Waste Land” includes lands available for cultivation whether not taken up for cultivation or taken up once but not cultivated during current year and the last five years or more in succession for one reason or the other. Such lands may be either fallow covered with shrubs and Jungles which are not of any use.

They may be assessed or unassessed and may lie in isolated blocks or within cultivated holdings. In such situation, there is always some possibility of mixing up culturable waste land with fallow lands other than current fallows. Over and above, what is included under each category of land use is also a matter of judgement by a village revenue worker. Due to above reason, assessment, of various categories of land use by different agencies vary widely.

## 6.6 PAST AND PRESENT EFFORTS ON LANDUSE MANAGEMENT

A number of schemes/ programmes have been launched by various Central Govt. Organizations for effective landuse management in the country. Some of these programmes are described as follows:

(i) National Commission on India Agricultural (NCIA-1976): The most striking feature of this was to engage Government's attention to Social Forestry which in some way is still on-going.

(ii) National Waste Land Development Board (NWDB - May 1985): Principal aim was to reclaim Waste Lands through a massive programme of afforestation.

(iii) Department of Waste Land Development (DWD): Integrated Waste Land Development Projects (IVDP) solemn was launched in 1989 in which land use capability were to be developed. The project compound included soil and moisture conservation, small scale engineering structures and vegetative measure like gully-plugging, check-dams, water-harvesting structures, terracing, bunding, trenching, vegetative barriers etc.

(iv) Deptt. of Agriculture and Co-operation (MOAC) - MOAC has a number of schemes directly or indirectly connected with development of waste land as follows:-

(a) Scheme of soil conservation in the catchment of RPV Projects.

(b) Integrated Watershed Management in the catchment of flood prone rivers.

(c) Reclamation of Special Problem Areas and Improvement of Productivity.

(d) Scheme of Watershed Management for shifting cultivation Area in N-E Region.

(e) National Watershed Development Projects for rainfed area.

(v) Ministry of Environment and Forest (MOEF) - The MOEF regulates the following scheme for Improvement of degraded forest lands:

1) Integrated Afforestation and Eco-Development Project
2) Fuel wood and Fodder Project
3) Non-Timber Forest Scheme
4) Grant-in-Aid Scheme
5) Aerial Seeding Scheme
6) Eco-Task Force.

(vi) Department of Poverty Alleviation and Rural Employment (DPARE)- DPARE tackles Waste Land development under "Draught Prone Area Programme"

(vii) Planning Commission: Hill Area Development Program (HADP)

(viii) NABARD - NABARD is also playing an important role in promoting a few major Waste Land development schemes under Farm-Forestry or Agro-Forestry Scheme.

## 6.7 SOIL CONSERVATION

Soil and water are two of the most important natural resources which are vital for the existence of life. As water flows down to stream channels during heavy rainfall, it carries with it the top productive cover of the soil profile causing soil erosion. The factors influencing the extent of soil erosion are climate, topography, physical and chemical characteristics of the soil and the vegetal cover. The abundance of vegetation can provide an effective protective cover against erosion caused both by water and wind. Thus, for preventing the damage of the land due to erosion, we must conserve the soil. Soil conservation aims at using the natural resources of soil and water to the best possible advantage so as to maintain and ensure ever-increasing productivity. It would not only facilitate prevention of siltation of reservoirs but also helps in creating conditions conducive to improvement of soil productivity.

Due to excessive and uncontrolled grazing and illegal felling of trees for meeting the local demand of fuel wood and timber, the forest area are subject to varying degrees of erosion resulting in loss of productive soil. The measures needed to be taken for improving the vegetative cover of the area would go a long way to ameliorate the problem of soil erosion as well.

Apart from the denuded areas in the forests, portion of the areas under the categories 'not available for cultivation' (12.49 th ha), 'fallow land' (34.65 th ha) and culturable wastes (2.39 th ha) may also constitute the land subject to soil erosion. In the case of 12.49 th ha of area ‘not available for cultivation’, some lands which are not under occupation of buildings, roads and railways etc. may be brought under soil conservation measures. Though no firm estimate of the extent of this area is available, it can be placed at about 1.6 th ha (10-15%) which would require soi1 conservation measures. Thus, of the total area of 49.53 th ha, about 16.38 th ha (14.78 + 1.60) needs to be protected from the vagaries of wind and water erosion in the state. Among the cultivated lands, irrigated areas which are generally leveled and bunded properly are subject to minimal soil erosion. But the rainfed area under crops other than paddy are likely to suffer from soil erosion to some extent. Out of the 76.82 th ha of net sown area projected for the year 2025, the gross irrigated area would be about 70 th ha, thus leaving 6.82 th ha of net sown area under rainfed cultivation.

Thus, it is seen that about 16.38 th ha of area under culturable waste and other waste land, fallows and pastures etc., and a portion of about 6.82 th ha of cultivated lands under rainfed conditions require soil conservation measures. However, it does not mean that all this area will need treatment. Normally, based on satellite imagery and field surveys, critical areas needing treatment are determined and their respective priorities are decided depending upon the severity of the problem.

The strategy for soil and water conservation has gradually evolved in the past three decades into integrated water-shed management plan which aims at articulation of production programmes and conservation measures to enhance aggregate returns from land in terms of agricultural and allied products and to increase employment opportunities to the farming families. Physical soil conservation works are being taken up under centrally sponsored schemes of soil conservation in the catchments of River Valley Projects (RVP) Schemes and Integrated Watershed Management (IWM) Schemes in the catchments of flood prone rivers. Soil conservation in the catchments of River Valley Projects is in operation in 28 river catchments in the country, out of which 8 catchments lie in the Ganga basin. The programme under this scheme consists of (i) identification and selection of priority watersheds; (ii) preparation of watershed management plan with multiple practices; and (iii) execution of package of treatment on the various types of lands as well as associated drainage system.

Teesta catchment is spread over Sikkim and West Bengal. Based on the priority delineation survey conducted by All India Soil & Land Use Survey Organisation, very high priority watersheds have been included for soil and water conservation management, as have been described in Chapter X. Nearly 1.74 lakh ha area has been identified as very high priority area in the state of Sikkim under Teesta catchment with regard to silt yield index in 36 sub-watersheds, out of a total of 97 sub-watersheds covering an area of 4.09 lakh ha. Soil conservation measures like contour/ graded bunding with vegetative hedge, check bunds, gully plugging, water harvesting structures, farm ponds, agro-forestry, afforestation, contour/ staggered trenches, loose boulder structures, drop/chute spillway structures and percolation/ silt detention tanks etc. The Department of Forest is the nodal department for implementation of these schemes.

The strategy for implementing soil conservation measures inter-a-lia includes:

(a) Adoption of a project approach to the treatment of catchment.

(b) Integration of sectoral measures for comprehensive watershed development and maintenance.

(c) Emphasis on sustainability of treatment measures.

(d) Vegetative thrust for conservation measures.

(e) Involvement of the persons, dependent on watershed in planning and execution, from time to time, for its development.

(f) Effective administrative arrangements for direction, control and co-ordination of the programme.

# CHAPTER - 7

# AGRICULTURE

# AGRICULTURE

## 7.1 GENERAL

Sikkim has basically an agrarian economy and predominantly rural population (about 90% of total population) and two-third of the overall work force depending on agriculture and allied activities, with only 16% of geographical area available for cultivation. About 40% of GDP is being contributed from this sector. Most of the agricultural land is upto 1800 meter elevation although certain portion of it extends even upto 8600 meter elevation. Even though agriculture is crucial to the economy of the state, it is largely rainfed with traditional technology and low level of inputs. Although rainfall in the state is quite high, but due to inadequate effort in harnessing the available resource, the area under irrigation is hardly around 11% of the operational area. Assured irrigation is even less than 5%. State is practically mono-cropped with kharif cultivation and for want of assured irrigation, multi-cropping has not been attempted. Level of productivity is low as compared to the national average. These are main factors attributable to the fact that the state has not reached a stage of self-sufficiency even though the population is only about Rs.5.40 lakh (2001 census)

Before merger of this state in the Union of India in 1975, the agriculture sector was characterized by uncertainty about land tenure rights, negligible public investment and over-dependence. This sector has recorded considerable progress during the last two decades. In the past, low productivity with negligible marketable surplus and other institutional inadequacies, led to agricultural backwardness. Some of the specific reasons responsible for agricultural backwardness in Sikkim till 1975 were:

- Physical features of the state, necessitating terrace cultivation
- Extreme concentration in land-holding patterns
- Low cropping intensity due to mono-cropping
- Outmoded technologies of production
- Inadequate thrust on agriculture in terms of investment and planning
- Inadequate infrastructural support in transportation, communication, irrigation, technical research and marketing.

In the post merger period, the strategy was to provide a package of services aimed at consolidating peasant economy. This covered land reforms, agricultural credit and marketing, provision of inputs like seeds, fertilizers, minor irrigation, and encouragement to horticulture and cash crops. Thus, despite the limited cultivable land in Sikkim, agricultural development has made considerable progress during the last two decades.

## 7.2 AREA UNDER CROPS, DRY AND WASTE LAND

The district-wise distribution of cultivable land under the broad headings of paddy area, total dry land, wasteland and cardamom area is given in Table 7.1.

**Table 7.1 District-wise area of few crops, dry and waste land (1976-83) (percentage of total cultivable area)**

**(Unit : percent)**

| District | Paddy field | Dry land | Waste land | Cardamom area | Total cultivable land |
|---|---|---|---|---|---|
| North | 8.03 | 10.96 | 8.07 | 32.42 | 14.76 |
| East | 23.15 | 20.73 | 52.39 | 28.74 | 28.96 |
| South | 44.05 | 32.90 | 15.15 | 20.78 | 26.95 |
| West | 24.78 | 35.41 | 24.39 | 18.06 | 29.34 |
| **Total** | **100** | **100** | **100** | **100** | **100** |
| **Area in th ha** | **14.68** | **64.74** | **11.73** | **21.76** | **112.9** |
| **Percentage of total cultivable area** | **(13%)** | **(57.3%)** | **(10.4%)** | **(19.3%)** | **(100%)** |

Source: Sikkim Human Development Report, 2001

It may be seen that dry land constitutes about 58% of the cultivable area with its 35.41% in the west district and 32.90% in south district. This is followed by cardamom area as 19%, paddy 13% and wasteland 10%. The area under cardamom is highest at 32.42%, of its total area in north district while the paddy area at 44.05% is highest in south district. East district is characterised by the maximum waste land at 52.39% of its total area while in west district it is 24.39%. This distribution is helpful in projecting an optimal cropping pattern in various districts of the state for each of the above four categories.

Vegetation distribution in the upper Teesta basin in Sikkim is also of the great significance to land use. Better management of the pastures or grass lands on scientific basis is imperative for higher production and stability of hilly terrain. The grass lands of the upper Teesta basin affect the stability of the land and also the ecosystem. The grasslands in different ecological sites have some characteristic problems depending upon the local environment specially in terms of climatic and latitudinal zones.

Like the upper part of the basin in Sikkim, of late more areas under forests of the middle Teesta basin are being replaced by plantation or cash crops like seed – potato, ginger, turmeric cultivation, off-season vegetables and other seeds of temperate-vegetation e.g. black pepper, cardamom, cinnamon including fruits and fuel-fodder trees etc. on terraced and other lands.

The current status of pastures or grassland production almost at its lowest level has disturbed the ecosystem. Exploitation to the maximum has been the rule; may be out of necessity, but in these regions, no efforts have been made to restore the original vegetation destroyed through unplanned exploitation. In the wake of efficient livestock production and for the betterment of soils, the development of grasslands or pastures in the Himalayas assumes a greater significance in the overall land utilisation for agriculture, animal husbandry and forestry and for maintaining the requisite ecological balance for the integrated development and for maintaining the ecosystems.

In consideration to the above, taking into cognisance the terrain slope and soil depth in Sikkim hills, the recommended land use in the state is given in Table 7.2.

## Table 7.2 Criteria for land capability classification in hills and recommended landuse

| Sl. No. | Slopes (%) | Soil depth (cm) | Erosion hazard | Recommended land use |
|---|---|---|---|---|
| 1. | Less than 2 | More than 150 | None or slight | Very little of such land exist. Suitable for agriculture, contour farming corporation conservation agronomic practices. |
| 2. | 2 to 10 | 150-300 | Wetness in low lying areas (valleys) which are flat. Other areas are prone to moderate sheet and rill erosion. | Drainage necessary on flat wetlands. On sloping land graded narrow based terraces, bunds or trenches. Bench terraces for slopes greater than 6%. Contour cultivation. Crop-rotation and conservation agronomic practices. |
| 3. | 10 to 16 | Varies, but usually around 150 | Serious water erosion | Graded trenches or graded bench terraces contour, cultivation, crop-rotation conservation agronomy, grass for stabilizing slopes and embankments. Plantation crops like tea, coffee and fruit orchards. |
| 4. | 16 to 30 | Varies, but usually around 150 | Serious water erosion | Graded bench terracing contour cultivation corporation conservation agronomy, intensive conservation measures. |
| 5. | Slopes above 33% | 90-150 | Serious | Natural forests to be conserved and appropriately managed Man made forests of pasture and grassland development with conservation practices (Silvi-pasture) |
| 6. | Slopes above 33% | 30-60 | Serious | Intensive soil conservation measures with the same land use as for Class IV. |
| 7. | Slopes 33% | 15-30 | Serious | Natural Forests. |
| 8. | All slopes | Land than 25 posed rock Surface, no soils, or soils only in small pockets. | Serious | Wildlife and recreation. |

## 7.3 LAND HOLDINGS

Distribution of operational landholdings in Sikkim is skewed. In 1990-91 the lowest echelon of landholders i.e. the marginal holders, representing about 50 per cent of landholdings, held 10.3 per cent of the total operational land area. The East district had the highest concentration of landholding by marginal farmers both in terms of number of holdings (56 per cent) and area (12.8 per cent) (Table 6.5). In contrast, farmers with large holdings (more than 10 ha) accounted for 2.3 per cent of the landholdings, but owned 20.2 per cent of the operational area as a whole The North district had the highest number of large farmers who, with over 5 per cent of the operational holdings, owning 30 percent of the operated land within the district. It is observed from the Table 7.3 that except in the East district, land holdings and operated area are well distributed in other districts, at least among the small and semi-medium farmers.

**Table 7.3 District-wise and size/class-wise distribution of land holdings (1991)**

**(Unit: Percentage)**

| Category | North District | | East District | | South District | | West District | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **No** | **Area** | **No** | **Area** | **No** | **Area** | **No** | **Area** | **No** | **Area** |
| Marginal | 49.0 | 8.5 | 56.0 | 12.8 | 44.3 | 9.7 | 46.0 | 10 | 50 | 10.3 |
| Small | 10.0 | 5.1 | 22.0 | 22.0 | 25.0 | 18.5 | 21.0 | 17 | | |
| Semi medium | 18.0 | 20.0 | 14.0 | 23.0 | 18.0 | 24.0 | 20.0 | 28 | | |
| Medium | 17.0 | 36.0 | 6.4 | 23.0 | 10.0 | 26.0 | 11.2 | 31 | | |
| Large | 5.3 | 30.0 | 1.3 | 17.0 | 3.0 | 22.0 | 2.1 | 14 | 2.3 | 20.2 |
| Figures | 4,942 nos. | 14,407 ha | 19,666 nos. | 32,936 ha | 12,548 nos. | 28,575 ha | 13,971 nos. | 31,088 ha | 51127 nos. | 107006 ha |
| **Total** | **99.3** | **99.6** | **99.7** | **97.8** | **100.3** | **100.2** | **100.3** | **100** | | |

Source: Sikkim Human Development Report 2001, Table 3.5.

The extent of fragmentation and partition of land is notable in the state as increase in the number of holding has gone up substantially from 17000 in 1950-58 to 54500 in 1976-83. The same has, however, shown a downward tendency in 1991 at 51127.

## 7.4 CROP CALENDER

Broad crop calendar proposed for the crops suited to the state of Sikkim is given at Table 7.4. This Table provides the month-wise key activities in cultivation *viz*. land preparation, sowing and transplantation, irrigation, harvesting and threshing etc for various crops. In order to compute the crop water requirement for the selected crops, a specific crop calendar has been traced out in light of the above broad crop calendar and is presented at Table 7.5.

**Table 7.4 Month-wise calendar of various agricultural operations in the state**

| Month | Preparation | Sowing and transplanting | Irrigation and intercultural | Harvesting and Threshing |
|---|---|---|---|---|
| January | Kharif Maize, Summer Urd, Summer Buckwheat & Potato, Sweet Potato, ginger, Turmeric and Tapioca | Summer Potato | Wheat, Barley, Urd, Field pea, Rape seed & Mustard, Safflower, Winter & Tanioca and Orange | Urd, Safflower Sweet Patato, Ginger, Turmeric, Tapioca and Orange |
| February | Kharif Maize, Summer Urd Summer Buckwheat & Potato, Sweet Potato ginger, Turmeric and Tapioca | Kharif Maize, Summer Urd, Summer Buckwheat & Potato, Sweet Potato, ginger, Turmeric and Tapioca | Wheat, Barley, Rape seed & Mustard, Winter Potato | Urd, Fieldpea, Safflower, Rape seed and Mustard and Winter Potato |
| March | Kharif Maize, Summer Urd, Summer Buckwheat & Potato, Sweet Potato, ginger, Turmeric, Tapioca | Kharif Maize, Summer Urd, Summer Buckwheat & Potato, sweet Potato, ginger, Turmeric, Tapioca | Wheat Barley, Rape seed & Mustard, Winter Potato | Rape seed & Mustard and Winter Potato |

| Month | Preparation | Sowing and transplanting | Irrigation and intercultural | Harvesting and Threshing |
|---|---|---|---|---|
| | Moong and Cowpea | Moong and Cowpea | | |
| April | Rice, Ragi, Moong, Cowpea, Clusterbean and Orange | Moong Cowpea & Clusterbean | Kharif Maize, Wheat, Barley, Summer Backwhat, Urd, Summer & Sweet Potato, Ginger, Turmeric and Tapioca | Wheat, barley and Rape seed & Mustard |
| May | Rice, Ragi, Clusterbean, Orange, Soyabean, Large Cardamom | Rice, Ragi, Clusterbean and Orange | Kharif Maize, Moong, Summer Backwhat, Urd, Cowpea, Clusterbean, Summer & Sweet Potato, Ginger, Turmeric and Tapioca | Wheat and Barley |
| June | Rice, Rabi, Maize & Urd, Ragi, Rice Rabi Buckwhat, Soyabean, Safflower and Large Cardamom | Rice, Ragi, Clusterbean, Soyabean, Lage Cardamom and Orange | Rice, Kharif Maize, Ragi Summer Buckwheat, Urd, Moong, Cowpea, Clusterbeen, Summer & Sweet Potato, Ginger, Trumeric and Tapioca | Summer Buckwheat and Summer Urd |
| July | Rice, Rabi Maize & Urd, Ragi, Rabi Buckwheat, Soyabean, Safflower and large Cardomom | Rice, Rabi Maize, Rabi Buckwheat, Rabi Urd, Soyabean, Safflower and Large Cardomom | Rice, Kharif Maize, Ragi, Summer Buckwheat, Urd, Moong, Cowpea, Clusterbean, Summer & Sweet Potato, Ginger Turmeric and Tapioca | Summer Buckwheat and Summer Urd, Moong. Cowpea and clusterbean |

**Table 7.5 Specific Crop Calendar for selected Crops proposed in Sikkim**

| Name of Crop | Crop duration in days | Date of sowing | Date of transplantation | Date of harvest |
|---|---|---|---|---|
| 1. **Kharif** | | | | |
| Paddy | 143 | June 21-31 | July 21-31 | Nov 11-20 |
| 2. **Rabi** | | | | |
| Wheat | 133 | Oct 11-20 | | Feb 20-28 |

## 7.5 CROPPING PATTERN

### 7.5.1 Existing Status

Sikkim being a hilly region and heavy rainfall zone, the climate is suitable for growing certain varieties of crops including commercial crops like cardamom, potato, ginger and other horticulture crops. Maize and rice are the principal crops of the state followed by wheat, pulses and cardamom. Introduction of new crops (including wheat, rajmah, rape seed and mustard), extension of more areas under high-yielding and improved varieties of seeds, increased use of fertilizers and pesticides and expansion of area under double or multiple cropping have been successful in converting agriculture from subsistence farming into an economically viable venture.

District-wise crop area estimate of the state for 1990-92 and 1999-2000 are given in Table 7.6 and 7.7, respectively. A perusal of these tables indicates some marginal decrease in area under maize and pluses during the above period.

**Table 7.6 District-wise crops area estimates of Sikkim 1990-92**

**(Unit: th ha)**

| Sl. No. | Crops / Particulars | District | | | | Total |
|---|---|---|---|---|---|---|
| | | North | East | West | South | |
| A | **Cereals** | | | | | |
| | Rice | 1.14 | 5.98 | 2.27 | 2.06 | 11.43 |
| | Wheat | 0.64 | 1.27 | 1.77 | 1.54 | 5.22 |
| | Maize | 3.00 | 9.58 | 14.29 | 13.41 | 40.28 |
| | Finger-millet | 0.51 | 1.13 | 1.64 | 0.68 | 3.95 |
| | Barley | 0.10 | 0.23 | 0.40 | 0.11 | 0.85 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Buckwheat | 0.11 | 0.38 | 0.75 | 0.41 | 1.65 |
| | **Total cereals** | **5.50** | **18.56** | **21.12** | **18.20** | **63.39** |
| B | **Pulses** | **0.07** | **1.36** | **3.23** | **1.23** | **5.88** |
| **Total foodgrains (A+B)** | | **5.57** | **19.92** | **24.35** | **19.43** | **69.27** |
| C | Oil seeds | 0.31 | 1.71 | 2.46 | 1.09 | 5.59 |
| D | Vegetables | 0.32 | 0.90 | 1.37 | 1.93 | 4.52 |
| E | Fruits | 0.65 | 1.08 | 0.53 | 0.56 | 4.81 |
| F | Misc. Crops | 7.78 | 8.29 | 7.88 | 7.20 | 31.15 |
| **Gross cropped area** | | **14.62** | **31.90** | **36.60** | **30.22** | **113.34** |

*Source: Crop Area Statistics of Sikkim 1990-92, Department of Agriculture, Govt. of Sikkim (P/3)*

Gross cropped area is highest at 36.60 th ha in west district, followed by 31.90 th ha and 30.22 th ha in east & south districts. The area in north district is substantially lower at 14.62 th ha due to snow-covered hilly terrain. Gross cropped area of 113.34 th ha and the net sown area of the order of 63.25 th ha yields a cropping intensity of about 179%.

**Table 7.7 District-wise area under principal crops during 1999-2000 and 2002-03**

**(Unit : th ha)**

| Crop | District | | | | State |
|---|---|---|---|---|---|
| | North | South | East | West | |
| Maize | 3.09/3.03 | 13.30/13.40 | 9.70/9.54 | 13.30/13.47 | 39.39/39.44 |
| Rice | 1.41/0.85 | 2.40/2.34 | 6.72/6.50 | 5.38/5.10 | 15.91/14.79 |
| Wheat | 1.04/0.85 | 1.96/1.50 | 2.55/1.98 | 2.55/2.0 | 8.10/6.33 |
| Barley | 0.15/0.14 | 0.20/0.20 | 0.34/0.44 | 0.45/0.45 | 1.14/1.23 |
| Pulses | 0.08 | 2.25 | 1.74 | 2.54 | 6.71 |

From Table 7.9, it is seen that there is overall marginal decrease in the above relevant years in maize area if compared with the status in 1990-92 in Table 7.8 whereas rice and wheat both have recorded some increase. It is also seen that in the above two years, the area for given crops is almost same except wheat which has recorded 22% decrease.

During 2001-02, panchayatwise verification of area under each crop was undertaken by the state Govt. on the basis of 100% enumeration. The result of this verification is presented in Table 7.8 indicating the 'reported' area and 'actual' area under cultivation.

**Table 7.8 Verification of cropped area on the basis of Panchayatwise 100% enumeration for 2001-02**
**(Unit : th ha)**

| Crops | 2001-02 (Reported) | 2001-02 (Actual) | Difference (%) |
|---|---|---|---|
| Total cereals | 70.26 | 60.46 | (-)16 |
| Total Pulses | 6.30 | 5.08 | (-)24 |
| Oil seeds | 10.10 | 6.65 | (-)52 |
| Total fruits | 15.30 | 2.45 | (-)524 |
| Vegetables | 5.22 | 2.27 | (-)130 |
| Ginger | 5.10 | 3.27 | (-)56 |
| Large Cardamom | 28.58 | 21.22 | (-)11 |

The above table indicates that the 'actual' area is invariably on lower side than that of 'reported' area. The variations in case of total cereals, pulses & oilseeds are of the order of (-) 16%, (-) 24% and (-) 52% respectively. However, the same are substantially higher in case of fruits at (-) 524% and vegetables at (-) 130%. These variations narrowed down to (-) 56% and (-) 11% for ginger and large cardamom. Overall crop areas, production and yield rate for total food crops recorded 20%, 34% and 12% decrease respectively. The above details indicate that the crops which are not under organised sector such as fruits & vegetables are more susceptible to reporting of unrealistic figures. Since horticulture development involves substantial scope of increased economic activity in the state, some state level mechanism needs to be evolved to exercise adequate control on this front.

### 7.5.2 Cropping Pattern and Irrigation Intensity

The proposed cropping pattern and irrigation intensities are described in detail in Chapter XV. The same are given as follows :

**Table 7.9 Proposed cropping pattern and irrigation intensity**

| Sl.No. | Crop | Irrigated area (ha) |
|---|---|---|
| | **Kharif** | |
| 1. | Paddy | 15 |
| 2. | Maize | 25 |
| | **Sub Total** | **40** |
| | **Rabi** | |
| 3. | Wheat | 10 |
| 4. | Pulses | 3 |
| 5. | Mustard | 3 |
| 6. | Vegetables & Fruits | 2 |
| | **Sub Total** | **18** |
| | Perennial / hot weather | |
| 7. | Potato | 2 |
| 8. | Large Cardamom | 10 |
| | **Sub Total** | **12** |
| | **Grand Total** | **70** |

## 7.6 CROP WATER REQUIREMENT

Procedure for calculation of crop water requirements and irrigation requirements are mainly based on methodologies presented in FAO Irrigation and Drainage Paper No. 24 “Crop Water Requirements”, Paper No. 33 “Yield Response to Water” and Paper No. 46 “CROPWAT” – A Computer Program for Irrigation Planning & Management based on the approach of Penman–Montieth as recommended by the FAO Expert Consultation held in May 1990 in Rome. This is widely used for calculation of crop water requirement in the country and abroad and the same has been used in this study.

This concept recognizes evapo-transpiration of the crop (ETc), as the most important consumptive demand of a crop. According to this concept, crop evapo-transpiration is assessed through the following relationship:

$$ETc = Kc. \times ET_o.$$

Here Kc is the Crop coefficient, which depends on crop characteristics like time of planting and sowing, total growing season, length of crop development stages etc. The value of Kc varies from crop to crop.

$ET_o$ is the reference potential evapo-transpiration. It is the rate of evapo-transpiration from an extensive grass surface of 8 to 15 cm tall green grass cover of uniform height, actively growing, completely shading the ground and not short of water. The well accepted methodology of estimation of $ET_o$ in this country and most part of the World is Modified Penman Method. Based on this methodology, the Penman Montieth model has been used for the computation of $ET_o$ for the present study. $ET_o$ has been determined for Gangtok for which the agro-climatalogical data *viz*. mean monthly temperature, relative humidity, sunshine hours (cloud cover) and mean wind velocity were collected on monthly basis.

The $ET_o$ worked out for Gangtok has been considered to be representative of the state of Sikkim as a whole, in absence of further data for working out crop water requirement studies in present study.

## 7.7 NET IRRIGATION REQUIREMENT

### 7.7.1 Agro-Climatological Data

The mean monthly values of temperature, relative humidity, sunshine hours and wind speed at Gangtok* station has been considered to work out monthly $ET_o$ -values These are given in Table 7.10, 7.11, 7.12 and 7.13 respectively.

**Table 7.10 Monthly mean air temperature ($^0C$)**

| Month | Max | Min |
|---|---|---|
| January | 20.7 | 7.5 |
| February | 21.3 | 7.5 |
| March | 22.1 | 10.3 |
| April | 24.6 | 10.7 |
| May | 25.1 | 12.6 |
| June | 25.8 | 14.7 |
| July | 25.3 | 14.5 |
| August | 26.8 | 14.8 |
| September | 26.9 | 14.7 |
| October | 25.9 | 13.3 |

| | | |
|---|---|---|
| November | 23.7 | 9.9 |
| December | 22.9 | 7.0 |

**Table 7.11 Mean monthly relative humidity (%)**

| Month | Mean |
|---|---|
| January | 68.3 |
| February | 63.8 |
| March | 65.5 |
| April | 66.2 |
| May | 73.9 |
| June | 84.0 |
| July | 88.7 |
| August | 80.9 |
| September | 75.5 |
| October | 68.0 |
| November | 69.6 |
| December | 63.9 |

Lat $27^0$ 33'N, Long-$88^0$ 60'E, ht. above MSL – 1812 m

**Table 7.12 Monthly sunshine hour**

| Month | Sunshine hours |
|---|---|
| January | 4.3 |
| February | 5.0 |
| March | 4.9 |
| April | 5.9 |
| May | 5.6 |
| June | 3.6 |
| July | 2.1 |
| August | 3.3 |
| September | 3.4 |
| October | 6.3 |
| November | 6.4 |
| December | 4.5 |

(Source : Master plan for Irrigation Development , Sikkim - 1995 )

**Table 7.13 Monthly mean wind speed**

| Month | Mean (km/day) |
|---|---|
| January | 52.8 |
| February | 62.4 |
| March | 91.2 |
| April | 98.4 |
| May | 81.6 |
| June | 50.4 |
| July | 43.2 |
| August | 43.2 |
| September | 43.2 |
| October | 64.8 |
| November | 55.2 |
| December | 45.6 |

### 7.7.2 Reference Evapotranspiration (ETo)

As stated in section 7.6, ETo has been worked out using the above climatological data and the same is given in Table 7.14.

**Table 7.14 Reference evapo-transpiration**

**Unit: mm/day**

| Month | Value |
|---|---|
| January | 1.67 |
| February | 2.20 |
| March | 2.86 |
| April | 3.63 |
| May | 3.67 |
| June | 3.18 |
| July | 2.74 |
| August | 2.98 |

| | |
|---|---|
| September | 2.72 |
| October | 2.79 |
| November | 2.06 |
| December | 1.59 |

### 7.7.3 Crop Coefficient

As stated in section 7.6., the value of crop coefficient, Kc, is crop-specific which varies from crop to crop and also according to the stage of the crop. There are four stages of crops in general as indicated in FAO publication. With reference to FAO Publication No. 24, the crop factors (Kc) and period of growth stages of each crop under consideration, have been finalised for assessment of water requirement for the principal crops viz. paddy and wheat and the same are given in Table 7.15.

**Table 7.15 Duration of crop stages and crop coefficient, Kc, for principal crops in Sikkim**

| Sl. No | Name of crop | Duration | | | | | Crop coefficient, kc. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | I Initial | II Devel-opment | III Mid season | IV Late season | I Initial | II Devel-opment | III Mid season | IV Late season |
| 1 | **Kharif** | | | | | | | | | |
| | Paddy | 143 | 20+11 | 40 | 40 | 32 | 0.85 | 1.05 | 1.05 | 0.90 |
| 2 | **Rabi** | | | | | | | | | |
| | Wheat | 133 | 21 | 40 | 40 | 32 | 0.40 | 0.70 | 1.1 | =>0.2 |

### 7.7.4 Effective Rainfall

The crop water requirement can be fully or partly met by the rainfall. All the rainfall is not effective as part of it gets lost by surface runoff, deep percolation & evaporation. That part of rainfall which is actually available to the crop for evapo-transpiration is the effective rainfall. The effectiveness of the rainfall depends on rainfall intensity and duration, land slope, ground water condition, soil characteristics, vegetative cover, temperature and field management practices, etc.

Monthly rainfall values for the stations were collected from IMD for various stations for varying periods as described in Chapter III. The missing values of rainfall have been estimated using standard statistical method.

However, for the purpose of working out irrigation water requirement, normal rainfall values, as obtained from IMD have been used. From the normal rainfall values, effective monthly rainfall has been computed by USBR method. Daily effective rainfall has been worked out proportionately from the monthly effective rainfall values and such values have been used in computation of net irrigation requirement for different crops. The month-wise average and effective rainfall is given in Table 7.16.

**Table 7.16 Month-wise total and effective rainfall**

**Unit : mm/ month**

| Month | Total Rainfall | Effective Rainfall |
|---|---|---|
| January | 37.0 | 34.8 |
| February | 53.0 | 48.5 |
| March | 104.1 | 86.8 |
| April | 151.7 | 114.9 |
| May | 287.6 | 153.8 |
| June | 442.7 | 169.0 |
| July | 480.1 | 173.0 |
| August | 440.1 | 169.0 |
| September | 331.8 | 158.2 |
| October | 156.0 | 117.1 |

| | | |
|---|---|---|
| November | 30.7 | 29.2 |
| December | 19.1 | 18.5 |
| **Total** | **2533.9** | **1273.1** |

N.B. : Effective rainfall calculated using the USBR formulas:
Effective R. = (125 - 0.2 * Total R.)* Total R. / 125 ….(Total R. < 250 mm/month)
Effective R. = 0.1 * Total R. - 125 ….(Total R. > 250 mm/month)

### 7.7.5 Net irrigation water requirement

With the above parameters, 10 daily net irrigation requirements have been worked out for paddy and wheat. The detailed calculations of the same are given in Tables 7.17 and 7.18 respectively.

### Table 7.17 Net irrigation requirement for paddy

*Date of Sowing* *June* 21-30 *Duration* *143 days*
*Transplantation* *July* 21-31
*Harvest* *Nov* 11-21

| **Date of Start - 10 daily 1** | **ETo 2** | **Crop Coeff. Kc 3** | **CWR ( Etc ) 4=2*3** | **Perco-lation Loss 5** | **Req. for Land Preparation 6** | **Effective Rainfall 7** | **Net Irrigation Requirement 8=4+5+6-7** |
|---|---|---|---|---|---|---|---|
| **a) Nursery Period*** | | | | | | | |
| 21-Jun | 31.8 | 0.85 | 27.03 | 0.00 | 125.00 | 56.4 | 9.56 |
| 01-Jul | 27.4 | 0.85 | 23.29 | 0.00 | | 55.8 | -3.25 |
| 11-Jul | 27.4 | 0.85 | 23.29 | 0.00 | | 55.8 | -3.25 |
| **b) Cropping Period** | | | | | | | |
| 21-Jul | 30.1 | 0.88 | 26.52 | 55.00 | 125.00 | 61.4 | 145.14 |
| 01-Aug | 29.8 | 0.93 | 27.71 | 50.00 | | 54.5 | 23.20 |
| 11-Aug | 29.8 | 0.98 | 29.20 | 50.00 | | 54.5 | 24.69 |
| 21-Aug | 32.8 | 1.03 | 33.76 | 55.00 | | 60.0 | 28.80 |
| 01-Sep | 27.2 | 1.05 | 28.56 | 50.00 | | 52.7 | 25.83 |
| 11-Sep | 27.2 | 1.05 | 28.56 | 50.00 | | 52.7 | 25.83 |
| 21-Sep | 27.2 | 1.05 | 28.56 | 50.00 | | 52.7 | 25.83 |
| 01-Oct | 27.9 | 1.03 | 28.74 | 50.00 | | 37.8 | 40.96 |
| 11-Oct | 27.9 | 0.97 | 27.06 | 50.00 | | 37.8 | 39.29 |
| 21-Oct | 30.7 | 0.92 | 28.23 | 55.00 | | 41.6 | 41.68 |
| 01-Nov | 20.6 | 0.87 | 17.92 | 50.00 | | 9.7 | 58.19 |
| | | | **Total** | | | | **488.98** |

* Area reduced to 1/10 th for seedling

**Table 7.18 Net irrigation requirement for wheat**

*Date of Sowing* *Oct 11-20* *Duration* *133 days*

*Harvest* *Feb 11-21*

**(Unit : mm/period)**

| Date of Start - 10 daily<br>1 | ETo<br>2 | Crop Coeff. Kc<br>3 | CWR ( Etc )<br>4=2*3 | Effective Rainfall<br>5 | Net Irrigation Requirement<br>6=4-5 |
|---|---|---|---|---|---|
| 11-Oct | 27.9 | 0.40 | 11.16 | 37.8 | 0.00 |
| 21-Oct | 30.7 | 0.40 | 12.28 | 41.6 | 0.00 |
| 01-Nov | 20.6 | 0.42 | 8.65 | 9.7 | 0.00 |
| 11-Nov | 20.6 | 0.50 | 10.30 | 9.7 | 0.57 |
| 21-Nov | 20.6 | 0.58 | 11.95 | 9.7 | 2.21 |
| 01-Dec | 15.9 | 0.65 | 10.34 | 6.0 | 4.37 |
| 11-Dec | 15.9 | 0.75 | 11.93 | 6.0 | 5.96 |
| 21-Dec | 17.5 | 0.85 | 14.87 | 6.6 | 8.30 |
| 01-Jan | 16.7 | 0.95 | 15.87 | 11.2 | 4.64 |
| 11-Jan | 16.7 | 1.05 | 17.54 | 11.2 | 6.31 |
| 21-Jan | 18.4 | 0.95 | 17.45 | 12.3 | 5.10 |
| 01-Feb | 22.0 | 0.65 | 14.30 | 17.3 | 0.00 |
| 11-Feb | 22.0 | 0.35 | 7.70 | 17.3 | |
| **Total** | | | | | **37.46** |

### 7.7.6 Irrigation Efficiency

A large quantity of water diverted at the headworks of a canal system is lost through seepage and surface evaporation of the conveyance system while flowing from the headworks to the field. Again, in field also there are losses of water in form of percolation losses below root zone of crops in water handling process by the farmers. The loss of water through the conveyance system is termed as conveyance losses. The conveyance system comprises of main canals, branches, distributaries, minors and water courses. The loss of water in the field is termed as field application losses.

### 7.7.7 Conveyance Efficiency

Conveyance efficiency accounts for the losses in the conveyance system. The losses in the conveyance system primarily depend on the type of materials used in construction of the channel and its wetted perimeter. Lesser the perimeter, lesser will be the losses and higher the efficiency and vice versa. The lined system offers lesser conveyance loss, consequently higher efficiency compared to the unlined one. If Ec be the conveyance efficiency of the system, then Ec can be represented by

$$E_c = E_{fc} \times E_{wc} \times E_{mi} \times E_{disty} \times E_{bc} \times E_{mc}$$

Here E represents the efficiency and the subscripts c, fc, wc, mi, disty, bc & mc represent conveyance, field channel, water course, minor, distributary, branch canal and main canal respectively. However, in case of Sikkim, since there are no major and medium projects, involving large distribution network right from main canal to field channels, it is prudent to consider the losses only in minors, water courses and field channels which are relatively smaller in length, with lesser wetted perimeter. And therefore, the conveyance efficiency can be represented by the following:

$$E_c = E_{fc} \times E_{wc} \times E_{mi}$$

### 7.7.8 Field Application Efficiency

Field application efficiency depends upon the method of irrigation. In the present study, it has been taken as 0.85 for ponded crops i.e. paddy and 0.65 for non-ponded crops.

Since field channels, water courses and minors are of smaller length with smaller area of cross section, the conveyance and regulation losses through them are considered as 0.95 for each component. i.e.

$$E_{fc} = E_{wc} = E_{mi} = 0.95.$$

The percolation losses have been considered only after transplanting operation of paddy and not during nursery stage.

### 7.7.9 Overall Efficiency

Taking these parameters together the efficiency of the system have been computed as shown below:-

For ponded crops, overall efficiency, E

$$= E_a \times E_{fc} \times E_{wc} \times E_{mi} \times E_{disty} \times E_{bc} \times E_{mc}$$
$$= 0.85 \times 0.95 \times 0.95 \times 0.95$$
$$= 0.73$$

For non-ponded crops, overall efficiency E

$$= E_a \times E_{fc} \times E_{wc} \times E_{mi} \times E_{disty} \times E_{bc} \times E_{mc}$$
$$= 0.65 \times 0.95 \times 0.95 \times 0.95$$
$$= 0.56$$

The gross irrigation requirement at the head works has been worked out considering the project efficiency as 0.73 for the ponded crop and that as 0.56 for non-ponded crops.

## 7.8 GROSS IRRIGATION REQUIREMENT

After applying the irrigation efficiency of 0.73 for paddy crops and 0.56 for other crops, gross water requirements (in Mcm) have been worked out at canal head for the paddy and wheat crops and are given in Table 7.19.

**Table 7.19 Gross irrigation requirement for paddy and wheat**

| Crop | Area under irrigation (th ha) | Net irrigation requirement | | Efficiency (%) | Gross irrigation requirement |
|---|---|---|---|---|---|
| | | mm | Mcm | | (Mcm) |
| Paddy | 15 | 489 | 73.35 | 73 | 100.50 |
| Wheat | 10 | 38 | 3.80 | 56 | 6.80 |

## 7.9 AGRICULTURE PRODUCTION AND YIELD

Details of production of total cereals and pulses in some of the years during 1980-81 to 2002-03 are contained in Table 7.20.

**Table 7.20 Food production in Sikkim (1980-03)**

**(Unit: tonnes)**

| Crops | 1980-81 | 1985-86 | 1995-96 | 1990-91 | 2000-01 | 2001-02 | 2002-03 |
|---|---|---|---|---|---|---|---|
| Maize | 28930 | 47000 | 58810 | 56560 | 59610 | 50940 | 45960 |
| Rice | 10630 | 16500 | 25300 | 21880 | 21350 | 13420 | 18330 |
| Wheat | 13310 | 16200 | 21600 | 15300 | 10100 | 5520 | 8750 |
| Barley | 460 | 1400 | 2860 | 1570 | | 970 | 1495 |
| Buck Wheat | 1380 | 2000 | 2540 | 1740 | 6970 | 1690 | 1655 |
| Finger Millet | 3840 | 4300 | 7310 | 4750 | | 2090 | 3740 |
| Pulses | 3320 | 10010 | 15020 | 5920 | 5160 | 3660 | 6230 |
| **Total (cereal+pulses)** | **61870** | **97410** | **133440** | **107720** | **103190** | **78290** | **86250** |

Source: Sikkim Human Development Report 2001, Table 3.8 and Govt. of Sikkim trainer's manual & other

From above data, it appears that overall production of the total cereals and pulses has increased from 61870 tonnes in 1980-81 to peak of 133440 tonnes in 1990-91 but has gradually reduced to 86250 tonnes in 2002-03. These figures hardly indicate any reasonable pattern of long term growth rate. However, for short-term estimation, if last three years data from the above table is taken into consideration with similar correction as in 2001-02 applied to even 2000-01 data, the position so arrived may be of some use. By applying 34% reduction correction in the production figure of 103190 tonnes in 2000-01, as has been arrived at during panchayatwise 100% enumeration carried out in the year 2001-2002 (para 7.5), the production would reduce to a likely figure of 68105 tonnes. In such a case, yearly increase with productivity in last two years with respect to their preceding years may be deemed at 15% and 10% per annum respectively.

Though maize has never been a staple food in Sikkim, its production has steadily increased since 1980-81 and contributes to even over 60 percent of the total foodgrain production in recent times in the State (Table 8.20). On the other hand, the share of rice, the main food item in the traditional diet has been varying “between” 16.94 per cent to 21.25 per cent (except the year 2000-01). Wheat production, which increased to its highest level in absolute terms in the 1990-91 had declined to a lowest level of 7% in the year 2001-02 i.e. almost to less than half of it.

**Table 7.21 Share of different crops in total food grain production (1980-03)**

(Unit : Percent)

| Crops | 1980-81 | 1985-86 | 1990-91 | 1995-96 | 2000-01 | 2001-02 | 2002-03 |
|---|---|---|---|---|---|---|---|
| Maize | 46.76 | 48.25 | 44.07 | 52.51 | 64.00 | 65.00 | 53.30 |
| Rice | 17.18 | 16.94 | 18.96 | 20.31 | 12.20 | 17.10 | 21.25 |

| Crops | 1980-81 | 1985-86 | 1990-91 | 1995-96 | 2000-01 | 2001-02 | 2002-03 |
|---|---|---|---|---|---|---|---|
| Wheat | 21.51 | 16.63 | 16.19 | 14.20 | 10.80 | 7.00 | 10.24 |
| Barley | 0.74 | 1.44 | 2.14 | 1.46 | 7.50 | 1.24 | 1.73 |
| Buck Wheat | 2.23 | 2.05 | 1.90 | 1.62 | | 2.16 | 1.92 |
| Finger Millet | 6.21 | 4.41 | 5.48 | 4.40 | | 2.67 | 4.43 |
| Pulses | 5.37 | 10.28 | 11.26 | 5.50 | 5.50 | 4.68 | 7.22 |
| **Total** | **100** | **100** | **100** | **100** | **100** | **100** | **100** |

District-wise details of food production during 1998-99 and 2002-03 are given in Table 8.10. It shows that the west district was contributed maximum in both the years i.e. 36% & 37% whereas north district the minimum i.e. 6.25% and 5.4%. The contribution of south and east districts varies from 26 to 31.7% to 31.7 and 25.7% respectively.

**Table 7.22 District-wise Food Production in 1998-99 and 2002-03**

**(Unit : tonnes)**

| Crops | North | East | South | West | Total |
|---|---|---|---|---|---|
| Rice | 1917/670 | 9290/9010 | 3270/3150 | 7480/5500 | 21957/18330 (-)16% |
| Wheat | 826/907 | 2370/2740 | 10202000 | 2200/3100 | 6416/8747 + 36% |
| Maize | 2230/2160 | 13450/6680 | 16620/18500 | 1850018600 | 50800 (-) 9.5% |
| Finger Millet | 643/330 | 1520/1150 | 950/960 | 1600/1300 | 4713/3740 |
| Barley | 207/100 | 270/530 | 140/200 | 600/665 | 1217/1495 |
| Buckwheat | 148/145 | 440410 | 480/480 | 480/620 | 1548/1655 |
| Total cereals | 5381/4332 | 27350/20520 | 22480/25790 | 30860/29785 | 86071/79927 |
| Pulses | 657 | 1580 | 1670 | 2280 | 5596 |
| **Total Foodgrain** | **6038** | **28920** | **24150** | **33140** | **92248** |

Source: Sikkim Human Development Report 2001, Table-3.10 and Govt. of Sikkim

Total food grain production in West district is highest (36%) followed by east district (31%), the south district (26%) and the north district (only 7%). East district production is highest with respect to rice and wheat while maize production is highest in west district.

The decennial mean crop area, production and productivity of major crops for the period 1975-76 to 2000-01 i.e. in 25 years is given in Table 7.23.

**Table 7.23 Percentage gain/loss during 25 years (1975-76 to 2000-01)**

| Sl. No. | Crops | Mean crop area (th ha) | Production | Productivity |
|---|---|---|---|---|
| 1. | Total cereals | 48.16 | 214.70 | 112.44 |
| 2. | Pulses | 254.70 | 637.14 | 108.00 |
| 3. | Oil seeds | 395.00 | 954.28 | 111.14 |
| 4. | Other fruits, seasonal veg. Other tubers | 232.69 | 767.18 | 259.70 |
| 5. | Total cash crops | 191.92 | 452.09 | 89.21 |
| 6. | Total cropped | 99.12 | 330.70 | 116.39 |

Source: Trainer's Manual (2001) A & H Deptt, Govt. of Sikkim

From the above, it emanates that the production of total cereals and pulses are in the range of around 8.6% and 25.5% per annum respectively, latter being significant from the point of view of most important source of protein for the common people. The oil seeds, other fruits, seasonal vegetables and other tubers also record very high growth rate in production / productivity and their cropped areas which also is significant for evolving future strategy for the state.

## 7.10 STRATEGIES PROPOSED BY THE STATE FOR ADOPTION DURING TENTH FIVE YEAR PLAN

The growth in agriculture production over a decade has not been satisfactory primarily due to low level of investment in land development and irrigation agriculture, etc. For ensuring systematic and long-term sustainable agriculture, state Govt. has embarked upon a definite strategy during Xth Five Year Plan to address the problems being faced in a development of this sector. The same are given below:

### I. Adequate investment in land development and water harvesting structure

Land development is envisaged for conservation of soil, plant nutrient and moisture with people's participation. The ratio of government support and farmers' contribution is envisaged to be in the ratio of 3:7.

For storage of water during rainy season, water harvesting structures are to be constructed. Utilisation of this water for irrigation during the dry period may be had either through drip or sprinkler system of irrigation. The farmers' participation in implementation of this programme may be 50% of the cost of the programme. If the land is developed and irrigated, the farmers themselves will go for intensive agriculture and increase the productivity per unit area.

By adopting the above approach, it is anticipated that a growth rate of 10% to 25% may be achieved in terms of crop production over the Tenth Five Year Plan period.

## II. Strengthening the government farms to meet the requirement of

a. Adaptive trials and research work
b. Testing of the new technologies before taking to the farmers
c. Production of Foundation and first generation Certified Seed
d. Serving as demonstration farm
e. Training Center for the area covered by it.

## III. Encouraging private Seed Farms as Joint Venture Undertaking

No private entrepreneurs venture to take up the seed production industry due to stringent land sale/transfer / lease system of the state unless the State Government takes up a joint collaborator. The production of certified seed in the farmer's field has been taken up in large scale with a view to reduce the import of seed by at least 25% during 2003-2004.

## IV. Mechanisation Farming

With adequate investment in land development, the mechanisation of agriculture is one of the priority sectors. This would include the following:

i. Large scale testing of power tillers, power/ bullock drawn tools and implements, improved harvesting and threshing tools and implements including storage in the government farms followed by farmers field. In 2002-03, testing of power tillers has been completed and is going to be introduced to the farmers.

ii. Adequate subsidy to the farmers to adopt these improved tools and implements in the beginning to be tapered off progressively. In 2002-03, improved iron plough from Haryana is being tested and will be provided to the farmers, if found satisfactory.

**V. Large Scale demonstration on package technology involving HYV, fertiliser and Integrated Pest Management (IPM)**

The main emphasis is to be on consumption of fertilisers as the present level of fertiliser use in the state is one of the lowest in the country (less than 10 kg/ha). For the demonstration to be effective, the proposed strategy is:

a. To cover every village in the state
b. Every farmer shall be convinced for a period of 2 years in succession so that the farmers are well convinced.
c. All the farmers to be covered over a period of 6-10 years

**VI. Development of Human Resource through**

a. Regular training of the farmers
i. In the field
ii. In the training center to be established in each district with hostel facilities.
b. Up gradation of the skill of the extension staff
d. Strengthening the skill of the specialist

**VII. Post harvest storage, processing, packing including consumption -** The emphasis is to encourage to have more of wheat based food. The work of storage of wheat seed was to be initiated from 2002-03.

**VIII. Strengthening of the database.** The regular updating of the data shall be initiated alongwith a website is to ensure its easy occurs to all beneficiaries, as and when required.

The physical status of IX$^{th}$ Plan and the proposal for X$^{th}$ Plan for some important strategic parameters as covered in the above strategies under various activities is described as follows:

### 7.10.1 Crop Husbandry

#### *7.10.1.1 High Yielding Varieties Program*

The objective of the program is to introduce and promote new and better high yielding and improved varieties of field crops in the State. While efforts to produce the certified seed in state have already been started, the deficit seed shall have to be brought from outside the state for all the hybrid crops. The physical achievement during IXth Plan & targets for Xth Plan are given in Table 7.24.

***Table 7. Details 24 of high yielding varieties program***

| S No | Item | Unit | 9$^{th}$ Plan | 10$^{th}$ Plan | 2002-03 | 2003-04 |
|---|---|---|---|---|---|---|
| **1** | **HYV Seeds (Deficit)** | | | | | |
| a) | Cereals | Tonne | 994. 54 | 1665.00 | 270.00 | 300.00 |
| b) | Pulses | Tonne | 22.9 | 62.00 | 10.00 | 30.00 |
| c) | Oilseeds | Tonne | 57.88 | 75.00 | 10.00 | 10.00 |
| | **Total** | **Tonne** | **1074.61** | **1802.00** | **290.00** | **340.00** |
| **2** | **HYV Demonstration with the full inputs** | | | | | |
| a) | Cereals | Ha | 99.45 | 166.50 | 27.00 | 500 |
| b) | Pulses | Ha | 2.21 | 6.20 | 1.00 | 250 |
| c) | Oilseeds | Ha | 5.79 | 7.50 | 1.00 | 250 |
| | **Total** | **Ha** | **107.45** | **180.20** | **29.00** | **1000** |

### 7.10.1.2 *Seed Multiplication and Distribution*

The production and distribution of improved seeds of field crops constitute a primary activity of agricultural development. The scheme aims to produce quality seeds and ensure supply of improved seeds of field crops to farmers at right time and in adequate quantities in the State. Sikkim, having not covered under the National Seed Project as well as having no State Seeds Corporation, requires at least the basic infrastructure for seed testing, certification and quality control of seeds. The details of Seed Multiplication and Distribution Program are given in Table 7.25.

**Table 7.25 Xth plan proposal for seed multiplication and districts**

| Sl No | Item of Expenditure | Unit | 9th Plan | 10th Plan | AD 2002-03 | AD 2003-04 |
|---|---|---|---|---|---|---|
| 1 | Foundation seed production | | | | | |
| a | Cereals | Tonnes | 263.42 | 270.00 | 22.00 | 55.00 |
| b | Pulses | Tonnes | 13.60 | 13.10 | 2.30 | 5.00 |
| c | Oil Seeds | Tonnes | 20.42 | 30.00 | 5.00 | 5.00 |
| | **Total** | **Tonnes** | **279.44** | **313.10** | **29.30** | **65.00** |
| 2 | Formers Field certified and Labeled Seed Production | | | | | |
| a | Cereals | Tonnes | 128.39 | 410.00 | 50.00 | 100.00 |
| b | Pulses | Tonnes | 28.80 | 70.00 | 10.00 | 50.00 |
| c | Oil Seeds | Tonnes | 27.40 | 70.00 | 10.00 | 50.00 |
| | **Total** | **Tonnes** | **184.59** | **550.00** | **70.00** | **200.00** |
| 3 | Seed Testing and certification | 000'nos | 4.90 | 26.80 | 5.00 | 10.00 |
| 4 | Seed processing & distribution | Tonnes | 61.60 | 863.10 | 120.00 | 125.00 |

### 7.10.1.3 *Manures & Fertilizers*

In the state of Sikkim, the consumption of fertilisers, one of most important agricultural inputs for enhancing production and productivity of crops, is one of the lowest in the country. Efforts are on way, to improve use of fertilizers through promotional measures like subsidy, demonstrations and opening of the retail outlets. Effective distribution through the Sikkim Marketing Federation (SIMFED) is being emphasized. Further, corrective measures are to be undertaken to improve upon the availability of requisite macro and micro-nutrients.

### 7.10.1.4 *Extension and Training*

The extension and training activities provide the means through which transfer of technology to farmers may be achieved. The scheme aims to disseminate scientific knowledge to the grass-root level through a system of training, audio-visual aids, printed materials, meetings, field days, exhibitions, crop competitions, conducted tours, group discussions, etc. including practical demonstration of crop production practices.

### 7.10.1.5 *Commercial Crops - Mushroom Development*

Sikkim, having varied agro-climatic conditions, has a good scope of mushroom cultivation. With the establishment of a mushroom spawn complex and initiation of promotional measures like training and demonstration, a lot of people have shown interest in mushroom cultivation including unemployed educated youth. It is aimed to popularise mushroom cultivation, particularly Oyster and White Button mushrooms, with more trainings and demonstration.

#### 7.10.1.6 *Storage & Warehousing*

The seed production program has not been effective due to lack of proper storage facilities in the state. The production of the crops was also hindered by the lack of proper storage facilities both of the inputs and the outputs. Emphasis is being given to create adequate storage facilities both at state level and the Panchayat level.

### 7.10.2 Soil and Water Conservation

According to State Govt. information, out of 1.09 lakh ha of land under operational holding in the State, the area which is not prone to severe erosion is about 12,000 ha. The remaining area under rainfed crops is mostly of Class-II and above.

The National Bureau of Soil Survey and Land Use Planning has estimated that there is no land of Class-I and less than 3% of Class-II and rest of Class-III and above. The soil conservation in agricultural land is needed as an important development measure due to prevalence of sloppy terrain, high intensity rain and poor water retention capacity of soil. There is immense scope of improving productivity with the soil conservation measures in agricultural land in the State.

Of various soil and water conservation measures, maintenance of nurseries for propagating planting materials and two soil conservation models in Government Farms and a small scale program of soil reclamation are proposed to be carried out in the State. Other programs like water conservation, garland plantation, other agronomic measures, command area development and agro-meteorology, which were considered as important programmes in the Ninth Plan period are being pursued in Tenth plan period also.

### 7.10.3 Financial Performance

A summary of financial achievements during IXth Plan, the targets for Xth Plan and Annual Plans 2002-03 and 2003-04, in respect of all the activities including mentioned above are given at in Table 7.26.

**Table 7.26 Summary of the expenditure of IX$^{th}$ plan and proposal for X$^{th}$ plan period**

| Sl. No. | Head of expenditure | IXth Plan expenditure | Xth Plan | 2002-03 | 2003-04 |
|---|---|---|---|---|---|
| **A.** | **Crop Husbandry** | | | | |
| 1. | Direction of administration | 50.34 | 77.00 | 31.00 | 18.00 |
| 2. | HYV programme | 238.65 | 411.00 | 48.00 | 82.00 |
| 3. | Seed Multiplication & distribution | 261.00 | 459.00 | 39.95 | 51.00 |
| 4. | Agriculture forms | 235.32 | 342.00 | 124.00 | 136.00 |
| 5. | Manures & fertilisers | 756.99 | 716.00 | 100.60 | 188.00 |
| 6. | Soil testing | 95.64 | 115.00 | 18.70 | 20.00 |
| 7. | Plant protection | 60.97 | 127.00 | 8.50 | 15.00 |
| 8. | Extension & training | 61.62 | 492.00 | 36.00 | 73.50 |
| 9. | Agricultural economics and statistics | 25.38 | 45.00 | 9.00 | 11.00 |
| 10. | Agricultural engineers | 65.95 | 236.00 | 24.50 | 46.00 |
| 11. | National agricultural insurance scheme | 7.28 | 158.00 | 5.00 | 10.00 |
| | Technology Mission | | | | |
| 12. | Pluses | 23.86 | 59.00 | 5.00 | 5.00 |
| 13. | Oilseeds | 98.11 | 150.00 | 20.00 | 20.00 |
| 14. | Maize | 30.21 | 63.00 | 8.75 | 10.50 |
| 15. | Commercial crops – Mushroom development | 29.91 | 50.00 | 14.00 | 14.00 |

| | | | | | |
|---|---|---|---|---|---|
| | **Total of crop husbandry** | **2041.23** | **3500.00** | **493.00** | **700.00** |
| **B.** | **Agriculture research** | 172.00 | 300.00 | 27.00 | 60.0 |
| **C.** | **Storage & warehousing** | 79.69 | 200.00 | 15.00 | 40.00 |
| | **Total above** | **2292.90** | | | |
| **D.** | **Soil and water conservation** | 251.31 | 600.00 | 35.00 | 15.00 |
| | **Grand total** | **2544.21** | **4600.00** | **570.00** | **950.00** |

## 7.11 IMPROVED CULTIVATION PRACTICES

For intensifying the agriculture, crop cultivation practices may have to be improved. The same are described below for some major crops viz. paddy, maize, wheat, rapeseed / mustard and sugarcane.

### 7.11.1 Paddy

#### *7.11.1.1 Improved Varieties*

The first and foremost aspect of production technology is the selection of an appropriate variety for a given climatic and cultural condition. The contribution of other inputs will depend on the genetic potential of the improved variety. A number of new variety of seed are given every year from which the farmers and the VLW of the area can select the best variety suited for different climatic and cultural conditions.

The recommended varieties are:
Pant Dhan – 10, IR-36 VL-Dhan-61 (VL-89-1179) VL-89-1167, HPR-926, Tulsi (IET 7614)

#### *7.11.1.2 Crop Establishment*

Rice is adaptable to all kinds of soil i.e. sandy to heavy soils. It grows well in soils having a pH range between 5.5 and 6.5. It is best suited to the regions, which have high temperature, high humidity, prolonged sunshine and an assured supply of water. A temperature range of 20$^{o}$C to 37.7$^{o}$C (68$^{o}$ to 100$^{o}$ F) is required for optimum growth of rice.

(i) **Time of Sowing**

May to June - Nursery bed preparation
June, July - Transplanting

(ii) **Nursery Raising (Wet Nursery)**

The area should be ploughed twice in dry condition and then through puddling by giving 3-4 ploughings which prevents the growth of weeds and deep percolation of water. The field may be leveled properly and beds of 1 m width and of any convenient length may be leveled properly. Sprouted seeds may be broadcasted evenly keeping only a thin film of water. After the complete germination and when colceptiles starts turning green, water level is gradually raised to 2-3 cm.

(iii) **Seed Selection and Treatment**

Only well filled viable seeds @ 30-40 kg per ha should be used for sowing. Unhealthy light seeds floating in a solution of salt (1kg common salt in 10 lit of water) should be rejected. Untreated seeds of HYV should be soaked for 12 hours in a solution of wettable ceresan and strepto cycline. 10 gm of ceresan wet and 1 gm strepto cycline should be dissolved in 10 lit of water for 10-12 kg of seed. The seeds should then be dried in shade and used for sowing. To ensure rapid and uniform germination, selected seeds should be soaked for 24 hours in clean water, drained and incubated in a warm moist place for another 36-38 hours. Sprouted seeds should be used for sowing.

(iv) **Time of Transplanting**

The seedlings are ready for transplanting in kharif within 20-25 days (4-5 leaf stage) after sowing. Delay in transplanting leads to poor tillering, early flowering of the main tillers and reduction in yield 2 or 3 seedlings may be used with spacing in rows of 20 cm x 10 cm. Planting done in lines ensure uniform stand of the crop and facilitate intercultural operations.

***7.11.1.3 Crop Nutrition***

For high yielding varieties, adequate fertilizer is essential. For each 100 sq m of nursery bed, 1 kg of Nitrogen, 0.5 kg of $P_2O_5$, and 0.5 kg of $K_2O$ may be applied by broadcasting and lightly worked in just before sowing of the seeds. Fertilizer application in the main field is recommended as follows:

| | | |
|---|---|---|
| Nitrogen (Urea-96 kgs) | - | 60 kg |
| $P_2 O_5$ (DAP 87 kgs) | - | 40 kg |
| $K_2 O$ (MOP 50 kgs) | - | 30 kg |

All the phosphorus, potash and half of nitrogen should be applied and incorporated in the soil in the last puddling. Remaining Nitrogen should be applied in two equal split doses, first at 21 days and second after 42 days of transplanting. Draining the field and applying 40-50 kg of zinc sulphate to the soil or foliar application of 0.5% zinc sulphate solution i.e. 1 kg of zinc sulphate and 0.5 kg quick lime in 200 lit of water should be made in case of zinc deficiency in the current crop.

#### *7.11.1.4 Weed Management*

Apply machete granules @ 30-35 kg/ha or 1.2 lit Machete mixed in 60 kg sand in 4-5 cm standing water, 5-7 days after transplanting.

#### *7.11.1.5 Plant Protection*

Many pests and diseases attack the rice crop which reduce the yield. The common diseases are blight, blast, foot-rot while the common pests are stem borer, leaf roller, rice bug and rice grass hopper.

#### *7.11.1.6 Irrigation*

2-5 cm water level should be maintained after seedlings are well established and till the crop flowers. Prior to top dressing of Nitrogen the field may be drained for 1-2 days and then the fertilizer is applied and the field is reflooded within 24 hours. 4-5 cm. water level should be maintained from the flowering time till the grains become hard. After this, it should be drained out to facilitate the harvesting operations.

### 7.11.2 Maize

#### *7.11.2.1 Improved Varieties*

The varieties recommended are

| | | | | |
|---|---|---|---|---|
| (i) | Hybrid | Proagro Hybrid | - | 3485 |
| | | Proagro Hybrid | - | 3455 |
| | | Pac-701 | - | 705 |
| | | Ganga – 11,Him 120 ect. | | |

| | | |
|---|---|---|
| (ii) | Composite | Prabha<br>NLD – White<br>Palmira<br>VL – Makka – 88 |

Mansar, Swan Composite, Muneng-8531, etc.

The seed of hybrids are never to be used for second year as these are made by crossing two inbreed line which may or may not produce even to the extent of local varieties. Hybrid seeds should be changed every year. Composite seeds are to be changed every 3-5 year.

### *7.11.2.2 Crop Establishment*

(i) **Land Preparation**

Soil should be well pulverized and it should be free from clods, stubbles of previous crops and weeds. Adequate moisture in the seeding zone should be ensured.

(ii) **Time of Sowing and harvesting**

In lower elevation - February to March

In higher elevation - March to April

For Rabi Maize - July to August at lower hills

Maize crop is harvested manually when the cobs dry and turns, yellowish in colour with good management of yield of maize can be obtained – hydrid – 30-40 qlt/ha, composite – 20-30 qlt/ha.

(iii) **Depth of sowing**

Seed should be placed 5-6 cm deep below the soil where sufficient soil moisture is available to enable germination.

(iv) **Seed rate and Spacing**

22-22 kg of seed per hectare is sufficient if the seed viability is around 85%. Seed rate can be augmented according to seed size and viability. In case of bold seeded varieties, the seed rate increases.

The seed rate mentioned above is for net area sown but in case of terrace field, the net area is usually 50-70% the gross area and hence, the seed rate, quantity of fertilizer, etc. has to be decreased based on percentage of net area available. When the time of sowing is delayed, the seed rate increases proportionately.

For hybrid and composite varieties, row to row spacing of 60 cm (2ft) and plant to plant spacing of 18-25 cm (7-10 inch) is provided. Hybrids and most of composite are dwarf and hence spacing between row to row and plant to plant is much lower than the local varieties. The lower spacing between row to row and plant to plant should also go hand in hand with adequate plant nutrient through fertilizer.

***7.11.2.3 Crop Nutrition***

High yielding varieties require high does of fertilizer and hence if enough nutrients are not available the performance of HYV hybrids is not as high as it should be. 1000 kg or 50 baskets of well rotten farm yard manure can supply about 5 kg of Nitrogen and similar amount of Phosphorus and Potash (which is equivalent to 10 kg DAP + 7kg Urea + 3kg MOP) and hence meeting nutrient requirement of the crop through farm yard manure/compost only may not be possible without application of fertilizer. The farmyard manure/compost, however, improves the soil texture and increases water holding capacity of soil. For timely sown and with adequate soil moisture, the requirement of fertilizer will be as under:

For Hybrids - Approx. 120:60:30 to 40 NPK per ha or
DAP – 130 kg per ha
Urea – 210 kg per ha
MOP – 50-65 kg per ha

For composite - Approxc 100:60:30 to 40 NPK per ha.
DAP – 130 kg per ha
Urea – 165 kg per ha
MOP – 50-65 kg per ha

The whole of DAP, MOP and 1/3$^{rd}$ Urea can be applied at the time of sowing or before sowing 1/3$^{rd}$ of Urea may be top dressed during first interculture. 1/3$^{rd}$ remaining Urea may be applied at second interculture or earthling up. The requirement of Nitrogen of the crop increases once flag leaf emerges. Deficiency of Zinc has been noticed in many places. When such deficiency is anticipated, 5-10 kg of $ZnSO_4$ per ha can be applied.

### *7.11.2.4 Weed Management*

Chemical weed control is not followed in the State and hence mechanical weed control is to be followed. Control of weed in time decreases competition of weed with maize crop for both soil moisture and plant nutrient.

### *7.11.2.5 Plant Protection*

For severe insects, diseases and pest's problem, the VLW should be contacted for timely control measures.

*7.11.2.6 Harvesting & Yield*

As the harvest approaches, the stems and leaves are usually straw coloured. Drain the field and inspect the grains on the upper portion of the penicle. Delay in harvest may affect the shedding and milling quality of the grain. When the moisture content of the grain is 20-25%, the crop is ready for harvest. It is harvested by sickle by manual labour, dried in the field for 3-4 days and then threshed by pedal thresher or by bullocks. Moisture should be reduced to 13-14% before milling or storage. Yield @ 25-30 qtl/ ha can be obtained with the above practice.

*7.11.2.7 Inter Cropping*

Inter cropping of Soybeam, Ginger, Beans, Millet pulses is easier with line sowing.

*7.11.2.8 Soil Management*

In case the soil is very acidic, pH of the soil has to be raised by applying Dolomite/ limestone based on soil test report. However, application of one ton of dolomite per ha is beneficial. If furrow application is followed, 200-500 kg of dolomite at least 15 days before sowing is economical.

**7.11.3 Wheat**

*7.11.3.1 Improved Varieties*

A number of new variety of wheat seeds are given every year under minikit programme from which the farmers and the VLW of the area can select the best variety suited for different climatic and cultural conditions. Varieties presently recommended are Sonali, VL - 738, Sonalika, VL-616, K-88.

### *7.11.3.2 Crop Establishment*

(i) **Land Preparation**

Soil should be well pulverized and it should be free from clods, stubbles of previous crops and weeds. Adequate moisture in the seeding zone should be ensured.

(ii) **Time of Sowing**

The most suitable sowing time is when the mean daily temperature is around $20^{o}$ - $23^{o}C$. This temperature in Sikkim is available from September onwards. Sowing of wheat from later part of September onwards will ensure adequate soil moisture. However, it must be ensured that germination is not effected by water logging conditions that may occur if there is excess rainfall. Sowing in the small ridges can prevent excess moisture in the root Zone. Wheat sowing should not be delayed beyond 15th of December.

Time of sowing depends upon the varieties. Some varieties are meant for early sowing and some are meant for late sowing. Sonalika and Sonali are usually recommended for mid to late sowing conditions.

In order to harvest wheat before rainy season and also to sow the Kharif crop in time, sowing of wheat done in late September to October is considered optimum. This will also enable the crop to germinate early and establish before the plant is affected by low soil moisture condition during the month of December to February.

(iii) **Depth of Sowing**

Seed should be placed 5-6 cm deep below the soil where sufficient soil moisture is available to enable germination.

(iv) **Seed Rate and Spacing**

100 kg of seed per hectare is sufficient if the seed viability is around 85%. Seed rate can be augmented according to seed size and viability. In case of bold seeded varieties, the seed rate is increased to 125 kg/ ha. The distance between rows should be 20-20.5 cm. It is always better to use seed drill for sowing.

The seed rate mentioned above is for net area sown but in case of terrace field, the net area is usually 50-70% of the gross area and hence, the seed rate, quantity of fertilizer etc, have to be decreased based on percentage of net area available. When the time of sowing is delayed, the seed rate increases proportionately. For very late sowing, it can be as high as 125 kg / ha.

### *7.11.3.3 Crop Nutrition*

For timely sowing and with adequate soil moisture, the requirement of fertilizer will be as under:

| | | |
|---|---|---|
| i) Nitrogen | 60-80 kg/ha |
| ii) Phosphorus | 40-60 kg/ha |
| iii) Potash | based on soil testing value. |

It is always better to get the soil tested. In the absence of soil testing report, generalized schedule to be followed may be as follows:

i) At the time of sowing or before sowing – 100 kg of DAP + 75 kg urea + 25 to 50kg of MOP

ii) Top dressing - 50 kg urea before Tillering.

iii) The fertilizer should be applied about 5 cm below and away from the seed for better result. Mixing fertilizer with the seed during time of sowing will decrease germination percentage considerably.

iv) In case if there is no adequate soil moisture the plant cannot up-take the nutrient and hence, irrigation and fertilization should go hand-in-hand. The rate of fertilizer application should be reduced if adequate moisture cannot be ensured.

#### *7.11.3.4 Weed Management*

Chemical weed control is not followed in the State and hence mechanical weed control is to be followed. Control of weed in time decreases competition of weed with wheat crop for both soil moisture and plant nutrient.

#### *7.11.3.5 Plant Protection*

For severe insects, diseases and pest's problem, the VLW should be contacted for timely control measures.

#### *7.11.3.6 Irrigation*

For the good wheat crop adequate soil moisture is important at 6 stages *viz.* :

i) Crown root initiation

ii) Tillering

iii) Late jointing

iv) Flowering

v) Milk stage

vi) Dough stage.

Of these period, adequate soil moisture at crown root initiation is most critical for proper germination. Many farmers do not irrigate the crop even if the water is available. Irrigating the crop during this stage increases the production substantially. For irrigating the wheat crop in paddy field, water can be collected in one of the top field and irrigate the lower field by flooding. Irrigation in land other than paddy field can be done by sprinkler irrigation.

#### *7.11.3.7 Inter Cropping*

In case if the crop is sown as rainfed and the rain is not anticipated in time, wheat can be grown in combination with mustard, which is more drought resistant. Inter cropping wheat with mustard in the ratio of 4 rows of wheat and 1 row of mustard will ensure better returns.

#### *7.11.3.8 Soil Reclamation*

In case if the soil is very acidic, pH of the soil has to be raised by applying Dolomite/ limestone based on soil test report. However, application of one ton of dolomite per hectare is beneficial. If furrow application is followed, 200-500 kg of dolomite at least 15 days before sowing is economical.

#### *7.11.3.9 Harvesting and Threshing*

The crop should be harvested when it turns golden yellow and is completely dry. Threshing can be done manually or mechanically in thresher. Before storage, the grain must be clean and properly dried.

## 7.11.4 Pulses: Urd (Black Gram)

### *7.11.4.1 Improved Varieties*

Following tolerant varieties of urd bean may be adopted:

| | | |
|---|---|---|
| Urd bean YMV | : | NEPZ : PDU 41, DPU 88-31, |
| Narendra Urd-1 | : | Pant U 30; |
| NWPS | : | Mash 338, PDU 1 UG218; |
| CZ | : | PDU 1 |
| SZ | : | WBU 108 |
| Powdery Mildew | : | SZ: LBG 17 LBG 648 (tolerant) |

### *7.11.4.2 Crop Establishment*

Urd requires a warm humid growing season, and is generally cultivated as post-Kharif relay crop with maize or as a pure crop after maize harvest. Heavier and water retentive soil is preferred where rainfall is scanty for better utilization of the residual soil moisture. It is also grown on the paddy field bunds. The crop is grown in the lower and mid-hills up to an elevation of 1400 meter.

(i) **Land Preparation**

The crop requires a fine seedbed. Thorough clearing of weeds and crop residues and one deep ploughing with soil turning plough followed by digging of sides and corners of the terraces is sufficient. Then, a shallow ploughing followed by seed sowing and digging or raking to cover over the seeds should be done at the time of sowing.

(ii) **Seed Rate And Sowing**

About 18-20 kg of seed is required for a pure crop. The seed is broadcasted and covered over the seeds during the month of July-August.

(iii) **Dose**

10 kg of normal size seeds such as Urd bean may be treated with 200 gm of Rhizobium and 200 gm phosphate solubilising bacteria/fungi inoculate by slurry method. Thus, 400 gm Rhizobia and 400 gm phosphate sloubilising bacteria/fungi is enough for seed treatment required for one hectare.

### *7.11.4.3 Weed Management*

Interculture is not required for rainfed urd as it affects the utilisation of residual moisture of the soil but manual weeding after 30-40 days of sowing is essential to suppress the weed growth at the early growth stage of the crop.

### *7.11.4.4 Plant Protection*

Need-based soil application of phosphate or foliar application of monocrotophus, dimethoate against thrips/ white files etc. shall be done. Need based foliar application of endosulfan, chlonophriphos against leaf defoliators such as prodenia caterpillar, pod borer etc. shall be undertaken.

### *7.11.4.5 Harvesting and Yield*

Plants are harvested when the pods are ripe during November December. The delay in harvesting may result in shattering of seeds. The plants are pulled out from the roots or cut and carried to the threshing floor where it is stocked and threshed after drying manually with sticks of bullocks. The grains are cleaned and dried before storage.

A pure crop of Urd bean may yield 400 to 500 kg/ ha depending to its management. The national average yield on Urd bean is 466 kg/ha (1996-97).

### 7.11.5 Other Pulses

Other pulse crops of Sikkim are ricebean, horse gram, cowpea, rajmash, field peas and french beans.

(i) **Rice Bean**

Ricebean is usually cultivated on paddy field bunds, mix-crop with maize or pure crop after maize harvest at mid and low-hills of Sikkim. Ricebean (Calcaratus Roxb or Vigna umbellata thunb) contains 16-25% protein and used same as that of Urd. Its cultivation method is same as that of Urdbean.

(ii) **Horse Gram**

Locally it is known as “Gahat” in Sikkim and is also cultivated same as that of Urd bean. It is a good source of protein and has medicinal value for patients suffering from urinary trouble and measles. Horse gram (Dolichos biflorus) plants are thin, climbing, bushy type attaining heights of 30-45 cm. Seed requirement is 45 kg/ ha whereas it is only 8 kg for a mixed crop. All other cultivation methods are same as that of Urdbean.

### 7.11.5 Cardamon and Ginger

The details of agriculture practices in respect of cardamon and ginger are given in the form of tables at Table 7.27 and 7.28 respectively.

**Table 7.27 Agriculture Practices for Cardamon**

| Sl. No | Crop | Varicties | Soil | Sowing Time | Seed Rate/ ha | Spacing (in cms) | Manure & Fertillzer/Ha | Irrigation | Harvesting (days) | Yield/ Ha tonnes | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Cardamom | Ramsey High Sawney Mcdium & High Altitute Golsey Low Altitude Ramla High Altitude Seremna Medium and Low Altitude. Varlangey High Altitude. SBL –5 & SBL 50 Medium and High altitude | Deep and well drained soil with Loamy texture land with modente land with mode create slopes is to be preferred | Sep.-Oct. in Nusery Scrolling Planting May- June | Scooding ha at the speding of 15 mx 1 m 4445 nos | Pri Nursery 10x Sec. Nursery 15×10 Planting in Plot 150 ×150 | Forest soils are generally rich in organic matter and nitrogen. However, nondeible oil Cakes may be applied@ 1kg / plant atlest once the two years in April May and in plantations with very high productivity fertilizers @ 40:60:40 KPK per ha may be applied in two split doces in April May and Sept. Application of bio-fertiliger may be highly beneficial. | For sustainable and better yield the corp may be irrigated during dry month. | Aug. Nov. | 0.180-0.200 | Pest : Leafeating Caterpillar. This insect is kept under control by their natural enemies. Therefore the use of insecticides are not advisable. However, if necessary spray of 0.5% Quanolphos or Endosuphan is recommended. Chirkey and Furkey : Management As long as virus inoculum in present in the field, control of vectors (aphids) fails to prevent disease spread. Being a virus disease, the affected plants cannot be cured, but the losses can be minimized by adopting appropriate management measures. Keep constant surveillance to detect |

| Sl. No | Crop | Varicties | Soil | Sowing Time | Seed Rate/ ha | Spacing (in cms) | Manure & Fertillzer/Ha | Irrigation | Harve sting (days) | Yield/ Ha tonnes | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | disease affected plants.<br>Adopt regular rouging of infected plants as soon as symptoms appear (uproot and destory affected plants). Repect detection and rouging at regular intervals.<br>Use seedlings produced in certitude nurseres.<br>Avoid sucker (rhizome) planting as far as possible. |

## Table 7.28 Agriculture practices for ginger

| S. No | Crop | Varieties | Soil | Sow-ing | Seed Rate/ ha | Spascing (in cms) | Manure & Fertilizer /Ha | Irrigation | Harvesting (day) | Yield/ha tonnes | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Gin-ger | Bhaisey Majholey<br>a) Jorethangy<br>b) Gorubathney | Light loamy soil with full of humus well drained soil is essential | March April | 16-25 Qtls. | 40× 20 × 8 on 30 cms raised bed 2 rows in each bed. | 10-20 tonnes FYM or one Itonne Neem cake and 75. kg N. : 80 kg P : 50 kg K Basal Dose :<br>Urea : 45 kg<br>Dap : 45 kg<br>MOP : 83 kg | Rainfed | 270-280 (days) Nov. Dec. | 10-15 tonnes | Toavoid disease problem use owngownhealthy and discease free seed. Treat Rhizome with 0.3% (30 gm in 10 Ltr. water). Manoozeb (Dithan M 45 indofil or Tratrhizome with Trichodema (one part TD & 5 Rhizone)<br>Rhizome Rot.<br>a) Soft Rot : Drechs soil with 0.2% (20 gm in 10 Ltr. water Dithone M 45<br>b) Dry Rot : Spray Bavistan (Carbendazime 0.1% 10 gm in 10 ltr. water<br>c) Bacterial Witl :<br>d) Removeinfected plant and drench soil with copper fungicide 0.2 % (20 gms in 10 Ltr. Water )<br>Nematode:<br>e) Hot6 water treatment 51-52 C for 10-15 minutes<br>f) White Grub Use biological control measure i.e. light trapon $1^{st}$ rain during March Apr. mix 4 ltr. Quinol phos/Ekalux with FYM and apply during planting on bed. |

## 7.12 SUMMING UP

The status of agriculture development and the strategies proposed to be adopted by the state Govt. may be summed up as follows:

1. The State is wholly a hilly state with no plain land.
2. The agro-climatic condition ranges form sub-tropical type in the lower valleys to alpine condition in upper reaches. No single crop or the variety of crop can suit to all the elevations. The crop and the variety have to be different for different elevations and sometimes even for different aspect of slope due to the presence of mighty Khangchendzonga range of mountain in the Northwest of the state.
3. There is no land of Class-I and less than 3% of the land has been classified as the land of Capability Class-II and rest of Class-III and above. The cultivation is done in sloping topography with or without proper bench terracing which call for careful and scientific approach of land utilisation so as to realize maximum benefit.
4. Except the paddy field, more than 50% of other lands are either improperly terraced or unterraced. As a consequence of which (i) plant nutrients are lost by runoff and leaching when there is high intensity rain during monsoon and (ii) cultivation is difficult due to sloppy terrain.
5. The principle field crops grown include cereals like maize, rice, wheat, finger - millet, buckwheat; pulses like urd, rice bean, field-pea, cluster-bean and rajmah; oilseeds like soyabean, rapeseed and mustard.

6. The irrigated area in the state is about 11% of the operational holdings but the area under assured irrigation is less than 5%. All the area under paddy crop has been considered as irrigated area but many paddy fields cannot be irrigated even in the kharif season if the rainfall is less than normal, resulting in inadequate surface runoff in the stream that can be collected for puddling of rice field. In 2002 kharif season, though the rainfall was more or less uniformly spread, many paddy fields had to be transplanted late due to inadequate runoff in the stream. Hence agriculture in the state is practically rainfed.
7. The total rainfall ranges from 2300 mm to 3500 mm - the east district receiving the higher rainfall than the south district. However, the rainfall is not uniformly distributed. The rainfall is very high and of very high intensity from May to September and tapers to almost zero by December - February. The rainfall values of most of the years show that during the Rabi season, the amount of precipitation does not meet the loss of soil moisture due to evaporation alone.
8. No system of harvesting the rainfall of the monsoon and utilization during the Rabi season has been established. Some water harvesting structures constructed during the recent years have been quite successful.
9. Presently, over three-fourth of the working population is dependent on agriculture and horticulture which contribute about 40% of the State GDP.
10. The state is deficit in food production coupled with the rice based food habit. With intensive cultivation and slight change of food habit, the state can even strive for food self-sufficiency. It will be

much cheaper to import fertilizer than the food itself as every unit of fertiliser increases the food production by two or more units. Irrespective of whether it is food or fertiliser, the transportation cost in the hill is very high.

11. The population of the state has increased by about 33% over a decade (1991-2001) but the food production is substantially lagging. Moreover, the estimates of area and production in the state have also not been realistic to the extent that the estimation was based on the crop cutting experiment done in an unit area. The net sown area on an average ranges from 40-65% of the gross area due to area covered by terrace riser, boulders, stream bank, fodder grass / trees etc. Recently the method of estimation has been changed to intensive survey of area and production made by extrapolation of base data according to which sub statical reduction in production / productivity and even in area of crops have been seen.

12. Although horticulture is more profitable for the state, it has been the tendency of the average farmers to look for food security and grow annual crops in preference to meet their own requirement. To make the state as horticultural state, the stepping step will be to have intensive agriculture so that their requirement is met from less area and the rest is diverted to horticulture (fruits, cardamom etc. require long gestation period)

13. Apart from unfavourable geographical and socio-economic aspects like limited cultivable land, smaller land holdings, difficult terrain, diverse agro- climatic conditions, low farm income and lack of supportive infrastructure for agriculture development as also the absence of adequate number of other industries and the literacy

rate in the state being higher than the national average availability of more and more unemployed educated persons may have to seek their scope in the agriculture of agro-based industries under following three-pronged strategy.

a. Mechanization of agriculture
b. Agriculture not as medium of subsistence but as business enterprise
c. Higher level of inputs and technology.

14. The investment in agriculture has been stagnant or rather tapering over the successive plan periods. The investment pattern during Eighth and Ninth Five Year Plans is given in Table 7.28.

**Table 7.28 Investment pattern in agriculture in Eighth and Nineth FYP**

| | VIIIth Plan Expenditure | | | | | | IXth Plan Expenditure | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Particular** | **92-93** | **93-94** | **94-95** | **95-96** | **96-97** | **Total** | **97-98** | **98-99** | **99-00** | **00-01** | **01-02** | **Total** |
| Total State | 12033 | 11989 | 13250 | 21078 | 19279 | 776286 | 22000 | 19383 | 25000 | 28000 | 28150 | 122533 |
| Agriculture | 183 | 938 | 1215 | 1572 | 1159 | 6117 | 861 | 861 | 854 | 609 | 755 | 3940 |
| % of agriculture | 9.83 | 8.24 | 9.17 | 7.46 | 6.01 | 7.88 | 3.91 | 4.44 | 3.24 | 2.18 | 2.68 | 3.22 |

The above expenditure figures include agriculture, horticulture and soil conservation activities:

- In 2001-2002 the expenditure on establishment cost (salary, office expense, motor vehicle etc.) amounted to 45% for agriculture and 56% for soil conservation.
- The major development expenditure for agriculture was on seed and fertilizer.

- The allocation for the IXth Plan for the Crop Husbandry for Agriculture was 57% of approved outlay of Rs. 80.00 crore and that of Soil & Water Conservation was 14% of approved outlay of 16.25 crore which together indicates that as against Rs. 96.25 crore approved outlay, the expenditure has been only Rs. 39.40 crore i.e. about 41 % of the approved outlay for the ninth FYP.

# CHAPTER - 8
# HORTICULTURE

# HORTICULTURE

## 8.1 GENERAL

Land resources in Sikkim are constrained on account of demographic pressure. Diversification in the pattern of land use has to take into account both food security requirements and constraints imposed by the terrain. The limitations of terrace farming in terms of productivity, irrigation and the scope for extending cultivation highlight the constraints faced by farming for livelihood security. Under these conditions, innovative practices in land management, horticulture and floriculture (including marketing systems and linkages) medicinal and aromatic plants, Bee beeping, organic forming animal husbandry and fisheries have been identified as growth sectors.

Promotion of horticulture depends on successful processing and marketing practices. The nature of production, which is dispersed and small in quantity, does not allow farmers to realise economies of scale in marketing. Sikkim, in fact, has tremendous potential for the development of horticulture and floriculture, if marketing infrastructure is strengthened.

Marketing of the most important horticulture products (cardamom, orange and ginger) is almost totally dependent on private traders, merchants and middlemen. Value addition of almost all the hill products is lacking. Farmers are deprived both as producers and consumers. To promote horticulture, it may be necessary to create a market infrastructure through wholesale market, provide sale options, as well as set up collection and grading centers at the production sites. Activating existing co-operative societies to take up marketing and increasing cooperative co-operative coverage is also important in this context. The promotion of farmer's organization catering to specific commodities should also be encouraged.

## 8.2 HORTICULTURE

The state being hilly has limited scope of industrial growth, and hence has not adequately succeeded in decreasing the pressure on agriculture/horticulture as the agrarian population has decreased at minimal since its merger in the Indian Union (1975). The contribution of horticulture to the state's domestic product may be quite significant and therefore this sector shall receive priority attention for higher levels of rural prosperity. Horticulture includes varieties of fruits, vegetables, root and tuber crops, mushroom, honey, nuts, spice crops like large cardamom, ginger, turmeric, seed spices, medicinal and aromatic plants etc. The sector has established its importance in improving land use, promoting crop diversification, generating employment and above all providing nutritional security to the people. Horticulture also encompasses every aspect of aesthetics, economics and environmental regeneration.

### 8.2.1 Present Status

Horticulture production, including fruits, vegetables, potatoes, other tubers, cardamom, ginger and turmeric, has increased substantively between 1975-76 and 1999-2000 as shown in Table 8.1.

**Table 8.1 Horticulture production from 1975-76 to 1999-2000**

**(Unit: tonne)**

| Sl. No | Crops | 1975-76 | 1980-81 | 1985-86 | 1990-91 | 1995-96 | 1998-99 | 1999-00 |
|---|---|---|---|---|---|---|---|---|
| 1. | Fruits | 4700 | 6350 | 8200 | 10500 | 12000 | 8337 | 14916 |
| 2. | Potato | 5000 | 6646 | 16400 | 18000 | 24000 | 16274 | 16555 |
| 3. | L. Cardamom | 2300 | 3500 | 3900 | 2600 | 3600 | 1283 | 1925 |
| 4. | Other Tubers (Potato, Yams) | 100 | 200 | 400 | 600 | 1000 | 1740 | - |
| 5. | Ginger | 2000 | 3200 | 10900 | 16000 | 24000 | 13629 | 13842 |
| | **Total** | **14000** | **19696** | **39400** | **47100** | **63600** | **41263** | **47238** |

(Source: Government of Sikkim, Department of Horticulture, Gangtok)

In 1998-99, there was a very long spell of dryness in Sikkim. This had visible effect an agriculture production including that on cash crops. Districtwise break up of production during year 1998-99 is given in Table 8.2.

**Table 8.2 District-wise horticulture production in 1998-99**

**(Unit: tonne)**

| Sl. No. | Crops | North | East | South | West | Total |
|---|---|---|---|---|---|---|
| 1 | Fruits | 49 | 3685 | 1526 | 3090 | 8350 |
| 2 | Potato | 1213 | 3768 | 3825 | 7468 | 16274 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | Other Tubers | 70 | 390 | 650 | 630 | 1740 |
| 4 | L. cardamom | 547 | 480 | 143 | 113 | 1283 |
| 5 | Ginger | 116 | 3872 | 5227 | 4414 | 13629 |
| 6 | Total | 1995 (4.8%) | 12195 (29.5%) | 11371 (27.6%) | 15715 (38.1%) | 41276 (100%) |

Source: Sikkim Human Development Report 2001, Table-3.17

It is observed from the above table that the most important district in terms of horticulture production is west district which shares about 38% of the production with highest production of fruits and potato and second highest in ginger. South district is having highest production in ginger and other tubers. East and north districts are the highest in fruit produce and large Cardamom respectively.

The impact of horticulture on the livelihoods of people has, therefore, been substantial, although concerns about sustainability of development of horticulture shall be addressed in realistic manner taking cognizance of the prevailing eco-system of the state.

### 8.2.2 Tenth Plan Proposals

#### *8.2.2.1 Strategy*

Tenth Five Year Plan proposals have reviewed to status of horticulture development in the state and have analysed the situations in terms of state's strengths, weaknesses, and availability of hi-technology for its development in the country. These aspects are described as follows:

**i) Strengths**

- Horticulture is a wide product base, high volume of production surplus of large cardamom and ginger, and is a backbone of State’s economy;
- Favorable climate - tropical, sub-tropical, temperate and alpine for producing all kinds of horticultural crops around the year;
- Strategic geographical location to produce a variety of horticultural crops for high domestic demand and export in the neighboring States;
- Potential traditional crops for domestic and export market; and,
- Hot-spot of biodiversity of horticultural crops such as floriculture, medicinal and aromatic plants, apiculture, root and tuber crops, etc. which could be explored for commercial cultivation.

**ii) Weakness**

- More than 80% farmers are small and marginal with fragmented holdings (average 0.4 ha.);
- Produce multiple products in small quantities with heavy wastages mostly in land locked areas where transportation is difficult during monsoon season:
- Produce highly perishable products with no vital linkages of cold storages, marketing and distribution;
- Farmers’ organizations either non-existent or disorganized as against unionized traders;
- Exploitation by traders and commission agents;
- Business transactions between producers and wholesale traders have the same market-yard in the state:

- Farm-gate prices only 10-20% of retail price as compared to 70% in advanced countries;
- Glut situation with distress sale, followed by scarcities and vacuum in the market;
- Poor per hectare yields and limited crop varieties as compared to national and international standards;
- Lack of integration of horticulture with various agri-allied and rural development schemes;
- Lack of financial and management resources mainly due to existing land laws of the State.
-

**iii) Hi-Tech Horticulture available**

- High density plantations;
- Bio-technology/Micro-propagation (Tissue culture);
- Hi-Tech cultivation under controlled climatic condition i.e. Poly house, Green house, net house, etc.;
- Hi-Tech availability of Controlled Atmosphere storage with temperature, relative humidity, oxygen and carbon-dioxide manipulation in the multi-chamber Cold-chain storages and transport vehicles;
- Irrigation by drip, sprinklers, fertigation, water harvesting structures;
- Nursery management for quality seed/plant production;
- Organic farming;
- Use of plasticulture

### 8.2.2.2 Objectives

Taking cognisance of the above aspects, following objectives have been set forth for the Tenth Plan period with a view to achieve annual growth rate of 10% subject to adequate availability of funds.

1. Sustainable horticulture production of fruits, vegetables, root and tuber crops, floriculture, medicinal herbs, aromatic plants, beekeeping (honey), mushroom, spice crops such as large cardamom, ginger, turmeric etc. for high domestic demand and export;
2. To provide food and nutritional security to the people;
3. To persuade hobby and kitchen garden/ back-yard cultivators for commercial production of horticultural crops both for poverty alleviation as well as for rapid economic growth of the people;
4. To explore commercial cultivation of plant biodiversity i.e. medicinal and aromatic plants, floriculture fruits and vegetables etc.;
5. To develop high quality horticultural firms in identified belts and make such areas vibrant with horticultural activity which in turn will act as hubs for developing commercial horticulture and Agriculture Export Zone;
6. Develop marketing infrastructure of two wholesale and fourteen Rural/Apni Mandies for marketing of horticultural produce;
7. Creating Vital Linkages of Post Harvest management, could Chain infrastructure with Multi Chamber Controlled Atmosphere Stores at Wholesale and Apni Mandies for perishable horticultural produce storage, marketing and distribution of fruits, vegetables ginger, cardamom etc;

8. To provide facilities for primary processing of products such as extraction, fermentation, distillation, juice vending, pulping dressing, cutting, chopping etc.;
9. Providing all kinds of horticulture inputs such as tools equipments, plastics, packaging, crates, cartoons, aseptic packaging, nets, cardamom driers, etc.;
10. Capacity Building and Training of trainers, farmers, NGOs. Entrepreneurs on hi-tech horticulture and other capacity building programs;
11. To facilitate private investment in horticulture through back-ended subsidies of NHB, APEDA, BABARD, and other joint ventures;
12. To explore possibility of Horticultural produce export specially Cymbidium Orchids, Carnation, Gerberas in flowers; Ginger, large cardamom and Cherry Pepper through formation of Agri-Export Zones in Sikkim.

### *8.2.2.3 Production Programs*

Projection of production of important horticulture crops during in Tenth Plan period is given below:

**i) Fruits**

The 10$^{th}$ Plan envisage to produce 6800 tonne of orange and 2300 tonne of other fruits making a total of 9800 tonne of fruits with an annual growth rate of 10 percent. The Annual Plan Target proposed for 2002-03 was 4983 tonne of orange and 2300 tonne for other fruits. Out of this, only 3500 tonne of orange and 1840 tonne for other fruits is likely to be achieved due to hail storm damage of April – May 2002 which is about 73.32% of the total target. Annual target for 2003-04 has been proposed to 5480 tonne of orange fruit and 2,530 tonne of other fruits making a total 8010 tonne. An effort will be made to produce enough fruits of Mandarin orange and passion fruits for the state's requirement and for fruit preservation factory, Singtam. Mass production of buddling of orange, grafts of guava, mango, layers of litchi, seedlings/ cutting of passion fruits will be taken up in Government farms.

**ii) Vegetables**

The 10th plan envisages to produce 12,420 tonne kharif, 15,060 tonne rabi, 11,520 off-season making a total of 39,000 tonne of vegetables at the annual growth rate of 10%. The Annual Target for 2002-03 was 9,108 tonne kharif 11,044 tonne rabi and 8,448 off-season making a total of 28,600 tonne. Anticipated achievement of vegetable production is 8197 kharif vegetable, 10,492 tonne rabi vegetables and 8,026 tonne off-season making a total of 26,715 tonne. Production target proposed for 2003-04 is 10,020 tonne of kharif vegetables, 12,148 tonne of rabi vegetables and 9,293 tonne off-season vegetables making, a total of 31,461 tonne.

**iii) Root & Tuber Crops**

The 10th Plan envisages potato production of 17,618 tonne kharif potato, 17,960 tonne rabi potato and 2,700 tonne of other root and tuber crops making a total of 38,278 tonne at the end of Xth Plan with an annual growth of 10%. The annual target for 2002-03 has been proposed as 12,920 tonne of kharif potato, 13,167 tonne for rabi potato and 1,980 tonne other root and tuber crops, making a total of 28,067 tonne. Anticipated production out of this target is only 7,752 tonne of kharif potato, 10,534 tonne of rabi potato and 1,584 tonne of other root and tuber crops, making a total of 19,870 tonne which is about 70.80% less then the target. The short fall of production is attributable to the damage done by heavy hail storm to kharif potato resulting not only less production of the crop but also causing shortfall in seed potato availability affecting the rabi potato production also. Production target proposed for 2003-04 is 14,212 tonne of kharif potato, 14,483 tonne rabi potato, making a total of 28,695 tonne. Annual target for other root and tuber crops is 2,178 tonne.

**iv) Large Cardamom**

The 10th Plan target of Large Cardamom production has been envisaged to 6,300 tonne, with annual growth rate of 5%. The annual target proposed for 2002-03 was 4,620 tonne. The anticipated achievement out of this target is only 2,772 tonne which is due to heavy damage of cardamom plantations during April May, 2002. This will not only affect the production of 2002-03 but also for 2003-04 and 2004-05. Annual target of production for 2003-04 has been proposed to 4,850 tonne. The target will be achieved through replantation of old orchards, providing planting materials for gap filling, providing shade tree saplings etc. Large Cardamom orchards have a productive life of 15-20 years. About 10,000 ha of existing orchards need immediate replantation.

**v) Ginger**

The 10th Plan target of ginger production has been proposed to

35000 tonne, with annual growth rate of 8% and that of annual plan 2002-03 is 25300 tonne. The anticipated achievement against this target is also 25,300 tonne. Annual target for 2003-04 has been proposed to 27830 tonne. This will be achieved through creating awareness of ginger diseases to farmers, disease free seed production of ginger in the seed villages providing disease free seed minikits, IPM activity to combat pests and diseases of ginger etc. are the important activities of this scheme. The scheme envisages to produce 200-250 tonne of disease free seed for distribution to the farmers. Production of healthy disease free seed in the seed villages and providing disease free seed on demonstration to the small and marginal farmers in the seed villages is the most important activity of this scheme.

### 8.2.3 Infrastructure Facilities

Vital linkages of post harvest, Cold Chain (Controlled atmosphere storages), marketing infrastructure and distribution is the weakest linkage in horticulture development. Major quantities of horticultural crops are lost after harvest, especially during handling from producers to consumers due to improper handling. These losses, which are both quantitative and qualitative, are estimated to be as high as 50% in most of the developing countries, and estimated to 37% and works out to the tune of Rs. 25,000 crores in India. These losses are more than 50% in Sikkim which are mainly attributable to its geographical location, high rainfall condition, lack of suitable variety for off-season cultivation and are very important from the stand point of human health economy and ecology.

The various measures for reducing these post-harvest losses are summarised as follows:

- Harvesting products at optimum maturity, and adequate (cool) time.
- Protecting the products from exposure to the sun after harvest.
- Avoid mechanical injury during harvesting.
- Use of pre-cooling and refrigeration.
- Use of appropriate high RH during storage and transport.
- Avoid infestation with diseases and insects, and use adequate control measures.
- Use of appropriate packing and packaging systems.
- Transport products adequately.
- Store the product properly at appropriate conditions.
- Gentle handling of the produce during all the post harvest chain.

During Tenth Five Year Plan and Annual Plans 2003-03 and 2003-04, physical and financial targets in respect of various activities under horticulture and other programmes are given in Table 8.3 & 8.4 respectively. The physical achievement during Ninth plan and anticipated achievement during April 2002-03 are also including in Table 8.3.

## Table 8.3 Physical targets and achievements for Tenth Five Year Plan & Two Annual Plan

| Sl. No | Items | Unit | Ninth Plan actual achiev-ement | Tenth Plan 2002-07 Target | Annual Plan 2002-03 Target | Anticip-ated Achlev-ement 2002-03 | Proposed Annual Poan 2003-04 Target |
|---|---|---|---|---|---|---|---|
| I | Fruit | | | | | | |
| i) | Sikkim Mandarin | 000 tonnes | | 6.800 | 4.983 | 3.500 | 5.480 |
| ii) | Other Furits | 000 tonnes | | 2.300 | 2.300 | 1.840 | 2.530 |
| | **Sub-total** | **000 tonnes** | **10.05** | | | | |
| ii) | Vegetables | | | | | | |
| i) | Kharif Vegetables | 000 tonnes | | 12.420 | 9.108 | 8.197 | 10.020 |
| ii) | Rabi Vegetables | 000 tonnes | | 15.060 | 11.044 | 10.492 | 12.148 |
| iii) | Off-season Veg. | 000 tonnes | | 11.520 | 8.448 | 8.026 | 9.293 |
| | **Sub-total** | **000 tonnes** | **32.50** | **39.000** | **28.600** | **26.715** | **31.461** |
| III | Root & Tuber Crops | | | | | | |
| i) | Kharif Potato | 000 tonnes | | 17.618 | 12.920 | 7.752 | 14.212 |
| | Rabi Potato | 000 tonnes | | 17.960 | 13.167 | 10.534 | 14.483 |
| | Sub-total | 000 tonnes | | 35.578 | 26.087 | 18.286 | 28.695 |
| ii) | Other root & tubers | 000 tonnes | | 2.700 | 1.980 | 1.584 | 2.178 |
| | **Sub-total** | **000 tonnes** | **27.45** | **38.278** | **28.067** | **19.870** | **30.873** |
| IV | Spice Crops | | | | | | |
| i) | Large | 000 | | 6.300 | 4.620 | 2.772 | 4.850 |

| Sl. No | Items | Unit | Ninth Plan actual achiev-ement | Tenth Plan 2002-07 Target | Annual Plan 2002-03 Target | Anticip-ated Achlev-ement 2002-03 | Propose d Annual Poan 2003-04 Target |
|---|---|---|---|---|---|---|---|
| | Cardamom | tonnes | | | | | |
| ii) | Ginger | 000 tonnes | | 35.00 | 25.300 | 25.300 | 27.830 |
| iii) | Turmeric | 000 tonnes | | 5.030 | 2.232 | 2.232 | 2.455 |
| | **Sub-total** | **000 tonnes** | **30.89** | **46.330** | **32.152** | **30.304** | **35.135** |
| V | Floriculture | | | | | | |
| a) | Cut Flowers | Lakh Nos. | 10.00 | 15.000 | 11.000 | 11.000 | 12.100 |
| b) | Plants/ Bulbs | Lakh Nos. | 12.00 | 18.000 | 13.200 | 13.200 | 14.500 |
| | **Total Horticulture** | **000 tonnes** | **100.90** | **133.408** | **96.102** | **82.229** | **105.479** |

## Table 8.4 Summary of the budget

**(Unit : Lakh)**

| Budget Plan | Xth Plan (2002-07) | Annual Plan (2002-03) | Annual Plan (2003-04) |
|---|---|---|---|
| Horticulture Crop Husbandry | | | |
| Direction and administration | 250.00 | 47.50 | 55.00 |
| Horticulture Farms | 300.00 | 80.60 | 90.00 |
| Plant Protection/ IPM | 50.00 | 1.50 | 10.00 |
| Commercial Crops | 500.00 | 247.50 | 100.00 |
| Extension 7 Farmers' Training | 100.00 | 6.75 | 20.00 |
| Organic Farming & Micro-Organism | 50.00 | 1.00 | 10.00 |
| Floriculture | 380.00 | 24.30 | 76.00 |
| Fruits | 400.00 | 12.60 | 80.00 |
| Progeny Orchards | 250.00 | 66.25 | 50.0 |
| Vegetables | 250.00 | 4.00 | 50.00 |
| Medicinal & Aromatic Plants | 25.00 | 0.00 | 10.00 |

| Budget Plan | Xth Plan (2002-07) | Annual Plan (2002-03) | Annual Plan (2003-04) |
|---|---|---|---|
| Beekeeping | 25.00 | 0.00 | 5.00 |
| Organic Hort. Prodn. | 100.00 | 0.00 | 20.00 |
| Horticulture Crop Insurance | 20.00 | 3.00 | 4.00 |
| Horticulture Investment | 800.00 | 20.00 | 160.00 |
| Externally Aided Project | | 100.00 | 0.00 |
| Total Horti. Crop Prodn. | 3,500.00 | 395.00 | 740.00 |
| Agriculture Research & Education (Hort.) | 150.00 | 2.00 | 30.000 |
| Agriculture Marketing | 900.00 | 40.00 | 180.00 |
| Total Plan | 4550.00 | 437.00 | 915.00 |
| Non Plan | - | 365.45 | - |
| Technology Mission for I.D. Hort | - | 870.00 | - |
| Indo Swiss Project | - | 20.84 | - |
| Aus-Aid Project | - | 37.50 | - |
| **Grand Total** | **4550.00** | **1730.79** | **915.00** |

## 8.3 FLORICULTURE

Besides the investment for infrastructure, promotional activity in floriculture in Sikkim shall be strengthened with adequate budgetary input. Flowers are perishable and need special arrangements for transport and marketing as the consumer centers are located in far off places. The state does not have quality planting materials for large scale production. There is no check on outflow of planting materials, and much of the quality materials produced in the state find their way to West Bengal and north eastern states. Multiplication through conventional method is very slow due to limited resources, and tissue culture laboratories in both public and private sectors are still unable to meet the requirements.

Efforts are being made to improve the quality of production of cut flowers and bulbs and plants in recent years. A model floriculture garden has been set up at Namli and an orchid centre is coming up at Pakyong.

A strategy to strengthen the floriculture sub-sector should therefore, include the following:

- Enactment of strong legislation to check outflow of quality planting materials from the state.
- Induction of modern technologies including large scale tissue culture.
- Development of tissue culture laboratories in both the public and private sectors.
- Large scale demonstrations for transfer of technology to the farmers.
- Strong budgetary support as floriculture is capital intensive.
- Infrastructure facility for marketing, transport, packaging and handling.

Floriculture has a good scope in Sikkim but constrained by lack of the following infrastructure and policy decision.

(i) Introduction of modern technologies – including tissue culture both in public and Private sectors- is most essential for mass multiplication of desired quality materials.

(ii) Strong budgetary support as capital investment.

(iii) Infrastructure facility for post-harvest and marketing.

Floriculture has a tremendous potential but the state has yet to see break through. During the $IX^{th}$ Plan, the activity was limited to introduction of commercial varieties of flowers and multiplication in Government farms and farmers field. The scheme envisages to address introuction of commercial flowers, multiplication, cooperative marketing through wholesale markets and export through formation of Agri-Export Zones in Sikkim. For this two entrepreneurs for Agri-Export Zone formation have been identified for Cymbidium and Carnation. They have initiated the work at Pakyong. The priority flowers are m order of cymbidium orchids, Carnation, Anthuriurn, Gladioli, Lillium, tropical orchids etc.

Production Technology up-gradation through demonstration for cut flower production, providing technology of pre and post harvest and providing working facility to the field workers in the districts is essential and has been proposed in this Plan. The tenth plan target of cut flower production and Plants/Bulbs has been fixed to 15 lakh and 18 lakh, and Annual Target was 11 lakh and 13.2 lakh respectively, which has been anticipated to achieve. Annual Target for 2003-04 for cut flower production and planting material has been proposed to 12.1 lakh and 14.5 lakh respectively.

## 8.4 MEDICINAL AND AROMATIC PLANTS

Sikkim is a hot-spot of biodiversity of medicinal and aromatic plants. To begin with detail survey, documentation and identification of medicinal and aromatic plants is essential. Further, herbal gardens have to be established at low, mid, high and alpine hills for development of cultural practices and commercial exploration of these species. Under the technical collaboration with CIMAP, Lucknow, work on Agro-technique development of some indigenous medicinal and aromatic plants has been proposed during the Tenth Plan. Further, a few technology developed medicinal and aromatic plants of economic importance will be introduced under the technical guidance of CIMAP, Lucknow for cultivation in Sikkim.

## 8.5 BEEKEEPING

Honey bees are known for honey as well as an effective pollinizer of crops and are known to increase crop production. Most of the horticultural crops such as large cardamom, many kinds of vegetables are cross, pollinated crops. In such crops pollination is done by the bees. Under this scheme, nucleus beekeeping centre will be established in one Government farm and improved bee species will be introduced for colony multiplication and distribution to the horticulture crop growers.

## 8.6 ORGANIC FARMING

There is a good scope of production of organically grown food products provided the market of such products are explored. Under this scheme efforts will be made to explore commercial production and marketing of such organic horticultural products, fruits, vegetables and spices.

## 8.7 ANIMAL HUSBANDRY

Livestock rearing is a way of life, a tradition, which, for centuries, has shaped the thoughts, the outlook, the culture and the economic life of the people of Sikkim. Animal husbandry therefore, is and will continue to be central to all strategies for planned socio-economic development of the State. Keeping these strategies in view, the main objective of the department of Animal Husbandry and Veterinary Services is to increase the production of milk eggs, meat and wool. Due emphasis has been laid on development of animal husbandry in the Xth Five Year (2002-2007) plan. Some of the activities envisaged under this programme are summarised as under:

### 8.7.1 Veterinary Services and Animal Health

In order to increase the productivity of various types of livestock, it is essential to have a sound network of veterinary hospital, dispensaries and stockman centre to monitor and control different types of disease occurring in livestock and poultry. These hospitals should be provided with basic facilities for carrying out various disease investigation works in the district and also at the State level. Already some works in this respect has been done during the 9th Five Year Plan. However, further improvement of these laboratories is required. Apart from creating these facilities at the district level, these facilities should be made available to farmer within reasonable distance. This is essential to curb the outbreak of any infection and communicable disease. A proper disease reporting system and disease surveillance forms an important aspect of field veterinary care during the Annual Plan 2003-2004.

### 8.7.2 Cattle Development Scheme

This is an ongoing scheme and is envisaged to intensify the activities through package of measures to increase the productivity of the local animals through programme of upgrading the local stock with the use of better quality semen from proven sires. The conversion of Karfecter farm into the State Bull Rearing Farm would eventually serve as a nucleus farm for launching the Indo-Swiss Project on Cattle Development and fodder cultivation in Sikkim. Attempts are being made to produce sufficient numbers of superior quality bulls at Karfecter farm and allot them to inaccessible areas where transport of liquid nitrogen is not possible.

### 8.7.3 Poultry Development

Poultry farming is commercially viable and employment oriented activity aimed at perceptible improvement in the economic condition of the rural poor. It is imperative to encourage adoption of poultry as a supplementary activity which would contribute significantly towards improvement of the living standards of the rural population. Few years ago, the department has created infrastructure as Hatchery-cum-

Breeding farm of 5,000 layer and 10,000 broiler parent stock in Bermiok, south Sikkim in collaboration with M/s. Venkateshware Hatcheries Limited, Pune. During 2003-2004, it is proposed to establish eight poultry societies-two each in every district.

### 8.7.4 Sheep and Wool Development

Sheep rearing is a traditional activity amongst people inhabiting the alpine areas of the State whose subsidiary is the carpet and blanket weaving industry. Moreover, there is a growing demand for both mutton and wool in the State. Thrust is being given to stregthen the existing infrastructure and continues the ongoing schemes.

### 8.7.5 Piggery Development

Pig husbandry is a very popular and lucrative occupation amongst the local Sikkimese. The department has introduced 10 nos. of Durac breed of pigs which has been imported from Bhutan. The Department is in the process of introducing fast growing breed of pigs and accordingly 80 nos. of exotic Hampshire breed of pigs have been introduced in the state and more number of exotic pigs shall be introduced for cross-breeding purpose.

### 8.7.6 Other Livestock Development

A yak farm was established at Thangu in North Sikkim and in order to prevent in-breeding amongst the local yak population, 14 male yaks have been imported from Bhutan. The department has also established an Angora Rabbit Farm at Rabum in North Sikkim.

### 8.7.7 Extension and Training

To have a close interaction with the farmers and the department personnel as well as to familiarizes them with the latest scientific advancement in the field of livestock raising, a separate extension and training cell has also been constituted. District level Extension and Training Cell is also envisaged to be opened shortly.

### 8.7.8 Dairy Development

The Dairy Development programme in the East, West and South district is being implemented through Sikkim Milk Union Ltd. However, it has still not been able to be a self-sustaining organisation. For the last two decades, the organisation has not shown any progress especially in field of milk quality improvement, procurement and marketing.

### 8.7.9 Centrally Sponsored Schemes

Under the centrally sponsored scheme, one Dairy Plant at Mangan and one Chilling Plant at Kabi has been constructed with central assistance. North district has been completely neglected in the field of dairying as compared with other three districts of the State.

The State has been implementing various centrally sponsored schemes both for the control of livestock disease and for increasing livestock productivity. Keeping in view the importance of these schemes, centrally sponsored schemes which are on 50:50 sharing basis shall be continued.

## 8.8 FISHERIES

Fisheries are an important area of economic activity. Farmers are encouraged to take up fish farming for economic growth and to generate self employment. Through this activity, they are able to produce much needed protein in their own ponds. Fisheries Department proposes to upgrade to maximum growth of the existing infrastructure. The main thrust is to be given to trout and carp and conservation of riverine fisheries during the tenth five year plan. During 2003 - 04, it is proposed to continue production of carp fish seed for distribution to farmers, production of trout seed for stocking in river and stress would be given on strengthening the conservation of riverine fishery in order to achieve a marginal growth rate in fish production.

For fisheries development, several programs are under way in the state. Some of these are described as under:

### 8.8.1 Trout Fish Seed Production

Due to the establishment of five trout farms at different centres of the state, the proposal envisages production of trout seed for stocking at different resources of high altitude lakes and streams. The program also provides for the production of quality seed of rainbow trout for the distribution among farmers covered under Pilot Project under Cold Water Fisheries. Provision is also meant for the capital expenditure for maintenance of the old farms.

### 8.8.2 Carps and Cat Fish Seed Production

All carp farms of the state are maintained under this program. The seed of carp and cat fish are produced for the distribution among farmers. The maximum emphasis is given to the grass carp seed production. Rothak fish Farm acts as the main pillar for this purpose. Phase-wise construction of Fish Farm at Fourteenth Mile is envisaged under this program. Some of the old farms are also to be maintained for maximum yield under this provision.

### 8.8.3 Conservation of Riverine Fisheries

The above conservation program includes patrolling, repair of Fisheries guards quarters, etc. Major thrust is being given for conservation of riverine fishery.

### 8.8.4 Propagation of Mahaseer

To promote angling in Sikkim, the population of Mahaseer in the rivers are to be maintained through stocking in good number. The seeds are raised at Mahaseer Farm, Tenth Mile, South Sikkim.

### 8.8.5 Development of Inland Fisheries

This provision envisages the support to the farmers for the production of fish seed in the private sector. The research activity for the development of agriculture is also planned under this program.

### 8.8.6 Fish Farmers Development Agency (FFDA)

Through this agency, State Govt. is making efforts to popularize the fish farming among the farmers by giving them subsidy, training allowance and contingency expenditure.

The physical and financial targets for fisheries development in Sikkim are given in Table 8.5 & 8.6 respectively. Physical targets and achievements during ninth plan and anticipate achievements during 2002-03 are also included in Table 8.5.

**Table 8.5 Physical targets and achievements for fisheries development**

| Sl. No. | Item | Unit | Ninth Plan 2000-07 | | Tenth Plan (02-07) | Annual Plan 20002-04 | | Annual Plan (03-04) |
|---|---|---|---|---|---|---|---|---|
| | | | Target | Achieve-ment | Target | Target | Achieve-ment | Target |
| 1. | Fish Production | Tonne | 180 | 140 | 180 | 150 | 150 | 160 |
| 2 | Fish seed production | Million | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | a) Frys | | 4.00 | 2.00 | 4.00 | 2.80 | 2.80 | 2.80 |
| | b) Fingerlings | | 0.50 | 0.40 | 0.80 | 0.60 | 0.60 | 0.60 |
| 3. | Water Area | ha | | | | | | |
| | a) Nursery | | 6.00 | 5.00 | 8.00 | 6.50 | 6.50 | 7.00 |
| | b) Rearing | | 35.00 | 32.00 | 45.00 | 36.50 | 36.50 | 38.00 |

**Table 8.6 Financial targets for fishers development for Tenth Five Year Plans**

**(Unit: Rs in Lakh)**

| Sl. No. | Scheme | Tenth Plan Proposed | | Annual Plan (2003-2004) | |
|---|---|---|---|---|---|
| | | Outlay | For capital exp. | Outlay | For capital exp. |
| 1. | Direction and Administration | 30 | -- | 12 | -- |
| 2. | Trout Fish Seed Production | 35 | 10.00 | 8 | 3 |
| 3. | Carp and Cat Fish Seed Production | 55 | 30.00 | 20 | 15 |
| 4. | Conservation of Riverine Fisheries | 20 | 10 | 8 | 2 |
| 5. | Propagation of Mahaseer | 15 | 5 | 2 | 1 |
| 6. | Development of Inland Fisheries | 10 | -- | 2 | -- |
| 7. | F.F.D.A. | 20 | -- | 4 | -- |
| 8. | Extension and Training | 10 | -- | 10 | 10 |
| 9. | Other Expenditure | 5 | 5 | 2 | 2 |
| | Total | 200 | 60 | 68 | 33 |

# CHAPTER - 9

# DROUGHT PRONE AREAS IN THE STATE

# DROUGHT PRONE AREAS IN THE STATE

## 9.1 GENERAL

As described in Para 6.1, the minimum rainfall prescribed in dry region for crops is 250 mm to 350 mm during winter and 500 mm in summer. Having observed some regions with rainfall characteristics less than the above in the state and consequent upon the frequent occurrence of droughts in these locations, a survey was conducted by the state for proper assessment of its status and taking appropriate measures for tacking the problem.

## 9.2 RAINFALL

The data on rainfall recorded at five different stations was collected and tabulated for the years 1986, 1987, 1988, 1989 and 1990 and the mean values were worked out alongwith the maximum and minimum values for each of the station.

Table 9.1 Yearly fainfall, year, mean, maximum, minimum (worked out)

| Sl. No. | Station | District | 1986 Mean | 1986 Max | 1986 Min | 1987 Mean | 1987 Max | 1987 Min | 1988 Mean | 1988 Max | 1988 Min |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Gangtok | East | 258.65 | 763.6 | 25.20 | 340.01 | 881.90 | 10.30 | 289.47 | 739.9 | 20.20 |
| 2. | Tadong | East | 207.50 | 640.31 | 22.30 | 781.1 | 648.50 | 9.30 | 218.41 | 678.5 | 17.30 |
| 3. | Gyalshing | West | 202.86 | 548.80 | 21.40 | 279.70 | 653.00 | 20.20 | NA | NA | NA |
| 4. | Welli-Dara | South | 174.18 | 535.60 | - | 348.48 | 780.90 | 16.5 | NA | NA | NA |
| 5. | Namthang | South | 171.27 | 393.00 | 17.00 | 245.75 | 630.00 | 4.60 | NA | NA | NA |
| 6. | BermiokB- | South | 144.80 | 567.00 | 25.00 | 261.22 | 507.00 | 27.00 | 157.56 | 308.00 | 46.00 |

| Sl. No. | Station | District | 1989 Mean | 1989 Max | 1989 Min | 1990 Mean | 1990 Max | 1990 Min |
|---|---|---|---|---|---|---|---|---|
| 1. | Gangtok | East | 246.82 | 643.30 | 10.8 | 329.33 | 700.7 | 5.00 |
| 2. | Tadong | East | 269.11 | 543.00 | 7.20 | 288.24 | 75.80 | 15.00 |
| 3. | Gyalshing | West | 226.89 | 636.30 | 19.90 | NA | NA | NA |
| 4. | Welli-Dara | South | 302.00 | 903.00 | - | 294.00 | 1043.00 | 16.5 |
| 5. | Namthang | South | 153.31 | 643.30 | 10.80 | 147.85 | 371.60 | 20.00 |

It is seen that the rainfall data tend to follow a definite trend, depicting a unique pattern of rainfall with the figures gradually moving down as south district is approached from East and West districts for all the years under observation. This means that the south district and the adjoining areas are usually drier as compared to the other parts of the state. The mean rainfall calculated for five years shows that the data for the various stations are close to the minimum limits prescribed for the winter in case of East and West District, whereas the data for the south district falls short of the minimum of 250 mm required during the winter, though the average of whole year rainfall was taken into consideration. This indicates that the areas taken up for survey constitute the regions with low and eratic rainfall and drought condition prevailed off and on.

## 9.3 REPORT OF THE SURVEY

The survey covered 132 blocks of the state falling in the less rainfall regions. The major part being that of the South District where 87 blocks were surveyed followed by the west district with 34 blocks, East district with 9 blocks and north district with 2 blocks. The total area surveyed was 32,499 ha of which 1783.86 ha is paddy field, 23435 ha is dry field and 6784 ha falls in other categories. The total geographical area of the region is 70,193 ha. The survey reveals that the area under dry field is 13 times more than the area under paddy field. This establishes the fact that this region is the driest area with less number of water sources available for irrigation and at the same time, the rainfall is also below the average. The reason for the dry situation in this part can be attributable to the absence of high hills and mountain peaks in the higher regions of the area, thus resulting in the rained seasonal streams which can not sustain the water requirement for the cultivation of paddy. It was also found that the number of perennial water sources do not exceed one for most parts. Corresponding to this, adverse geophysical situation, the steep slope percentage of above 50% coupled with barren hill slopes and the undulating terrain accelerate the runoff of rainwater quickly which drains down the hill into the rivers causing soil degradation and erosion to a large extent. This leaves the land without moisture in the soil and thus for most part of the year, the soils remain almost dry. Thus dry farming is the predominant feature of this area.

As regards the total number of households, the survey covered a total of 15,122 households, of which 10,943 households belong to the below 2 ha of land holding category, constituting 66.66% of the total, 4695 households consisting 30% are falling fall in the category of less than 1 ha of land holding. These are the marginal farmers and the farming alone does not become viable for them. These families alongwith those belonging to the landless category, numbering 2025 households are in need of other forms of employment to supplement their income and sustain the livelihood of family members. A major portion of those households falling above 2 ha land holding are also in need of subsidiary alternative farming employment to supplement their income and earnings since the dryland farming by itself does not become viable for meeting the needs of the family members. Districtwise details are given in Table 9.2.

A close look at the land classification as per the existing land use pattern depicts that out of the total land available for agriculture to the tune of 25,522.42 ha, the net cropped area is 24060.20 ha. The areas under different land uses, such as, barren land, land under non-agriculture uses, culturable waste, fallow land under miscellaneous tress to groves, current fallow respectively are stated to be of the order of 2743.67 ha, 7206.80 ha, 1208.56 ha, 411.99, 1294.06 ha and 1793.83 ha. The total cultivated cropped land of the region is 28251.04 ha as recorded in the findings of the survey. Districtwise land classification and their area in hectare are in Table 9.3.

## Table 9.2 Summary report of survey

| District | No. of Block | District wise area & Number of households area in ha. | | | | Number of Households | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Wet** | Dry | **Other** | **Total** | **Land-less** | **Less than 1 ha** | **1-2 ha** | **Above 2 ha** | **Total** | **Geogra-phical** |
| Namchi South | 87 | 863.751 | 13638.79 | 30.93 | 15031.05 | 1032 | 2898 | 2381 | 2545 | 8853 | 23462.91 |
| Gyalzing West | 34 | 270.98 | 6919.50 | 3000.5 | 10190.99 | 795 | 1257 | 1230 | 928 | 4210 | 11453.61 |
| Gangtok East | 9 | 612.24 | 2350.07 | 2700.64 | 5662.94 | 198 | 538 | 443 | 708 | 1887 | 3568.2 |
| Mangan North | 2 | 36.89 | 523.49 | 1054.17 | 1614.55 | - | - | 169 | - | 169 | 1718.33 |
| | **132** | **1783.86** | **23434.85** | **6784.24** | **32499.53** | **2025** | **4696** | **4223** | **4173** | **15122** | **70193.06** |

**Table 9.3 Land classification and area in ha**

| District | Total available for agriculture | Barren land | Land under non-agri uses | Cultur-able waste | Fallow land | Land under misc. trees groves | Current fallow | Net cropped area | Total cultivated cropped land |
|---|---|---|---|---|---|---|---|---|---|
| South | 14168.25 | 1188.49 | 2196.82 | 244.34 | 282.99 | 640.06 | 304.04 | 13943.10 | 15102.47 |
| West | 7961.70 | 669.67 | 2667.00 | 190.00 | 129.00 | 284.00 | 139.00 | 8166.00 | 9851.00 |
| East | 2728.39 | 781.73 | 2397.39 | 773.32 | - | 361.58 | 1313.90 | 1438.62 | 2759.18 |
| North | 664.09 | 103.78 | 1.69 | 0.90 | - | 8.42 | 36.89 | 512.48 | 538.39 |
| | **25522.43** | **2743.67** | **7262.90** | **12.08.56** | **411.99** | **1294.06** | **1793.83** | **24060.20** | **28251.04** |

The committee recommended certain agronomic and other development strategies which was subsequently reviewed by a departmental committee. This committee formulated a five years (1995-2000) physical and financial programme for implementation in the drought prone area. The details of the same are given below:

## 9.4 PACKAGE OF SCHEMES FORMULATED BY DEPARTMENTAL COMMITTEE

In the state there are many areas where hardly any rainfall occurs during winter season and in these areas, the fields remain dry for about six months i.e. w.e.f. November to April. On priority basis, major drought prone areas fall in south district, followed by west district and some parts of east and north districts. The above Committee collected the available relevant data and also undertook field surveys and identified total number of 188 blocks for Drought Prone Area Programme (DPAP) in four districts which included a geographical area of 70000 ha and 15,000 households with the area to be treated as 32,000 ha. To tackle this problem, schemes under the following categories were formulated for implementation during 1995-96 to 1999-2000.

a) Soil and water conservation measures
b) Agronomic measures
c) Horticulture measures
d) Other measures

The physical and financial targets were fixed for implementation of the above programme during five year time period the same are given in Table 9.4.

Table 9.4 Physical and financial targets for five years period

| Sl No | Programme (1995-96 to 1999-2000) | Physical Target | Financial outlay (Rs. lakh) |
|---|---|---|---|
| (i) | Soil and Water Conservation measures | | |
| 1 | Land development (' 000 ha) | 10 | 375 |
| 2 | Water harvesting structure (Nos) | 50 | 50 |
| 3 | Construction of compost pit (Nos) | 2500 | 25 |
| 4 | Vermicompost and construction of Vermicompost shed (Nos) | 2500 | 12.50 |
| 5 | Treatment of drainage lines | | |
| | - Vegetative measures (' 000 m) | 150 | 22.50 |
| | - Engineering measures (No. of structures) | 350 | 17.50 |
| | Total | | **502.50** |
| **(ii)** | **Agronomic measures** | | |
| 1 | Minimum tillage (' 000 ha) | 20 | 5.00 |
| 2 | Soil mulching (' 000 ha) | 20 | 20.00 |
| 3 | Contour cultivation (' 000 ha) | 20 | 5.00 |
| 4 | Drought resistant crop & improved varieties (' 000 ha) | 30 | 150.00 |
| 5 | Mixed cropping & relay cropping (' 000 ha) | 20 | 20.00 |
| 6 | Strip cropping (' 000 ha) | 5 | 5.00 |
| 7 | Crop rotation (' 000 ha) | 10 | 2.50 |
| 8 | Use of bio-fertilizer (' 000 ha) | 10 | 20.00 |
| 9 | Green Manuring (' 000 ha) | 5 | 7.50 |
| 10 | Reclamation of soil (' 000 ha) | 2.65 | 15.00 |
| 11 | Application of balanced fertilizer | 50 | 50.00 |
| 12 | Application of micro-nutrient | 5 | 10.00 |
| 13 | Bio-conservation | 8 | 104.00 |
| | **Total** | | **414.00** |

| Sl No | Programme (1995-96 to 1999-2000) | Physical Target | Financial outlay (Rs. lakh) |
|---|---|---|---|
| **(iii)** | **Horticulture Measures** | | |
| 1 | Planting new orchards of fruit beneficiary (0.5 ha) | 500 | 25.00 |
| 2 | Vegetable growing<br>0.2 ha / beneficiary (0.2 ha) | 500 | 25.00 |
| 3 | Ginger growing<br>0.2 ha / beneficiary (0.2 ha) | 1000 | 50.00 |
| 4 | Rabi potato<br>0.2 ha / beneficiary (0.2 ha) | 500 | 50.00 |
| 5 | Flower | 12.50 | 20.00 |
| | **Total** | | 175.00 |
| **(iv)** | **Other Measures** | | |
| 1 | Sprinkler Irrigation ((' 000 ha) | 1.00 | 150.00 |
| 2 | Tank Irrigation (' 000 ha) | 5.00 | 500.00 |
| 3 | Backyard poultry units (No) | 1500 | 8.00 |
| 4 | Sericulture units (No) | 1000 | 2.50 |
| 5 | Bee keeping (No) | 500 | 3.50 |
| 6 | Cottage industries (No) | 1000 | 10.00 |
| 7 | Publication & printing materials ((' 000 Nos) | 100.00 | 10.00 |
| 8 | Small live stock<br>System development (No) | 1500 | 30.00 |
| 9 | Training of farmers –<br>Each unit – 50 farmers (No of units ) | 500 | 15.00 |
| | Total | | **729.00 lakh** |

Apart from the above, the cost of Rs.53.00 lakh was added towards administrative supervision, monitoring and evaluation leaving to a total project cost of Rs.1873.50 lakh for the period 1995-96 to 1999-2000. The status of implementation of above programme is yet to be ascertained from the State Govt. authorities. Evaluation of this scheme would be helpful in formulating future strategy to be taken up in such area.

# CHAPTER - 10

## IRRIGATION AND WATER MANAGEMENT - PERSPECTIVE PLANNING

# IRRIGATION AND WATER MANAGEMENT - PERSPECTIVE PLANNING

## 10.1 GENERAL

As brought out in Chapter VI, the ultimate irrigation potential of the state has been considered as 70,000 ha out of which 20,000 ha is through major and medium irrigation schemes and 50,000 ha through minor irrigation schemes. Due to topographical constraints, irrigation has neither developed through major and medium schemes as these schemes cover a CCA of more than 10,000 ha and between 2,000 ha to 10,000 ha respectively nor there appears to be any scope for investigation. Therefore, for the purpose of perspective planning, whole of the ultimate potential of 70,000 ha has been considered to be developed through minor irrigation schemes by the year 2025.

## 10.2 PRESENT STATUS OF IRRIGATION DEVELOPMENT

To recapitulate the present status of irrigation development, as already described in para 6.2, out of created irrigation potential of 31.30 th ha, 23.68 th ha has been reported as utilized upto end of IX$^{th}$ Plan i.e. March, 2002. During X$^{th}$ plan (2002-07), a target of 4.50 th ha has been kept for creation of irrigation potential. Out of this, anticipated achievement for creation and utilization during 2002-03 and 2003-04 is of the order of 0.80 th ha and 0.98 th ha, respectively. Thus, it is anticipated that potential of 32.10 th ha would be created by March, 2004, out of which 24.66 th ha may be utilized.

As per Minor Irrigation (M.I.) Census (1995-96), 854 schemes were existing upto 1994 covering a CCA of 17.11 th ha and with gross irrigated area as 20 th ha, thus giving an irrigation intensity of about 117%. Subsequently, 322 schemes have been taken up during the period 1994 to 2003, totalling to 1176 no. of minor irrigation schemes with a total length of channels as 972.38 km, spread over all the four districts of the state. However, Master Plan for Irrigation Development, 1995 has envisaged 436 new schemes, covering an additional CCA of 24.55 th ha. Thus, after implementing the schemes listed in Master Plan, total no. of M.I. Schemes would be 1290 with a CCA of 41.66 thousand ha. Applying a moderate and reasonable irrigation intensity of 120%, the ultimate irrigation potential of 50,000 ha. Through minor irrigation schemes would, thus, be developed through these 1290 schemes covering a CCA of 41.66 th ha.

Master plan also envisages 30 lift irrigation schemes covering CCA of 0.60 th ha on a pilot scale. This water is proposed to be utilized through sprinkler and drip irrigation, which are described in succeeding paras. As far as, irrigation potential of 20,000 ha. Originally conceived to be developed through major and medium irrigation schemes is concerned, it would be appropriate to further identify other minor irrigation schemes with special thrust being given to lift irrigation and adopting sprinkler and drip techniques for irrigation.

## 10.3 IDENTIFICATION OF MINOR IRRIGATION SCHEMES

### 10.3.1 Criteria for Identification of New Minor Irrigation Schemes

For this purpose, it is essential to have the area needing irrigation, the water source and suitable topography for alignment of water courses and field channels. The largest size maps available form Survey of India are on the scale of 1:50,000 with contour interval of 20m/ 40m. Generally, the maps available are 20 to 30 years old and do not correctly depict existing cultivated areas etc. In the absence of cultivated area marked on these sheets, only land slope criteria could be used for planning of new scheme. The other important parameters considered are the lean period water yields from the catchment / watersheds and the prevailing cropping pattern in the area.

**Water Availability**

The State has heavy annual rainfall of the order of 2533.90 mm. However, this is restricted to few monsoon months of the year. The time distribution on average rainfall is given in Table 10.1.

**Table 10.1 Monthly average rainfall in the state**

| S. No. | Month | Average Rainfall (mm) | Percentage of Annual Rainfall |
|---|---|---|---|
| 1 | January | 37.0 | 1.46 |
| 2 | February | 53.0 | 2.09 |
| 3 | March | 104.1 | 4.11 |
| 4 | April | 151.7 | 5.99 |
| 5 | May | 287.6 | 11.35 |
| 6 | June | 442.7 | 17.47 |
| 7 | July | 480.1 | 18.95 |

| | | | |
|---|---|---|---|
| 8 | August | 440.1 | 17.37 |
| 9 | September | 331.8 | 13.09 |
| 10 | October | 156.0 | 6.16 |
| 11 | November | 30.7 | 1.21 |
| 12 | December | 19.1 | 0.75 |
| | **Total** | **2533.90** | **100.00** |

The above Table would reveal that during the kharif (April-Sept.) 84.22% of rainfall amounting 2134 mm occurs. In the Rabi period (Oct.-March), it is only 15.78% amounting to 399.90 mm However, during the period Nov to Jan (3 months), rainfall is hardly 80.8 mm i.e. 3.42%. Moreover, rainfall gradually reduces after certain elevation and also in some parts of South and West Sikkim due to shadowing effect of adjoining hills. Thus, there is definite requirement of irrigation water during Rabi.

As would be seen from Chapter-5, the monthly flow data of the Teesta River at Sakalang and Coronation Bridge is quite low during the period November to February, being only about 5% to 7% of total average annual flow. Moreover, there is no discharge data available for 2$^{nd}$ and 3$^{rd}$ order streams. Hence on the basis toposheet studies, new minor irrigation schemes have broadly been planned in the Master Plan which needs to be further investigated properly for planning purposes and to establish their techno-economical feasibility.

### 10.3.2 Diversion / Lift Schemes

The first preference may be given to locate the project site in such a way that water can be diverted through gravity to intake canal and later distributed to field through gravity distribution system. Where diversion is not possible or in large rivers where it would be very costly, lift irrigation may be planned for a height varying from 3 m to 20 m or in exceptional cases upto 40 m presently, there is a scarce availability of power in the state. However, in view of the fact that state is endowed with vast hydel potential, the lift schemes may be techno-economically viable as have been proposed in the Master Plan.

#### 10.3.3 *Surface Water Tanks*

For providing critical irrigation to wheat crop during rabi season and to cardamom during dry months, masonry tanks roughly 2m x 2m and 2 to 3 m deep can be constructed to collect spring and rain water. The water so collected can be used through pipe distribution system to raise vegetables, fruit plants and for critical irrigation to wheat and cardamom. These tanks can be individually owned and constructed through bank loan and govt. subsidy.

#### 10.3.2.2 *Individual Pump Set On Surface Water Sources (Lift Irrigation Schemes)*

There are patches of cultivated land on the banks of the rivers and stream in the state. These isolated patches can be irrigated by mobile pump sets of 5 HP to 10 HP capacities to be individually owned.

## 10.4 DESIGN OF CANAL AND RELATED STRUCTURES

### 10.4.1 Design Criteria

The design criteria for different works of the schemes are given under separate sub heads as below:

#### 10.4.1.1 *Head Works*

All the head works provided are of the run-of-the-river system and as such a simple wier body wall would be adequate to divert the flows (especially during low flows) into the canals. In Sikkim, for most of the cases there are no head work structures and where constructed, they are mostly of a temporary (kutcha) type. Three types of typical designs are discussed as follows.

(i) Suitable site for head work has to be selected where preferably rock is available in stream bed and sides. Body wall can be for a height of 0.3m to 0. 5m above bed with the crest level at 0.I m above the FSL of canal. Length of body wall can be limited to a distance on either side of deep course upto a distance just sufficient to cover the stream bed at @ FSL + 0.1 m. This means that when the stream water level exceeds FSL + 0.1 m, it would overflow over the wier body wall as well as out flank the wier. In other words, the wier body wall will only obstruct and divert the low flows so as to command the canals to FSL depth and will not obstruct any flood flow occurring above the FSL. There will be no bank connections or abutments since the natural profile is allowed to remain as it is... For the off take into the canal, a wall may be constructed with its top kept just above the Maximum Flood Level (MFL). The canal sluice opening will be controlled by a stone slab shutter operated manually. Wherever necessary, a leading channel will be cut (excavated) from the deep course to sluice sill level. Sill of sluice will be kept 0.l m above the bed of this channel. A groove for a length of 0.6 m to l m will be left in the body wall of wier to serve as a scour vent. This scour vent will have sill level at 0.l m below sill *of* sluice i.e., the level *of* silt pit upstream. The scour vent will be manually operated by means of a stone shutter and is intended to clear the silt on the upstream of body wall as well as prevent silt entering the canal. Thus, the head works is an extremely simple structure with a simple body wall (plum concrete) of height 0.3 m to 0.5 m for a very short length and a head wall for locating the sluice.

*(ii)* Where rock is not available in the' stream bed or sides, the design of head work will be as per the type design presented in Fig. 10.1. In this case also, the crest of wier body wall will be at FSL +0.l m and the height of body wall will be 0 .3 m to 0. 5 m above the deep bed of the stream. However, the length of body wall will have to be sufficient to cover the width of stream up to MFL markings. This is done with an intention so as not to restrict the passage of stream and to retain its original regime of flow. At either end of the body wall, regular abutment and wings can be constructed, wherever needed. Canal offtake can be through the abutment or wings. Design of scour vent, silt pit and head sluice will be the same as

described above in the case of rocky bed (Fig.10.2). Since the water will be falling for a depth of 0.3 m to 0.5 m, there will be lesser energy dissipation requirement. If the regime of the stream is not disturbed, it may be able to take care of the same. However, apron of 0.6m depth sloping to the grade of streambed can be provided on the downstream of the body wall for the required distance. The body wall can be of R.C.C. 0.2 m thick and for a total depth of 2 m. It can be taken deeper to say 3 m, wherever required. This will act as a vertical pile, well anchored into the soil (bed of stream) to withstand retrogressions occurring, if any from the downstream side as well as to withstand the impact of flowing water under flood flow conditions.

(iv) The third type of headwork comprise of a flexible gabion type of body wall and structure and can be adopted where slopes and scours are more pronounced. This is a kind of check dam being commonly constructed across small stream to conserve stream flows with practically no submergence beyond stream course. The boulders locally available are stored in a steel wire. This is put up across the stream's mesh to make it as a small dam by anchoring it to the streamside (Fig. 10.3). The height of such structures is around 0.5 m and is normally used in the streams with width of about 10 to 15 m. The excess water overflows this structure storing some water to serve as source of recharge. The silt content of stream water in due course is deposited in the interstices of the boulders to make it more impermeable.

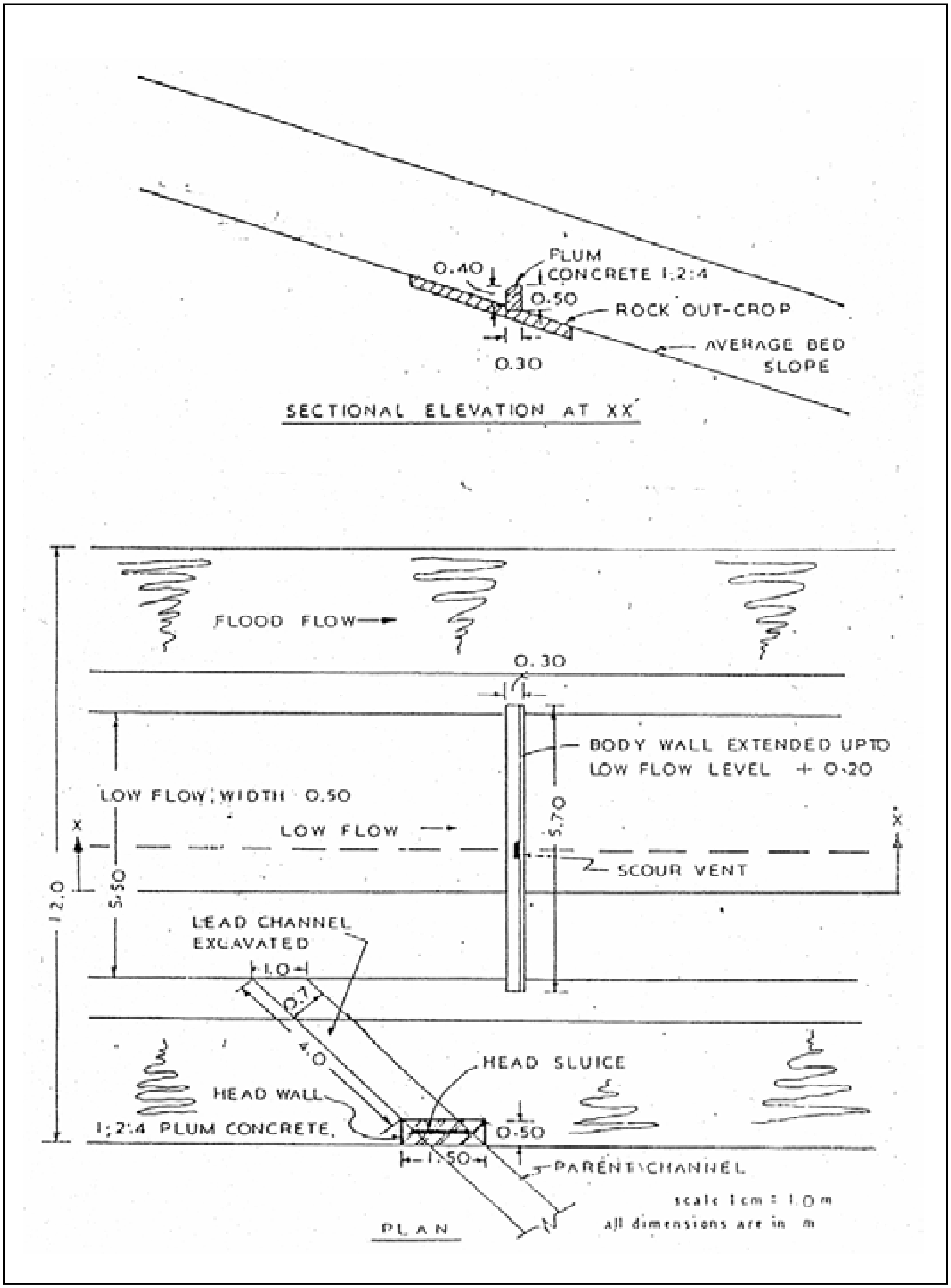



**Fig. 10.1 Details of head work in areas where sheet rock is available in stream bed**

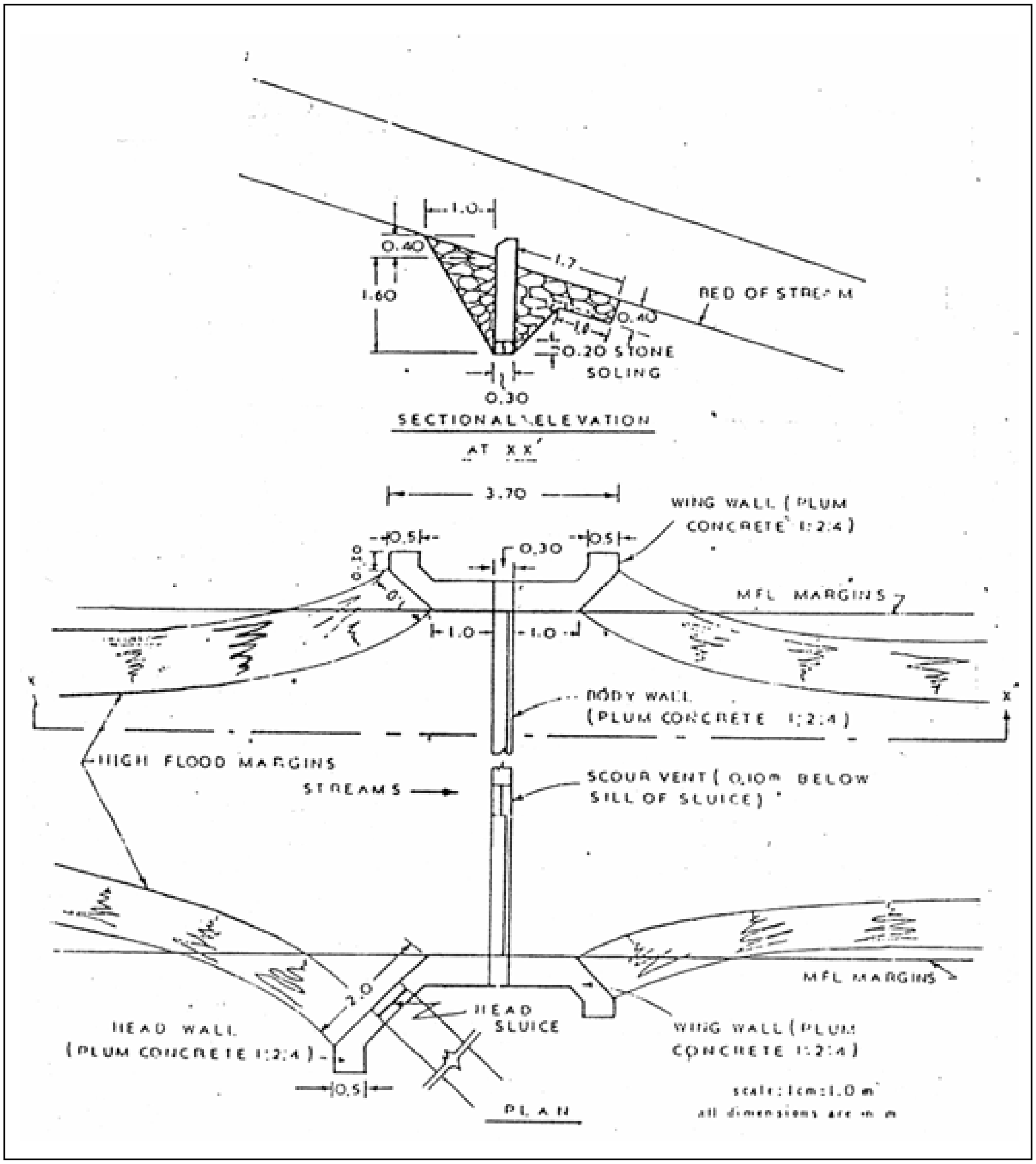



**Fig. 10.2 Details of head work in areas where sheet rock is not available in stream bed**

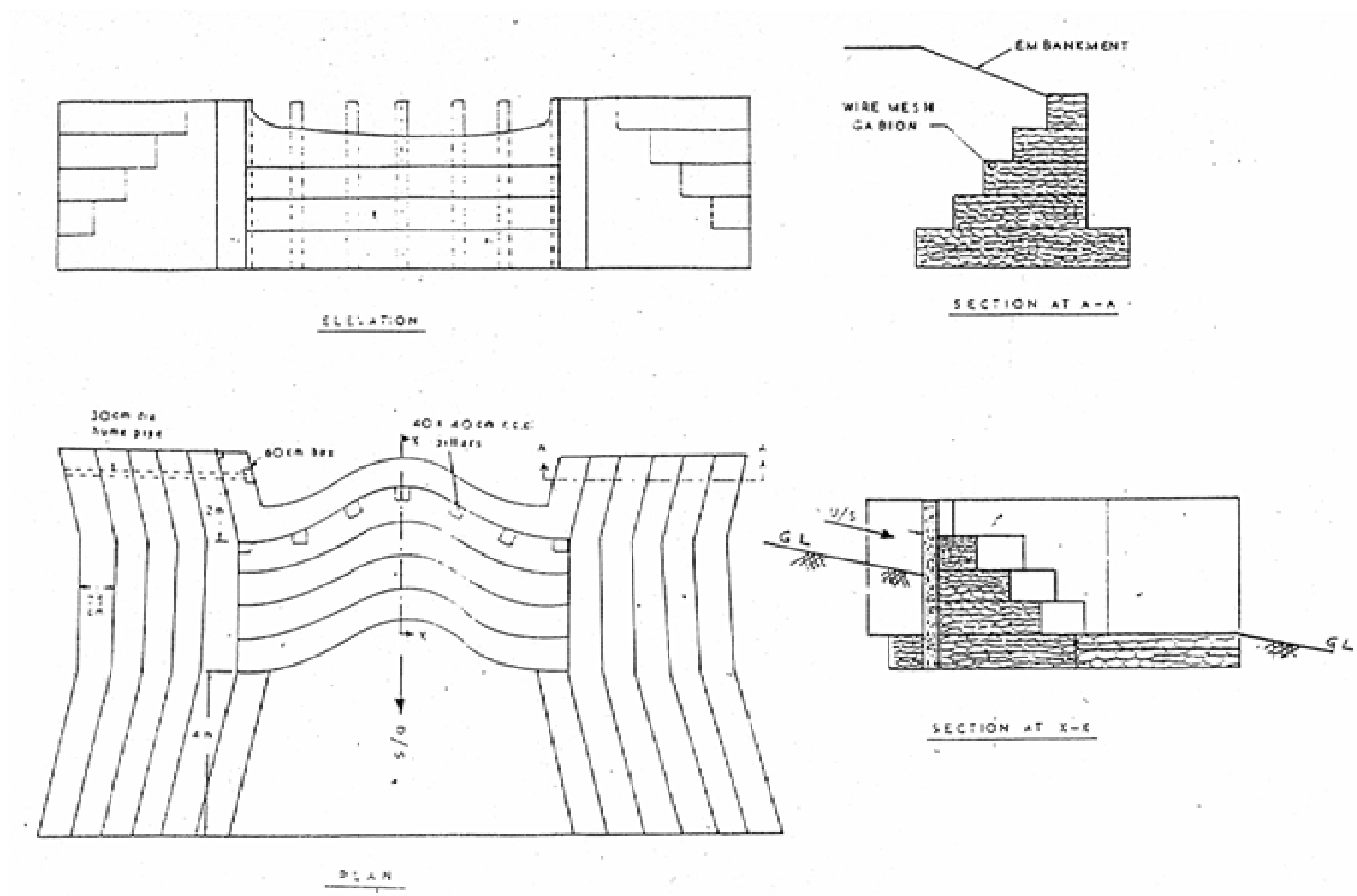



Fig. 10.3 Head works gabion drop structure

### 10.4.1.2 *Canals*

Land slopes in the agricultural areas are usually between 30% to 40%. In order to take canals along a contour in such a steep sloppy region, it is desirable that a minimum width of ledge is used. A ledge is required to accommodate the canal and provide a berm of 0.45 m width for people to walk along the canal. For example if 0.8 m width of ledge is needed, it would be necessary to cut the slope for a depth of about 1.5 m to 2 m and give it a steeper slope of say 60% and obtain the ledge. The canal portion has to be contained within the cut portion and not encroached upon the filled up soils, so as to ensure stability. A rectangular section for the channel is preferable since minimum width of ledge cutting will be required in this case. A typical design of channel, *ledge* width, slope of cutting on *hill* side, path for walking, lining of' canals etc. is given in Fig. 10.4. The canal is designed as per Manning's formula for a *value* of n = 0.015 for a lined canal. A slope of 1 in 150 is provided to facilitate economical design for canal and also to obtain a non-silting velocity in the canal. There are sufficient slopes available throughout the areas to facilitate giving this slope. Canals may be designed to carry the maximum irrigation water requirements in a given period for the design cropping pattern. For this purpose, it would be prudent to assume paddy crop for the entire command area and irrigation water is delivered at the time when there are no rains (i.e. drought period). A design norm of 1.2 lps/ ha may be adopted to take care of this. At times, when lesser quantities of water are needed (due to available soil moisture, change of crop, and lower demands of $ET_0$ etc.) the same can be delivered by suitable controls at the *sluice* points.

#### 10.4.1.3 *Drops*

Drops in the canal may be of simple design following the canal section. The drop as such may be inclined with 45% slope to facilitate water falling into the small stilling chamber. The stilling chamber may be for a length of 0.3 m to 1.0 m with bed depressed by 0.1 m. The length of stilling chamber depends upon the extent of fall of the drop. Typical lay out of drop is given in Fig. 10.5.

#### 10.4.1.4 *Sinking Areas*

In many schemes, it is seen that canals have to be taken for a portion of their lengths through sinking areas. Different designs are available to negotiate such areas. Several designs such as buried PVC pipes, buried RCC pipes have been tried already in some sinking areas. In areas where buried pipes pose the problem, it is recommended to use piles and take 250 mm dia PVC pipes over pile brackets. Piles may be at an interval of 3 m c/c and connected at top by a 75mm x 75mm angle. The PVC pipe with the weight of water inside will be supported by this angle and the load transmitted to the pile through the top pile bracket. This design has got the stability to withstand slides and provides visibility to facilitate periodical inspections. If any movement is noticed in any pile or set of piles, the same can be set right by adjusting the piles suitably or removing the piles and redoing the same in the correct location. Thus, in this design it will be possible to monitor the pipeline and take corrective measures, as and when required.

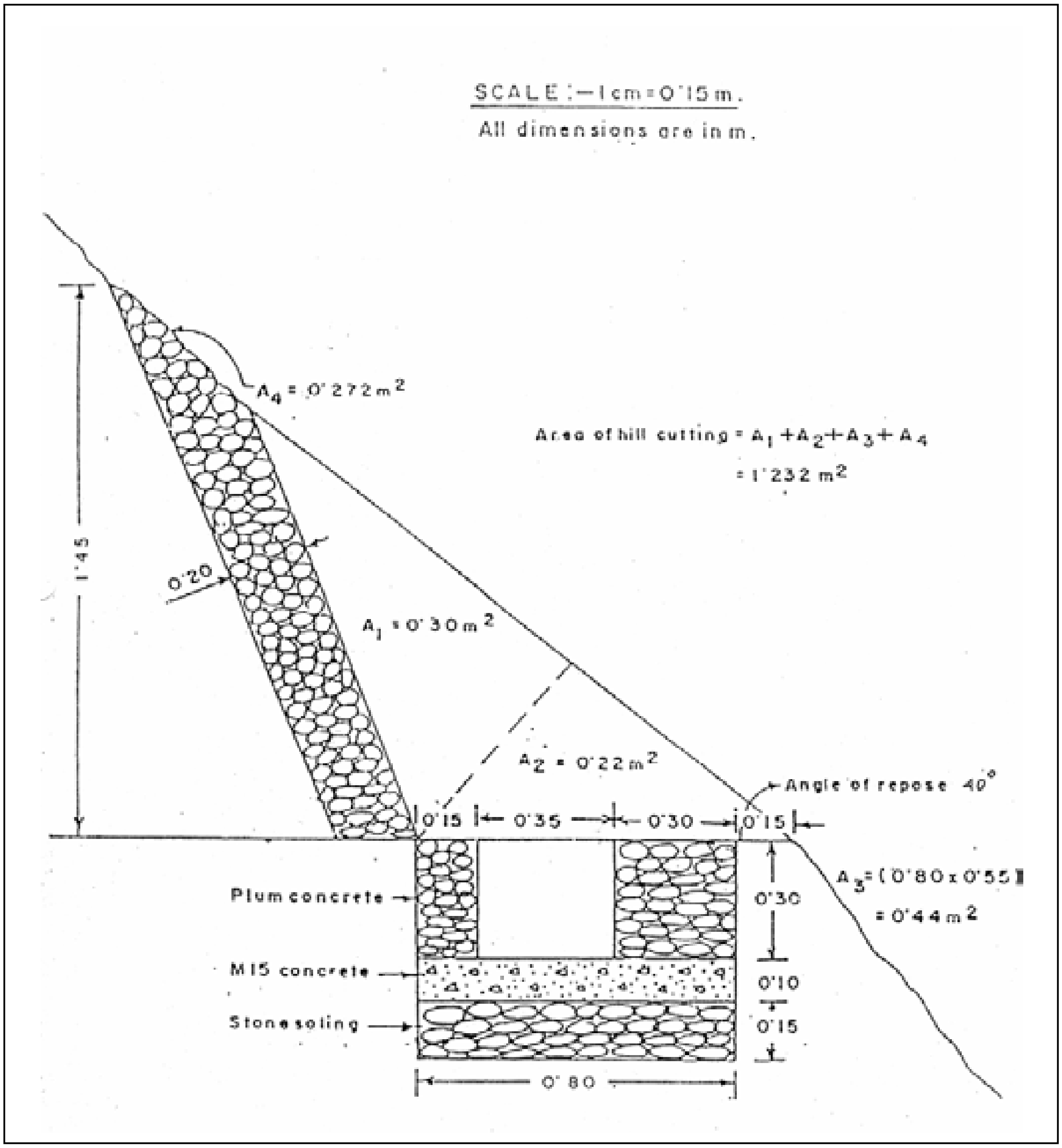



**Fig. 10.4 Typical design of channel**

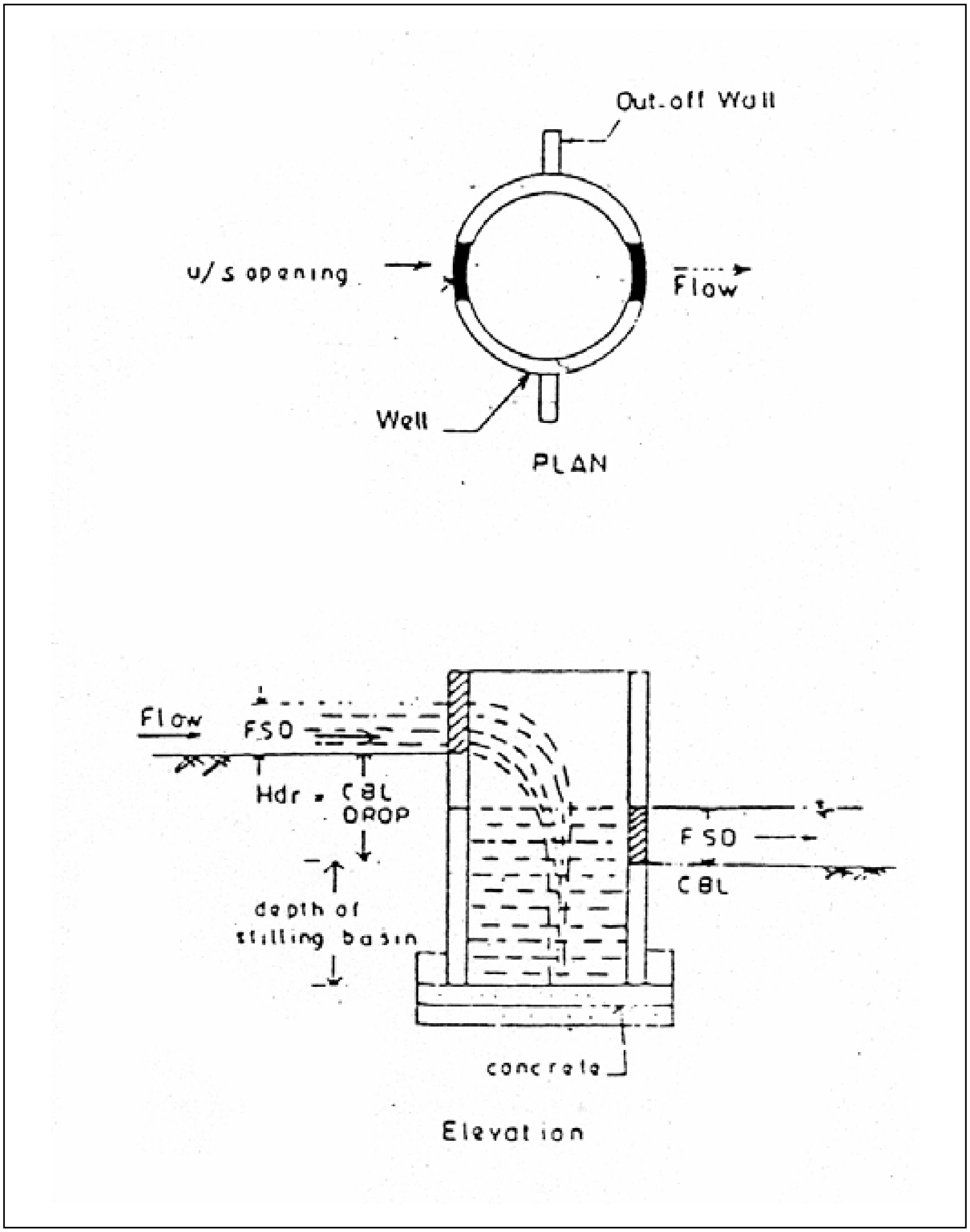



**Fig. 10.5 Type design of vertical well type drop**

### 10.4.1.5 *Catch Pits*

On either side of a pipe section, catch pits would be needed to make a smooth connection to the canal on either side. In some cases it is seen that bigger-than-required sizes are adopted for the catch pits. The internal dimension of the catch pit may be 0.5 m x 0.5 m (Fig. 10.6). Bed of catch pit may be 0.15 m below the bed of canal. Level of outlet (bed) from the catch pit may be the same as that of the inlet or kept 0.05 m below. Top level of catchpit may be the same as the top level of the lined canal.

### 10.4.1.6 *Retaining Walls*

When canals have to negotiate steep slopes it would be necessary to support the same by constructing retaining walls upto the required depth where flatter slopes are met with. A simple design of such retaining walls is shown in Fig.10.7. For accommodating the canal ledge, certain amount of cutting of slopes is necessary and this will make the slope further steeper. As such, the hillside portion of canal also has to be suitably protected as shown in this drawing. In many schemes, it is seen that the canals pass through such steeply sloping structures for short distances. The canal will have no command area in this reach, but in order to command a flatter area, it would be necessary to negotiate such steep slopes.

### 10.4.1.7 *Command Area Plan*

0n many of the new schemes and old schemes executed, command area development plan should be prepared, if not done already. This is the most important aspect of the project to facilitate proper maintenance, to increase productivity and develop the full irrigation potential created. Land Revenue records and maps will be helpful in preparing this map and the same has to be prepared during the investigation stage of the project. These should be implemented with following suggested design procedure :

(i) Details of the proposed project including stream, its catchment area site of head works, proposed alignment and length of canal, probable command area have to be marked in toposheet of 1:25000 scale.

(ii) The concerned block (village) map or maps for the above project area has to be identified (scale 1:2,000) and obtained.

(iii) Contours (20 m intervals), roads, village sites and other topographic features as given in the toposheet (1:25,000 scales) will have to be marked in this Block Plan.

(iv) Project proposals will have to be marked in the block plan. With the help of this block plan, field surveys will have to be done for canal and head works. Also by field inspection, the command areas where presently agricultural operations are being done will have to be marked in this block plan.

(v) Distribution of water and proposals for laterals will have to be planned next, and the same marked in the block plan. Delineation of canal command boundaries will have to be done in this block plan. Proposed cropping pattern proposed may then be indicated in this block map.

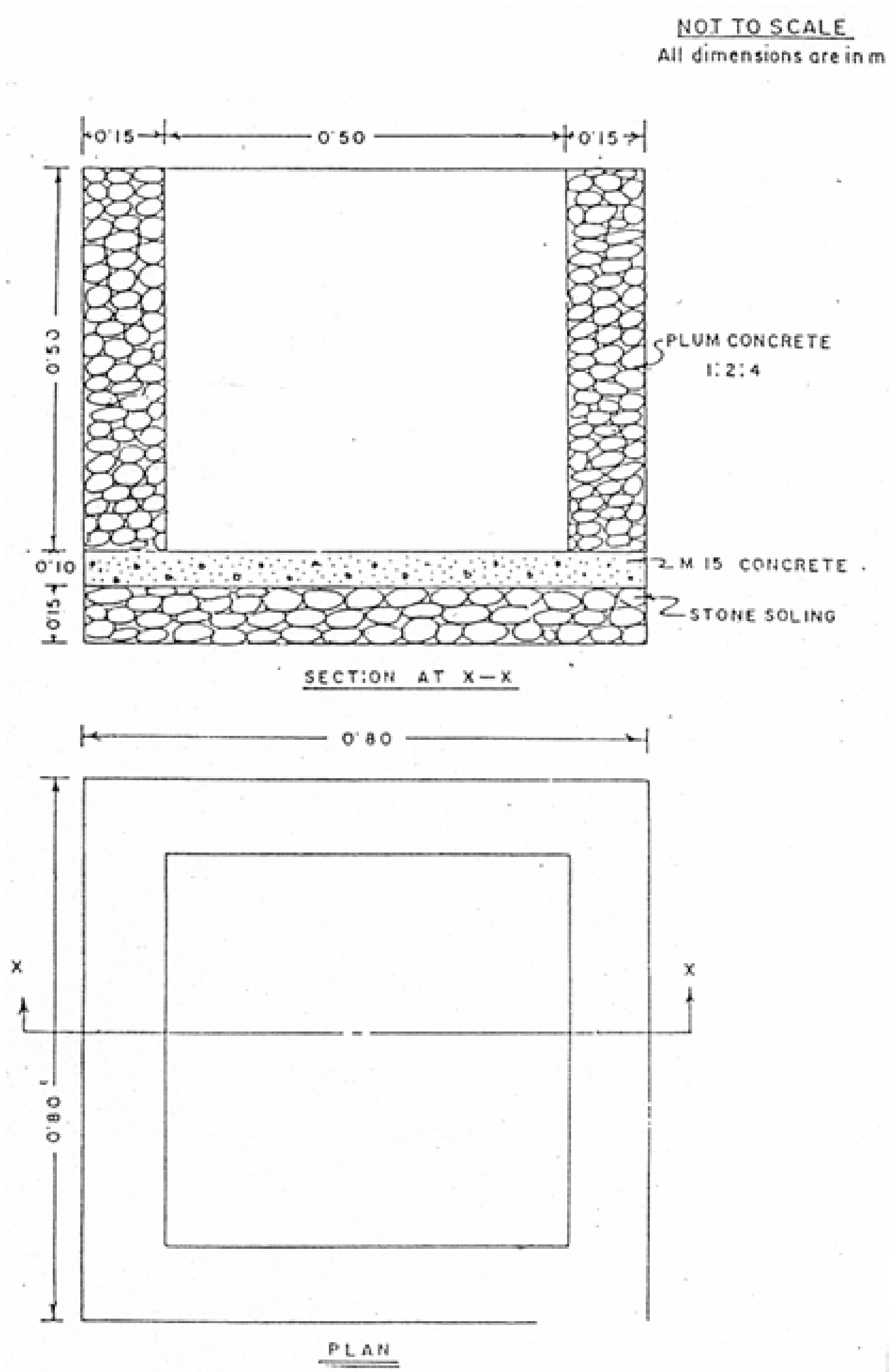



**Fig. 10.6 Details of catch pit**

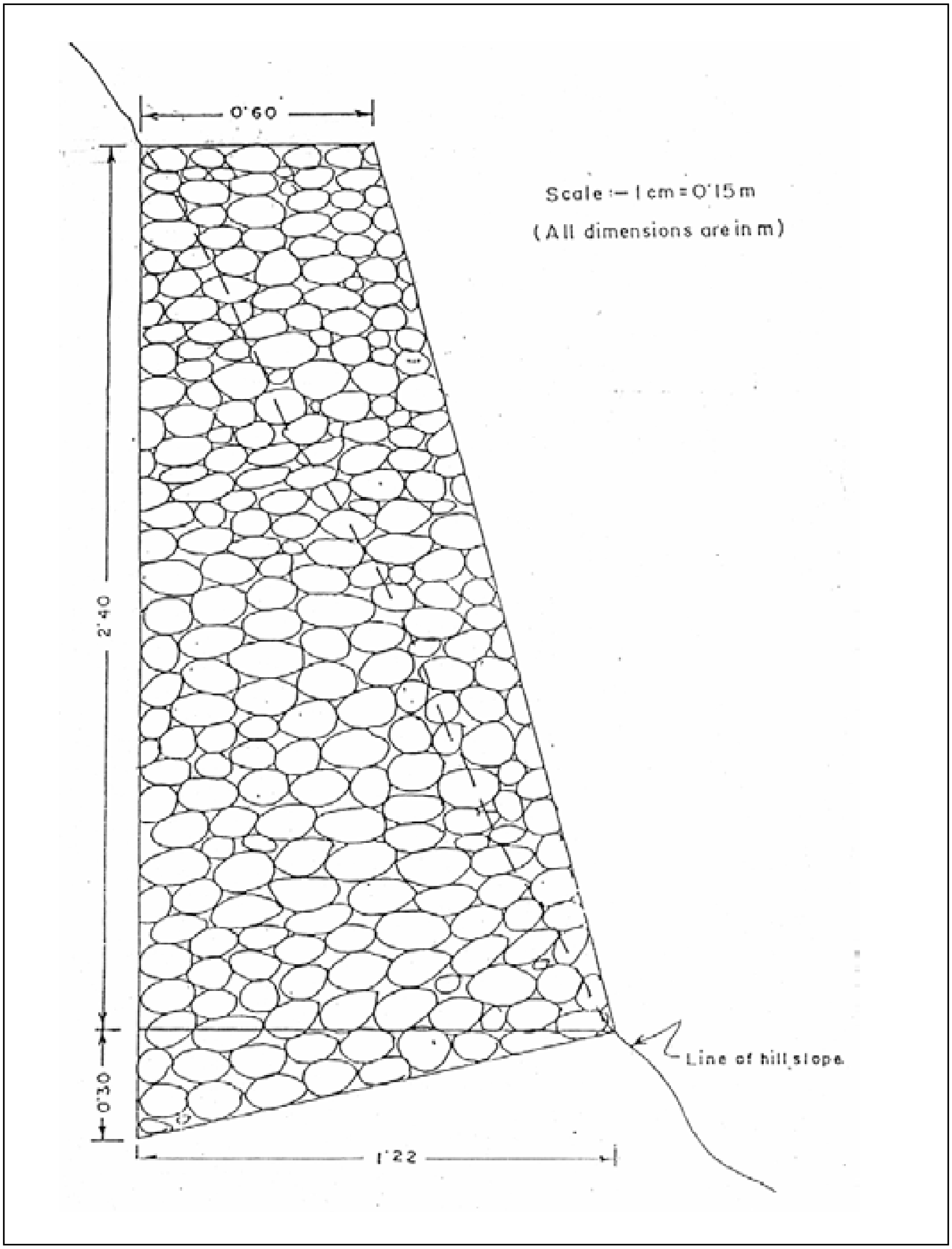



**Fig. 10.7 Details of retaining wall**

(vi) In the above process, command area map is prepared to a scale of 1:2,000 showing the details of head works, canals, drops, sinking zones, pipe lines, pile supports, retaining walls, catch pits, laterals, command area boundaries with survey numbers, proposed cropping pattern, natural topographic features like main stream and its catchment area, stream crossing, roads, villages, contours at 20 m intervals etc. Such. a map will be a great asset at the time of execution of work as well as at the time of operation and maintenance.

### 10.4.1.8 *Lift Irrigation Schemes*

The lift irrigation schemes are taken up for those areas which are located at higher level and can not be irrigated by flow irrigation. The source of water should be perennial to have a successful and self sufficient scheme. Normally lift irrigation schemes are small scale and will not involve lift of water more than 20 m. But in case of Sikkim as hill slopes are steep and rivers generally flow in deep cut valleys, the lift involved is very high being of the order of 40 m to 100 m. The main features of the scheme located on the bank of river, canal or a tank are as follows:

(i) Intake channel or pipe line joining the source of water to the inlet chamber
(ii) Inlet chamber
(iii) Inlet pipe line joining the inlet chamber to jack well
(iv) Jack well

(v) Pump house
(vi) Rising main
(vii) Delivery chamber
(viii) Water distribution system
(ix) Pumping equipment

Water lifted from streams/ nallahs is very costly water and shall therefore be used with maximum efficiency. For irrigation purposes, water use efficiency increases to a sizable extent with sprinkler and drip irrigation techniques. These are described below in brief:

## (a) Sprinkler Irrigation

Uneven terrain cut up lands and ravines get normally excluded from irrigation in view of high cost of providing crossings with conventional gravity flow irrigation system. Substantial area in large patches along the river though otherwise fertile and suitable is thus deprived of irrigation. Sprinkler irrigation in such areas is worth-applying and may prove to be economical too. With light textured soil ranging from sandy loam to loamy sand, the infiltration rate and conductivity being very high and also where frequent light irrigation is required because of the poor water holding capacity of the soil, the conventional surface irrigation system entails considerable loss of water in conveyance and deep percolation. In sprinkler system such losses are restricted to the bare minimum and with a limited quantity of water, a substantially larger area can be irrigated in comparison to surface irrigation.

Sprinkler irrigation is most suitable where the land is sloping and the cost of land shaping is high or land shaping is not feasible because of the shallow 'depth of soils. In the hills, small streams can be tapped at high levels for irrigating farms lower down with sprinklers thus doing away with the need of pumping sets to create a head. Though sprinkler irrigation can be applied to any crop other than paddy and jute, its advantages vary from crop to crop. Experiments conducted on a potato crop have shown that 50% more area can be irrigated with sprinklers than by the furrow method of irrigation.

Since fertilizers give higher yields when applied in split doses at frequent intervals, injection of fertilizers in the sprinkler system is simple and effective. Sprinklers can also be used to apply fungicides and weed killers. Sprinklers in sub-tropical climate can be used to protect crops against frost by spraying water on the plants when the temperature drops below freezing point.

**(b) Drip Irrigation System**

In this system, filtered water is conveyed in tubing's fed from the larger feeder lines, and allowed to drip slowly through nozzles at practically zero pressure to keep the soil surface around the plant root zone constantly wet, without wetting any area in between two plants. This method eliminates the evaporation loss which occurs in sprinkler sprays.

### 10.4.1.9 *Other Engineering Measures*

Besides the above, other engineering measures are also in vogue such as bench terracing, contour bunding, gully plugging etc. for the efficient land and water utilisation in the state. The Bench terracing and contour bunding are described as follows:

#### (a) Terracing

Special methodology is required on steep slopes of the hills, where the spacing between contours of the activity reduces, and velocity of runoff increases with high erosive capacity. The technology for correcting the destructive action is known as terracing. Bunding and terracing is a common practice among the Himalayan high-lands. Farming is carried out on terraces that have been erected with meticulous care over centuries. Terracing requires good care in developing as a system for avoiding breaching during heavy rains. The effectiveness of the system depends also on green cover management.

Bench terraces are a series of uniform, continuous, level strips running across the slope at vertical intervals supported by steep banks. The banks are built by earth and protected by grass or easily accessible rock. They are good for irrigation utilizing the rainwater and interflow between the rains. In high rainfall regions outward sloped benches allow free flow of water without breaching the terraces. In low rainfall regions reverse slope terraces help in water harvesting. These two types of terraces are used for crops mainly. One advantage of sloped terraces is that the cost of banks or raisers is reduced. Intermittent terracing is another combination of level benching with outward sloping terraces. In hillside ditches, level benching and outward sloping berth terraces are combined. This practice is good for semi-permanent, rain fed crops. Individual basins and orchard terraces are narrow benches alternating with outward slopes. Fruit plants can be planted either in pits or basins depending upon the soil profile and water requirement. Hexagon pattern is practiced in this system in heavy rainfall regions for crops requiring good transport routes. In convertible terraces, bench terraces are alternated with two outward sloped terraces sandwiching a basin. This practice is ideal for mixed fanning. The slopes of all these terraces are protected by grasses or crops (Fig. 10.8).

### (b) Contour Bunds

Contour bunds are suitable for the degraded and with lesser slope from 3 to 8%. A minimum bund section of 0.5 m is recommended for lighter and that of 1 m to 2 m for heavier soils. The spacing of the bunds will depend on the slope/contour interval of the land. The spacing between contour bunds will be more in lower slope and less in the higher slopes. This structure is effective both for soil and water conservation. Care must be taken to cultivate the land between two contour bunds parallel to the bunds so that each furrow will act as a water holding structure to check runoff and erosion. These areas can be used for growing maize, millet, potatoes, "cowpea, chillies and pulses. This cropping pattern will not possible their traditional way of life at the same time, conserving the soil and water with improved system.

### (c) Water Harvesting Structure

In drought prone are where even drinking water is scarce, water harvesting ponds may be planned depending upon the suitability of terrain and topography. A typical design of such pond is given at Fig.10.9.

## 10.5 TYPICAL DESIGN OF MINOR IRRIGATION SCHEMES

### 10.5.1 Restoration/ modernisation of Bathung Khola Minor Irrigation Scheme at Village Pastanga-Gaucharan in East District, Sikkim

#### 10.5.1.1 *History*

The diversion structure of the scheme is located near the left bank, little upstream of the culvert on Bathang Khola on Pastanga-Tibet foot – track, about 1½ km from the village Pastanga. From the above diversion structure, a channel takes off towards left side and runs along the hill slope for about 2 km to serve drinking water needs of Pastanga village as well as irrigate 5-6 ha of cultivated area. The above village has 90 house holds with a population of about 510.

Presently the above channel is filled up with silt coming from the hill slope and is damaged in most of its length. Thus, this scheme has become almost defunct. It was informed by Mukhia of the village that if restoration/modernization work on this channel as well as diversion structure is done up properly, its utility would be restored/increased in terms of stable drinking water supply and increased irrigation to some more areas, say up to 15 ha.

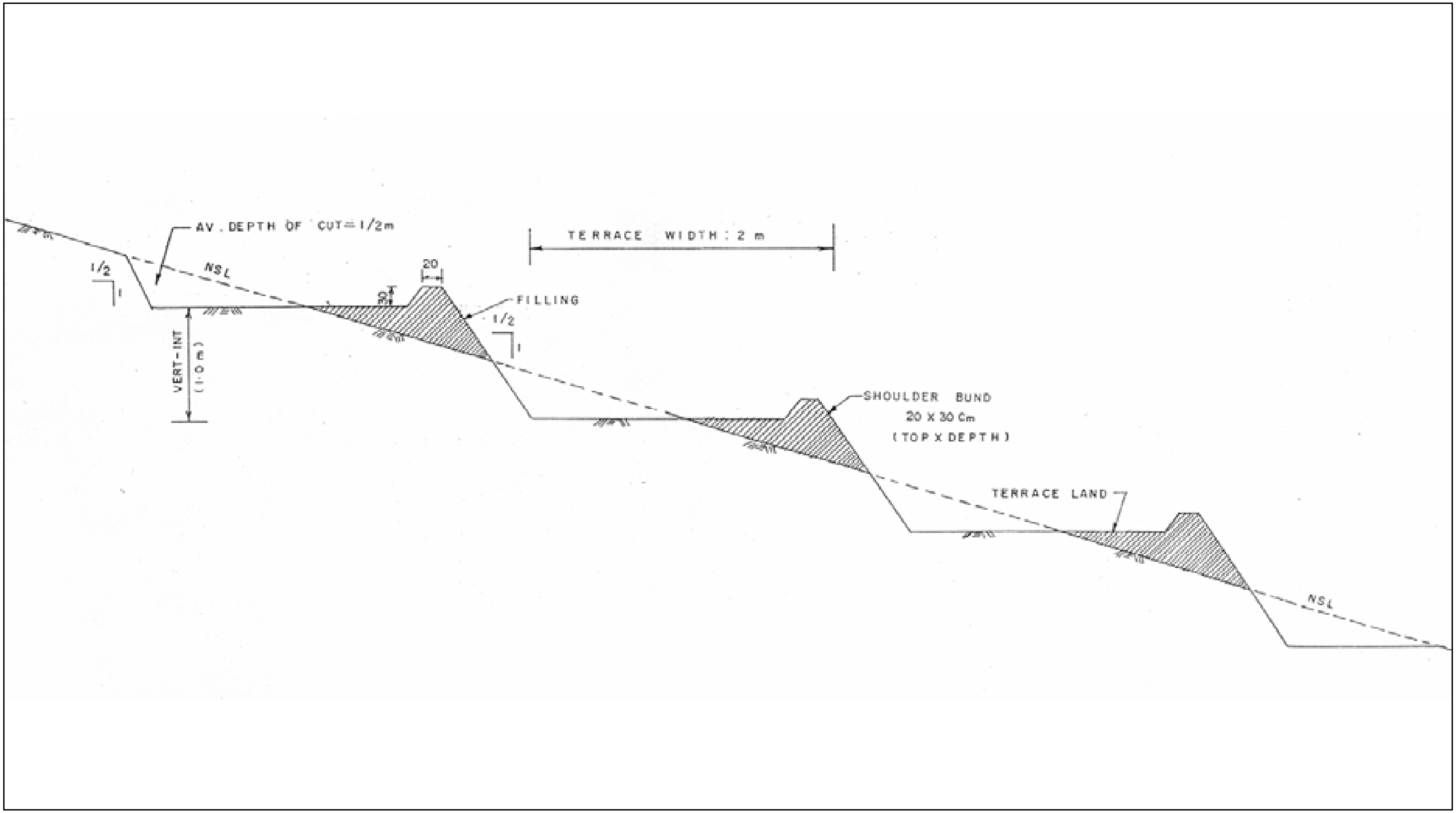



**Fig. 10.8 Typical view of bench terracing for paddy cultivation**

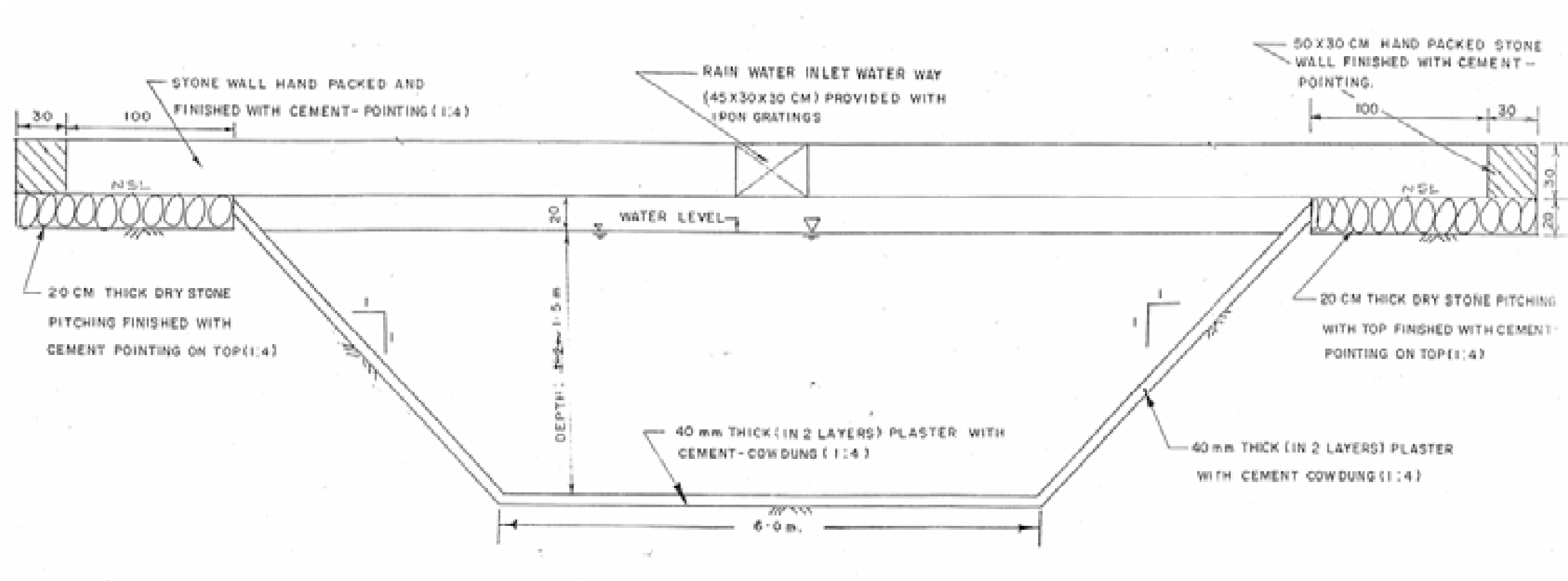



**Fig. 10.9 Typical section of small water harvesting pond (6x4m)**

### 10.5.1.2 *Hydrology and Irrigation Benefits*

The discharge in Bathung Khola on the day of visit to this scheme on 19.5.04 i.e. in a lean season was nearly 0.085 cumec (3 cusec). On the basis of vents provided in culvert in the d/s, it was also estimated that the maximum discharge in this Khola at the culvert site would be nearly 1.50 cumec (50 cusec). This discharge is able to cater to the irrigation requirement for 12 ha of proposed area under kharif. The proposed increase in irrigation due to above arrangement is given in Table 10.2.

**Table 10.2 Existing and proposed irrigation**

**(Unit : ha)**

| Sl. No. | Crop | Existing | Proposed | Increase in Irrigation |
|---|---|---|---|---|
| | **Kharif** | | | |
| 1. | Paddy | 3 | 10 | 7 |
| 2. | Maize | 2 | 2 | - |
| | **Sub-Total** | **5** | **12** | **7** |
| | **Rabi** | | | |
| 3. | Wheat | - | 8 | 8 |
| 4. | Millet | 3 | - | (-) 3 |
| 5. | Vegetables | 2 | 2 | - |
| | **Sub-Total** | **5** | **10** | **5** |
| | **Grand Total** | **10** | **22** | **12** |

#### 10.5.1.3 *Drinking Water Needs*

The population of Pastanga village is 509 presently. Taking 2% population increase per annum, the total population in ten years may become nearly 625. At the rate of 40 lped, the daily drinking water requirement would be 625 x 40 = 25000 lpd i.e. 0.29 l/sec. Even taking 30% over this quantity for the animals, the total requirement would be about 0.40 l/sec.

Thus the requirement of drinking water and irrigation to 12 ha would be met with available water.

#### 10.5.1.4 *Description of existing structure*

The diversion structure consists of a 0.92 m diameter and 1.25 m high well with a outlet vent at 0.45 m from the bed level. The channel takes off from this well which has a section of 45 cm x 30 cm and length of 2 km.

Taking 15 ha as duly for coverage by one cusec of discharge in this hilly area, the above available water is sufficient for the proposed irrigation.

#### 10.5.1.5 *Design of Well Type Intake Structure*

This structure incorporates drop upto 3 m and is being designed for a discharge of 1.5 cumec. The energy is proposed to be dissipated in the water cushion in the well, overcoming the friction through the pipes and the changes in direction of flow. The diverted water enters a vertical well and is then carried through a horizontal pipe or barrel to either open channel downstream or a similar smaller well. Diameter of the well is worked out as per the following formula:

Well diameter D (feet) = $v\left[\frac{2v}{g}+\frac{4y}{g}\right]^{0.5}$

Where v = velocity in the notch in ft/sec

$$= \frac{\text{Discharge (cusec)}}{\text{u/s canal bed width x u/s full supply depth (d)}}$$

and y = u/s canal bed level + d/3 - water level in the well

Water level in the well = d/s FSL + loss of head in pipe and well

Depth of water cushion W = $\frac{H_L + d}{3}$

Where $H_L$ = drop in feet.

The diameter of well should be minimum 90 cm (3ft). The velocity in the barrel should not exceed 1.5 m/sec (5 ft/sec). Bed and side protection on u/s side for a length of 3 m is being provided in the form of a profile wall and curtain wall of the end and pitching.

#### 10.5.1.6 *Estimate*

The restoration cost of this scheme incorporates construction of RCC well-type intake structure of 0.92 m diameter and 1.25 m height, two cutoff walls of 0.62 m to 0.92 m length and repair/ maintenance of the watercourse of about 2 km length. The cost estimate on lump sum basis is given as follows. However, the realistic estimate can be worked out by detailed survey of the scheme at pre-construction stage.

| | | | |
|---|---|---|---|
| 1. | Intake structure with one cut off walls each on both sides, including carriage of construction materials | L.S. | Rs. 1,00,000/- |
| 2. | Assuming repair/maintenance cost of channel per meter to be 1/6 th of the cost of construction of a new channel @ Rs. 600/- per m | 1/6x2000m x600/- | Rs. 2,00,000/- |
| | **Total** | | **Rs. 3,00,000/- (Rupees three lakh only)** |

### 10.5.2 Chalamthang Minor Irrigation Scheme, South Sikkim

#### 10.5.2.1 *History*

The proposed site is located at Chalamthang in South Sikkim, below the road Singtam to Namchi *via*. Tokal Bermiok. The fertile paddy field at Chalamthang does not receive required amount of water or number of watering due to the seepage along the earthen channel constructed long back. Besides, there is frequent washing out of the temporary head regulator. Moreover, there is lot of pressure from the land owners to take up the works immediately so that demand of poor villagers may be fulfilled.

### 10.5.2.2 *Hydrology and Irrigation Benefits*

The source of water for the said paddy field is Setikhola which carries a discharge of about 1 to 2 cusec during lean season. It is anticipated that a maximum discharge of 5 cusec would be sufficient to cater to the irrigation requirement of proposed 12 ha of paddy field.

**Existing and Proposed Irrigation**

**(Unit: ha)**

| Sl. No. | Crop | Existing | Proposed | Increase in Irrigation |
|---|---|---|---|---|
| | **Kharif** | | | |
| 1. | Paddy | 4 | 8 | 4 |
| 2. | Pulses | 2 | 2 | - |
| 3. | Maize (HYV) | 2 | 2 | - |
| | **Sub-Total** | **8** | **12** | **4** |
| | **Rabi** | | | |
| 4. | Wheat | 1 | 2 | 1 |
| 5. | Potato | 1 | 1 | - |
| 6. | Mustard | - | 2 | 2 |
| 7. | Vegetables | 0.5 | 1 | 0.5 |
| | **Sub-Total** | **2.5** | **6** | **3.5** |
| | **Grand Total** | **10.5** | **18** | **7.5** |

### 10.5.2.3 *Design*

The designed internal section of channel is 45 cm x 30 cm which shall convey of 1.2 cusec of water. The discharge has been calculated by applying the non-silting non-scouring velocity which is the critical velocity.

$$V = 0.55\, mY^{0.64}$$

Where V = Velocity of water

m = constant = 1.20

Y = Hydraulic mean depth = 0.35m

Discharge = V x Area

The discharge required for the proposed 18 ha of land would be calculated as below

$$\text{Discharge} = \frac{12}{\text{Duty of Kharif}}$$

$$= \frac{12}{15} = 0.8 \text{ cusec}$$

The designed discharge has been taken as 1.2 cusec. Therefore, there is further scope of increasing the culturable command area. The necessary head regulatory works as weir structure with catch pit arrangement has been proposed with necessary protective measures i.e. retaining wall so as to maintain the gradient of channel at required depressed land profile.

### 10.5.2.4 *Cost Estimate*

The cost of the above scheme has been worked out as Rs. 5.00 lakh on the schedule of rates 2002 and is proposed to be completed in a period of 5 months.

## 10.6 OPERATION AND MAINTENANCE OF MINOR IRRIGATION SCHEMES

Presently fund for operation and maintenance (O&M) of minor irrigation schemes are allocated on adhoc basis in the state per km of channel length. In some cases, farmers are themselves attending to this work where the channels have been constructed by them. But wherever amount has been allocated, it has not be found sufficient to cover all the required necessary works. Moreover, the above allocations perhaps include the cost of establishment which itself offsets the large proportion of the funds. In the absence of relevant data, it is not possible to get an idea of the bifurcation of the above allocation for actual works and establishment, but probably the share of latter had been around 50% of the allocation. It may be mentioned that water tax is not in vogue in the state to generate revenue for proper maintenance of M.I. Schemes and as a result, it was found during formulation of Master Plan for Irrigation Development (1995) that out of total of 854 schemes 419 are not able to generate the planned benefits. Out of these 419 schemes, 119 schemes were defunct and required rehabilitation, 105 were partially functioning, improvement was needed in 50 schemes and 145 required special repairs. During 1993-94, an amount of Rs. 24 lakh was allocated under non-plan provision for the purpose of operation and maintenance, and repair works of M.I. schemes. If this amount is considered against 22947 ha of created irrigation potential, it would amount to Rs. 105/- per ha and if it is worked out on the basis of potential utilized as 17070 ha, the availability of fund per ha would be Rs. 141/-.

As per information contained in Tenth Five Year Plan (2002-07) and Annual Plan (2003-04) Document of I & F Department, Govt. of Sikkim, at the instance of Planning Commission and Ministry of Water Resources, the Department has obtained approval of the State Cabinet to introduce water tax in Sikkim and bill is already vetted by the Law Department and the same is in the process of being placed in the next session of the State Assembly. Presumably this measure may improve the O&M aspect of M.I. Schemes in the state.

As per as norms for O&M, set by successive Finance Commissions, it may be mentioned that Ninth Finance Commission (1990-95) had recommended a norm of Rs. 180/- per ha for utilized created potential and Rs. 60/- for unutilized potential with provision of 5% per annum as escalation factor. Tenth Finance Commission (1995-2000) recommended the rate of Rs. 300/- per ha for utilized potential and Rs. 100/- per ha for unutilized potential with same rate of escalation. Now the Eleventh Finance Commission (2000-05) has recommended Rs. 450/- per ha for utilized potential and Rs. 150/- per ha for unutilized potential with 5% escalation factor per annum.

Appreciating the widely varying water rates from state to state and few state not charging these rates at all as well as the problems encountered in assessment of huge arrears in collection of irrigation revenue, finally reflecting upon the O&M aspects of irrigation schemes, the Planning Commission in 1991 constituted a Committee on Pricing of Irrigation Water under the Chairmanship of Dr. A. Vaidyanathan. The above committee recommended Rs. 310/- per ha as water charge as against 180/- per ha of O&M recommended by Ninth Finance Commission.

The above report was processed by a group of officials under the chairmanship of Secretary. Planning Commission who held that in first phase, the states should charge for the cost of the irrigation services at least to the level of O&M cost, in a span of five years. However, a view emerged that for various reasons, it would be difficult for North Eastern Region states to raise water rates to cover full O&M cost, and hence subsidies would have to be continued by the states. Since most of schemes in hilly areas are minor irrigation schemes, the O&M of these schemes should be gradually transferred to end users and till such time, these states may not recover water rates which are applicable to plain areas. However, the difference between the water rates and actual O&M cost should be clearly shown as loss in the State Annual Plans.

Since Eleventh Finance Commission has recommended Rs.450/- per ha of utilized potential and Rs.150/- per ha for unutilized potential and taking into consideration the view as above for continuance of subsidy in hilly states, it is suggested that 50% of the amount, recommended by Eleventh Finance Commission i.e. Rs. 225/- per ha of utilized potential and Rs. 75/- per ha of unutilized potential may be allocated as O&M cost which may be gradually increased with the introduction of appropriate water rates. Up to March 2002 i.e. end of IXth Plan, irrigation potential of 31.30 th ha was created, out of which 23.68 th ha was utilized. Considering the above criteria, this would necessitate O&M funds of Rs.59 lakh per annum. However, at ultimate stage of development with utilized irrigation potential of 70 th ha, O&M funds of the order of Rs.1.58 cr. would be required at present price level.

## 10.7 WATER RATES

The department of Irrigation and Flood Control, Govt of Sikkim in entrusted with the task of construction and maintenance of irrigation channels throughout the state. In order to make the beneficiaries accountable and responsible for careful use of water, it was proposed to levy a nominal amount of money in the form of tax per hectare per annum so that the revenue received as above could be utilised for maintenance of channels.

Accordingly, Sikkim Legislative Assembly passed the 'Sikkim Irrigation Water Tax Bill, 2002' in the budget session held from 23$^{rd}$ March, 2002 to 30$^{th}$ March, 2002. The same was duly assented to by the Governor of Sikkim on 3$^{rd}$ April, 2002.

In accordance with the provisions contained in the Bill, The following water tax has been stipulated :

| Sl. No. | Category of land | Classification | Rate per hectare (Rs.) |
|---|---|---|---|
| 1. | Paddy field | Class - I | 150 /- |
| | | Class - II | 80 /- |
| | | Class - III | 60 /- |
| 2. | Cardamom field | Class - I | 250 /- |

| | | | |
|---|---|---|---|
| | | Class - II | 200 /- |
| | | Class – III | 150 /- |
| | | Class - IV | 100 /- |
| 3. | Dry field | Class - I | 30 /- |
| | | Class - II | 20 /- |
| | | Class - III | 10 /- |

## 10.8 OPTIMISATION OF IRRIGATION CAPACITY UTILISATION

It is observed that out of irrigation potential of 31.3 th ha created upto 2002, an area of 23.68 th ha (75.6%) has been utilized. The issue of improved utilization of irrigation potential already created need to be tackled at three levels *viz*. statistically, physically and institutionally. State Govt. has carried out actual verification of cropped area and production figures during 2001-02 on the basis of panchayat-wise 100% enumeration. It was observed from the verification that the reported area and production figures under cereal crop were higher from the actuals by about 16% and 30% while the same for pulses where higher by about 24% and 52%. The maximum variation was observed in the figures of fruits where difference was 524% and 636% followed by vegetables at 130% and 131%. The above estimates put the whole system of our reporting to question. In view of the above, instead of judging the performance of irrigation system from the figures of potential created and utilized, it may be more appropriate if the focus is shifted to the amount of water made available through the system, the frequency of water supply, cropping pattern and yield. This can be done by reporting the utilization in terms of ‘number of waterings-hectare’ until a better system of volumetric water supply measurement is adopted.

Although above criteria may not be much relevant in the state of Sikkim because of irrigation development only through construction of diversion structures under minor irrigation schemes, an attempt may be made in respect of lift irrigation schemes. In case of minor irrigation schemes, potential and utilization figures are mainly decided on normative basis which need to be verified on ground so as to firm up the data base. Delay in construction of distribution network, especially field channels, water courses and proper land preparation for efficient use of water, are found to be main seasons for slow pace of utilization.

**Under Utilisation of Irrigation Potential**

The question of under-utilization of irrigation potential can also be viewed in terms of following:

(i) Under-utilization in terms of area
(ii) Under-utilization in terms of productivity

Under-utilisation in terms of area may be due to (a) cultivable area being on a higher ground and (b) change in cropping pattern, low water use efficiency or improper maintenance of the system.

(a) Cultivable area in the state of Sikkim is reported as 108.89 th ha during 1995-96, which constitutes only 15.3% of the geographical area and 63.3% of reporting area in the state of Sikkim, most of the area in the state is covered with snow and hence not available for cultivation. Below the snow line, some of the area which is being reported is occupied by pastures, fallow land and infrastructural installations. Irrigation system generally envisages gravity flow. It is also observed that undulating terrain, rolling topography and hilly slopes can not be easily irrigated by surface methods. Possible option to bring a high ground under irrigation could be either through site – specific diversion scheme or by lift irrigation. Also, such area becomes accessible through drip irrigation without much investment on land levelling and shaping. High value crops can be grown on these tracts which are more remunerative & yield higher production with efficient water utilization.

(b) Non-availability of land

Though the state of Sikkim is endowed with enough water, suitable sites for its storage and conveyance to the field are not available. In such a situation, irrigation has developed only through minor schemes. It may be observed that CCA covered by minor irrigation scheme is only of the order of 20-50 ha, going maximum upto 300 ha in some of the schemes.

Besides the above, there is considerable evidence that cropping pattern adopted by farmers are often much more water-intensive than assumed at the time of scheme formulation. This is also accompanied with low water use efficiency through traditional irrigation practices and inadequate funds for operation and maintenance of existing water courses and field channels.

## 10.9 PARTICIPATORY IRRIGATION MANAGEMENT IN THE STATE OF SIKKIM

Participatory Irrigation Management (PIM) as a programme for improvement in irrigation service in the state has not yet been taken up as per the available information. However, as per census of MI Schemes, 1995-96 (Table 5.6), out of a total of 854 schemes in the state, 235 are being managed by group of farmers which implies that the concept of PIM is being followed in the state in some form or the other. Farmers are motivated to take over irrigation schemes for irrigation management by themselves. There is further silver lining in the south district of the state wherein two third of the total schemes are under management of group of farmers as against about 28% in the state as a whole and 30% in west district. This indicates that there is enough awareness amongst the farmers to turn over all the irrigation schemes in the state which are minor in nature to the organized group of farmers under PIM, in a planned and phased manner. This would be helpful in better irrigation utilisation and maintenance of created infrastructure.

The purpose of Participatory Irrigation Management (PIM) activities in the State may be described as follows in brief:

(i) Participatory irrigation management which would improve service deliveries through better operation and maintenance and results in improved efficiency and equity in distribution as well as better reliability essential for high value crops should be introduced as a programme by Govt of Sikkim.

(ii) Physical sustainability of irrigation infrastructure would be ensured if water users' organisations manage the irrigation services.

(iii) A sense of partnership between the users and the government agencies would be promoted in participatory irrigation management system which enhances better communication and cooperation leading to mutual benefit.

(iv) The model of participatory irrigation management which is location-specific, depending on the prevailing socio-economic conditions varying from region to region should be deigned as suited for the state.

(v) The quality of farmers' leader, if needed improvement should be planned which very much determines the success of the system.

### 10.9.1 Steps Involved in Introducing PIM

Under the situation the problem of introduction of PIM in specific areas will have to be studied in depth and the system may be devised and set up afresh. This may be done in following steps:

(i) Identification of inadequacy, deficiency and shortcomings of the existing system.

(ii) Study of the socio-economic condition of the area.

(iii) Determination of suitable model for participatory irrigation management. The Model which is appropriate for the state should be evolved during Action Research for various regions of the state.

(iv) Identification of progressive and dynamic farmers' leaders who could be assigned responsibility.

(v) Identification of pilot project which could serve as eye opener and source of inspiration for other farmers.

(vi) Devising suitable linkage between farmers' organisations and various government agencies involved in irrigation.

(vii) Study of the legal status and designing necessary legal framework.

### 10.9.2 Activities Involved in Introducing PIM

Introduction of PIM is a socio-technical activity and as such it is complex in nature. The work will be done in steps mentioned below.

#### 10.9.2.1 *Preparation*

The details and information related to engineering aspects, agricultural aspects, agro-economic profile of the villages involved and available infrastructures will be collected and documented. This will help in assessing the existing condition and need for improvement. A list of beneficiaries with area of land owned i.e. Record of Right (ROR) will also be made. This will be as per channel system and village wise.

#### 10.9.2.2 *Delineation*

The channel system with their boundaries and villages will be delineated. It is proposed to form water users association as per hydraulic boundaries of the canal system.

#### 10.9.2.3 *Motivation and Awareness*

It is necessary that the farmers are made aware of various aspects of PIM and they are also suitably motivated. This may be done through I and FC Department functionaries and selected beneficiaries with the help of available NGOs in the area. Group discussions and seminars will also be organised very frequently at different levels.

#### 10.9.2.4 *Organisation*

Initially WUAs will be constituted on adhoc basis and after its functioning for sometime election will be held for constituting WUAs on regular basis.

#### 10.9.2.5 *Registration*

After the WUAs are finally constituted they will be registered under Societies Registration Act.

#### 10.9.2.6 *Interaction with Project Officers*

The Project Officers will have to interact with WUAs at all stages.

#### 10.9.2.7 *Training*

Training of farmers as well as Project Officers will be a very important component for capacity building and this will be organised suitably.

#### 10.9.2.8 *Joint Management*

Management of irrigation will initially be done jointly by the project officers and farmers so that they help each other and confidence building is done jointly.

#### 10.9.2.9 *Handing over*

After the joint management of the system for some time, when the farmers become well equipped for taking over the responsibility, the system would be finally transferred to them for management.

### 10.9.3 Status of PIM in the state

During visit to the state by WAPCOS team in May 2004, few examples of the initiatives taken by local people came to light. Local NGO i.e. Voluntary Health Association of Sikkim (VHAS) has organised the efforts in water resources development besides handling the environmental issues in a very professional and methodological manner. The activities taken up by the organisation are given below:

#### 10.9.3.1 *Ahlay Pokhari Water Harvesting Programme – Preliminary Planning*

There used to be a pond until 1968 near village Asang Thang (West Sikkim) which used to serve the small population of the area. Subsequent to the devastating floods the pond starting drying up during the winter months. It may be fortuitous that many of the water sources are drying up in this area due to the massive deforestation that is taking place rampantly. Moreover, due to increased pressure of population, these water shortages are adversely affecting the lives of the villagers. Presently, water requirements are met through a distant water source. With the onset of dry winter months, this source also doesn't get required quantum of flow. Carriage of water from the source to village takes up 4-5 hours of productive time, especially of school-going children. Since this water source is also on the verge of drying up, there is an urgent to plan some suitable augmentation measures to meet the requirement. For this purpose, a pond may be constructed to collect the water during monsoon season and its utilisation during dry months.

After discussion with the villagers, it was given to understand that there is a cluster of villages which are dependent on this source of water. The list of villages along with the number of households are given as follows:

1. Ahlay gaon - 25 households
2. Gurung gaon - 25 households
3. Rani gaon - 25 households

| | | | |
|---|---|---|---|
| 4. | Dumi gaon | - | 25 households |
| 5. | Sangbung gaon | - | 30 households |
| 6. | Upper Tinik | - | 10 households |
| | **Total** | **-** | **140 households** |

It is estimated that about 1000–1200 people will be benefited directly by this project. So the direct demand for water at a modest estimate at about 50 litres per person per day works out to a requirement of 50,000 – 60,000 litres per day.

Further, the area used to be very productive in vegetable and other farm produce. But due to the acute water shortage, productivity levels of the crops have reduced substantially. The area above the proposed pond is sparsely forested. The incidence of felling of trees by the villagers has been reported due to which the upstream area is subject to soil erosion.

The proposed pond area where the above reservoir is to be built is roughly about 54 m (180 feet) long, 15 m (50 feet) wide and 6 m (20 feet) deep. This would hold approximately 4, 5000,000 litre of water which would be able to supply water for a period of about 80 days. It is possible to increase the width and the depth of the reservoir to some extent at a late date, if so needed.

Community participation in order to implement this project will need to be set up to oversee the project. This is a must and a prerequisite. This will also ensure that farmers' own capabilities to implement, operate and maintain the projects will be developed over the project period. In such case, community members also become active stakeholders. The distribution of water amongst villages and villagers as well as the conservation aspects of the forest cover should be fully addressed by them in a reasonable manner which will, in turn, ensure sustainability of the project.

# CHAPTER - 11
# CARRYING CAPACITY - PERSPECTIVE PLANNING

# CARRYING CAPACITY – PERSPECTIVE PLANNING

## 11.1 GENERAL

Optional planning of available land and water resources in the state of Sikkim has been done considering the following three strategies:

(i) Maximise production per unit of area through multiple cropping, high yielding varieties etc.

(ii) Maximise the area served with available water through protective irrigation to supplement rainfall and using drought-resistant varieties.

(iii) Exploring the possibilities of lifting of surface water.

Almost every human and economic activity needs water as an essential requirement. Water may thus serve a variety of purposes, of which the following are more relevant for the state of Sikkim:

(i) Domestic and municipal water supply

(ii) Irrigation for growing crops

(iii) Generation of hydro-electric power

(iv) Fisheries

(v) Recreational uses

(vi) Livestock requirement.

In some of the above uses like irrigation and domestic supply, water has to be abstracted and transported from its source while in others, it is used in its natural receptacle itself e.g. fish and plant growing, and recreational uses. Each of these uses can be categorised as non-consumptive or consumptive. In case of hydro power generation, no water is consumed in the use as such, while in the case of industrial and urban water supply with planned waste water disposal system, 80% to 90% of abstracted water is returned back and thus may be again available for use. The return water may in most of the cases need some treatment and upgrading of its quality for the re-uses. Application of water by irrigation to agricultural crops also generates the return flow, although on a much reduced scale. However, the concept of return flood from irrigation and domestic uses has not been taken into consideration in this region because of hilly terrain.

An integrated water resources planning calls for attention to all the future needs of these uses. For the present perspective planning of water resources utilization in Sikkim on the macro level, obviously the consumptive uses need only be considered in detail, though non-consumptive requirements too have also been kept in view. By far, the greatest consumptive use of water is associated with irrigation.

Since a large population is to be supported, its basic needs of food and fiber in the first instance have necessarily to be provided for. Further, around seventy percent of the population depends upon agriculture directly for their living and therefore, agriculture has always been and continues to remain the main industry of our country.

Accordingly, planning for use of water for irrigation in the basin has been given attention. However, domestic requirements have also been taken into account and duly integrated so as to have a harmonious development for multifarious uses.

## 11.2 PERSPECTIVE PLANNING

For planning utilization of any resource, its need or requirement at the end of specified planning period for different uses are to be assessed. For this macro planning, the consumptive use of water only for two important purposes *viz*. Domestic and irrigation has been considered for the years 2025 and 2050.

## 11.3 PROJECTION OF NET SOWN AREA, GROSS CROPPED AREA AND IRRIGATED AREA

From the above statistics, it is observed that net sown area has suddenly reduced from the level of 78.38 th ha in 1980 to 63.25 th ha in 1990-91, a decrease of about 15.13 th ha (19.3%) over a period of 10 years. The same, however, has remained at 62.04 during 1995-96 which is only marginally less (about 1.9%) than the figure of 1990-91. During this period, it is also observed that though fallow land has remained more or less same at the levels of 13.90 th ha & 13.11th ha, the other uncultivated land & cultivable waste land, put together has increased from 5.24 th ha to 20.64 th ha. However, during 1995-96, there is a marked increase in fallow land other than current fallow, from the level of 9.20 th ha during 1990-91 to 29.57 th ha during 1995-96. The only perceptible reason for the sudden decrease in net sown area may be attributable to the increase in population and pressure on land resources, associated with accompanying infrastructure development activities such as building, roads, etc.

For management of land resources in the state of Sikkim, it would be appropriate if the area under ‘other fallow land’ is reduced by about 50% to a level of 14.78 th ha and this area is brought under ‘net sown area’ category. This would increase the net sown area from 62.04 th ha to 76.82 th ha.

During the year 1990-92, gross cropped area was reported as 113.34 th ha (see Table 7.6) with net sown area as 63.25 th ha (1990-91), thus giving a cropping intensity of 179.2%. Therefore, cropping intensity of 180% has been projected for the years 2025 & 2050. In this way, gross cropped area works out to 76.82 x 1.80 = 138.30 th ha. For working out the percent of cropped area under each crop, following points have been considered:

(i) The area under paddy cop was reported as 11.43 th ha, 15.91 th ha, 14.75 th ha during 1990-92, 1999-2000 and 2002-2003 respectively. Hence, depending upon the prevailing situation 15 th ha has been earmarked for this crop.

(ii) The extent of coverage under maize has varied from 39.39 th ha to 40.28 th ha. And therefore, 40 th ha has been considered under maize crop.

(iii) The area under wheat cultivation has increased from 5.22 th ha in 1990-92 to 8.10 th ha in 1999-2000. Therefore, 10 th ha of area has been considered under wheat cultivation.

(iv) Pulses have been cultivated in an area of about 6 th ha during the above period and hence, 3 th ha of area has been covered under kharif & rabi crop each.

(v) Although oilseeds occupied only 5.59 th ha and 6.65 th ha of area during 1990-92 and 2001-2002, 10 th ha of area -5 th ha under kharif crop (soybean) and 5 th ha under rabi crop (mustard) has been considered.

(vi) Millets have been considered to occupy 5 th ha of cropped area.

(vii) The share of large cardamom has been reported as 21.22 th ha. Accordingly, the area under cardamom has been projected as 25 th ha.

(viii) The area as under other crops *viz*. potato, ginger, fruits & vegetables and others have been considered as 7 th ha, 5 th ha, 10 th ha and 2.3 th ha.

With the above consideration, kharif crops occupy 73 th ha while rabi crops occupy 26 th ha of gross cropped area. The rest of the area to the extent of 39.3 th ha is being allocated to miscellaneous crops *viz*. Potato, cardamom, ginger and others.

Out of the above projected gross cropped area of 138.30 th ha, irrigation is being planned for 70 th ha, which is the ultimate irrigation potential of the state. Since irrigation schemes are mostly diversion structures, the irrigation is contemplated for the kharif crops and perennial crops. However, Rabi irrigation has also been envisaged, through storage ponds etc. For allocating the season-wise area under irrigation, recourse has been taken to the actual area being irrigated, as reported in the census of 1995-96 (see Table 5.6). As observed from Table 5.6, out of the total irrigated area of 12.49 th ha, an area of 57% has been irrigated in kharif, 29% in rabi, 10% in perennial and 4% others. Accordingly, the irrigated area under kharif has been taken as 40 th ha (57%), 18 th ha (26%) under rabi and 12 th ha (17%) under perennial and other crops. The crop wise details of the irrigated and rainfed areas under various crops are given in Table 11.1.

**Table 11.1 Proposed cropping pattern and irrigated area for the state of Sikkim**

**(Unit: th ha)**

| S.No. | Crop | Irrigated | Rainfed | Total Cropped Area |
|---|---|---|---|---|
| | **Kharif** | | | |
| 1. | Paddy | 15 | - | 15 |
| 2. | Maize | 25 | 15 | 40 |
| 3. | Millet | - | 5 | 5 |
| 4. | Pulses | - | 3 | 3 |
| 5. | Soyabean | - | 5 | 5 |
| 6. | Vegetable | - | 5 | 5 |
| | **Sub Total** | **40** | **33** | **73** |
| | **Rabi** | | | |
| 7. | Wheat | 10 | - | 10 |
| 8. | Pulses | 3 | - | 3 |
| 9. | Mustard | 3 | 2 | 5 |
| 10. | Vegetables & Fruits | 2 | 5 | 7 |
| | **Sub Total** | **18** | **7** | **25** |
| | **Perennial/hotweather** | | | |

| | | | | |
|---|---|---|---|---|
| 11. | Potato | 2 | 5 | 7 |
| 12. | Large Cardamom | 10 | 15 | 25 |
| 13. | Ginger | - | 5 | 5 |
| 14. | Others | - | 3.3 | 3.3 |
| | **Sub Total** | **12** | **28.3** | **40.3** |
| | **GrandTotal** | **70** | **68.3** | **138.3** |

## 11.4 DOMESTIC WATER REQUIREMENT

Out of the various important uses of water, after considering irrigation, the next is obviously the domestic use. This covers mainly the drinking water and other daily needs of human population. Though the minimum requirement for domestic use can be very small when the availability of water is high, the domestic consumption depends to a large extent on the living standards and the state of development. The total domestic demand will, therefore, depend on (a) population and (b) per capita daily demand. Population of the state for the years 2025 and 2050 has already been discussed in Chapter-III. Total population of the state which was 5,40,493 in 2001 has been estimated to be of the order of 9,68,173 and 14,13,673 in 2025 & 2050, respectively.

For assessment of domestic needs of water, the population scenario in the state in a long range time horizon with specific indication of urban and rural areas developments is a pre-requisite. It is observed that the rate of percentage increase in urban population (with respect total population) every five years during 1996-2016 has been projected around 12.5%. Therefore, considering the increase of 12.5% (over a period of five years) for twenty four years during 2001 to 2025 and around 15% (over a period of five years) for the period 2026-2050, the percentage of urban population with respect to total population has been projected as given in Table 11.2.

**Table 11.2 Projected urban and rural population of Sikkim for 2025 & 2050**

| Year | Total Population | Urban Population Rate of increase with respect to total population (%) | Nos. | Rural Nos. |
|---|---|---|---|---|
| 2001 | 5,40,493 (Actual) | 11.64 | 62,647 | 4,41,796 |
| 2025 | 9,68,173 (Projected) | 20.51 | 1,98,572 | 7,69,601 |
| 2050 | 14,13,673 (Projected) | 41.25 | 5,83,140 | 8,30,533 |

The increase in urban population is due to migration of a part of rural population of urban areas for livelihood as well as due to continuous conversion of some rural areas into urban areas.

The quantity of water required for domestic purpose depends mainly on the habits, social status, climatic conditions and customs of the people, besides the mode of supply. The requirement in urban areas is more than that in rural areas because of the additional water used for w/c, gardening and provision for fire fighting, etc.

For planning purposes, a general norm per capita per day for the country as a whole is being adopted which is considered minimum for domestic and non-domestic needs. The same is given as below:

(i) Communities with population upto 20,000

  (a) Water supply through stand post - 40 lpcd

  (b) Water supply through house Hold connections - 70 to 100 lpcd

(ii) Communities with population 20,000-1, 00,000 - 100 to 150 lpcd

(iii) Communities with population Above 1, 00,000 - 150 to 200 lpcd

Following the above norms i.e. 40 lpcd for rural and 100 lpcd for urban population, domestic water requirement for the state as whole have been worked out for the year 2025 and 2050. The same are given in Table 11.3.

**Table 11.3 Total domestic Water Requirement for 2025 & 2050**

| Year | Population | | | Annual Water Requirement (mcum) | | |
|---|---|---|---|---|---|---|
| | Urban | Rural | Total | Urban | Rural | Total |
| 2001 | 62,647 | 4,41,796 | 5,40,,493 | 2.29 | 6.45 | 8.74 |
| 2025 | 1,98,572 | 7,69,601 | 9,68,173 | 7.25 | 11.24 | 18.49 |
| 2050 | 5,83,140 | 8,30,533 | 14,13,673 | 21,28 | 12.13 | 33.41 |

## 11.5 IRRIGATION WATER REQUIREMENT

Crop wise irrigation water requirement have been worked out in detail in Chapter-VIII. Ultimate irrigation potential of 70 th ha has been planned to be developed and utilized by the year 2025. The details of irrigated area under each crop *vis-à-vis* the irrigation requirement is given in Table 11.4.

**Table 11.4 Gross irrigation water requirement**

| S. No. | Crop | Area (th ha) | Gross irritation requirement (mm) | Total water requirement |
|---|---|---|---|---|
| 1. | Kharif crops | 40 | 670 | 268 |
| 2. | Rabi crops | 18 | 68 | 12 |
| 3. | others | 12 | 400 (say) | 48 |
| | **Total** | **70** | | **328** |

## 11.6 TOTAL WATER REQUIREMENT

Water requirement for the state of Sikkim in the years 2025 and 2050 would be 346 Mcum and 362 Mcum, respectively. The details of the same are given in Table 11.5.

**Table 11.5 Total Water Requirement**

**(Unit: Mcum)**

| S. No. | Use | 2025 | 2050 |
|---|---|---|---|
| 1. | Domestic | 19 | 34 |
| 2. | Irrigation | 328 | 328 |
| | **Total** | **347** | **362** |

## 11.7 AGRICULTURE PRODUCTION

### 11.7.1 Yield and Production

The data on yields of various crops was collected for the year 1975-76 and 2000-01. Based on the realistic assessment, the yields have been projected for the years 2025 and 2050 for the ‘Irrigated and ‘Rainfed’ categories of crops separately as given in Table 11.6. Accordingly, the production of crops has been worked for the years 2025 & 2050 and given in Table 11.7 and the same is abstracted in Table 11.8.

### Table 11.6 Crop-wise actual and projected yield figures

**(Unit: tonne/ha)**

| Sl. No. | Crop | Actual | | Projected | | | |
|---|---|---|---|---|---|---|---|
| | | 1975-76 | 2000-01 | 2025 | | 2050 | |
| | | | | Irrigated | Rainfed | Irrigated | Rainfed |
| 1. | Paddy | 0.88 | 1.40 | 2.50 | 1.25 | 3.00 | 1.50 |
| 2. | Maize | 0.58 | 1.49 | 2.00 | 1.25 | 2.50 | 1.50 |
| 3. | Millet | 0.63 | 0.91 | 1.00 | 0.50 | 1.25 | 0.75 |
| 4. | Pulses | 0.41 | 0.86 | 1.50 | 1.00 | 2.00 | 1.25 |
| 5. | Oilseed | | | | | | |
| | Soyabean | 0.47 | 0.77 | 1.25 | 0.75 | 2.00 | 1.00 |
| | Mustard | NA | 0.45 | 1.00 | 0.50 | 1.50 | 0.75 |
| 6. | Vegetable | 2.00 | 4.73 | 10.00 | 5.00 | 15.00 | 7.50 |
| 7. | Wheat | 1.00 | 1.40 | 2.50 | 1.25 | 3.00 | 1.50 |
| 8. | Potato | 2.08 | 4.11 | 6.00 | 4.00 | 10.00 | 5.00 |
| 9. | Cardamom | 0.25 | 0.23 | 0.30 | 0.20 | 0.35 | 0.20 |
| 10. | Ginger | 4.00 | 4.70 | 10.00 | 7.00 | 15.00 | 10.00 |

# Table 11.7 Projected production for the years 2025 and 2050

| Sl. No. | Crops | Area | | | Yield (tonne/ha) | | Production (tonne/ha) | | | Yield (tonne/ha) | | Production (tonne/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Irrigated | Rainfed | Total | Irrigated | Rainfed | Irrigated | Rainfed | Total | Irrigated | Rainfed | Irrigated | Rainfed | Total |
| 1. | Paddy | 15.00 | - | 15.00 | 2.50 | 1.25 | 37.50 | - | 37.50 | 3.00 | 1.50 | 45.00 | - | 45.00 |
| 2. | Maize | 25.00 | 15.00 | 40.00 | 2.00 | 1.25 | 50.00 | 18.75 | 68.75 | 2.50 | 1.50 | 62.50 | 22.50 | 85.00 |
| 3. | Millet | - | 5.00 | 5.00 | 1.00 | 0.50 | - | 2.50 | 2.50 | 1.25 | 0.75 | - | 3.75 | 3.75 |
| 4. | Wheat | 10.00 | - | 10.00 | 2.50 | 1.25 | 25.00 | - | 25.00 | 3.00 | 1.50 | 30.00 | - | 30.00 |
| 5. | Pulses | 3.00 | 3.00 | 6.00 | 1.50 | 1.00 | 4.50 | 3.00 | 7.50 | 2.00 | 1.25 | 6.00 | 3.75 | 9.75 |
| 6. | Soyabean | - | 5.00 | 5.00 | 1.25 | 0.75 | - | 3.75 | 3.75 | 2.00 | 1.00 | - | 5.00 | 5.00 |
| 7. | Mustard | 3.00 | 2.00 | 5.00 | 1.00 | 0.50 | 3.00 | 1.00 | 4.00 | 1.50 | 0.75 | 4.50 | 1.50 | 6.00 |
| 8. | Vegetables | 2.00 | 10.00 | 12.00 | 10.00 | 5.00 | 20.00 | 50.00 | 70.00 | 15.00 | 7.50 | 30.00 | 75.00 | 105.00 |
| 9. | Potato | 2.00 | 5.00 | 7.00 | 6.00 | 4.00 | 12.00 | 20.00 | 32.00 | 10.00 | 5.00 | 20.00 | 25.00 | 45.00 |
| 10. | Cardamom | 10.00 | 15.00 | 25.00 | 0.30 | 0.20 | 3.00 | 3.00 | 6.00 | 0.35 | 0.20 | 3.50 | 3.00 | 6.50 |
| 11. | Ginger | - | 5.00 | 5.00 | 10.00 | 7.00 | - | 35.00 | 35.00 | 15.00 | 10.00 | - | 50.00 | 50.00 |

**Table 11.8 Actual ( 2001-02) and projected (2025-50) production for State of Sikkim**

**(Unit: th tonnes)**

| Sl. No. | Particulars | Actual 2001-02 | Proposed Production | |
|---|---|---|---|---|
| | | | 2025 | 2050 |
| 1. | Total Cereals | 74.63 | 133.75 | 173.75 |
| 2. | Total Pulses | 3.66 | 7.50 | 9.75 |
| 3. | Total Oilseeds | 4.04 | 7.75 | 11.00 |
| 4. | Total Food Crops | 82.33 | 149.00 | 194.50 |
| 5. | Cardamom | 4.06 | 6.00 | 6.50 |
| 6. | Ginger | 23.27 | 35.00 | 50.00 |
| 7. | Vegetables & Fruits | 14.82 | 70.00 | 105.00 |
| 8. | Potato | 11.91 | 32.00 | 45.00 |

From the above, it is seen that agriculture production of food crops would be about 149 th tonne and 194.50 th tonne for the years 2025 & 2050, respectively.

### 11.7.2 Per Capita Foodgrain Availability

For long term strategy of improving and stabilizing agricultural productivity to meet the growing population, the available options in terms of land resources are not unlimited. As can be seen from Table 6.2, the net sown area is getting reduced with the passage of time.

Per capita availability of foodgrains have shown an increasing trend from 1975-76 to 1990-91 (from 186.25 gm/capita/day to 231.43 gm/capita/day), while the same has declined to a level of 177.36 gm/capita/day during 2000-2001. The above figures for the state of

Sikkim are much lower than the national figure of 502 gram/capita/day for the year 1995 for India as a whole. This reflects on the low level of agricultural production primarily due to inadequate water resources development and management in the state. As regards the per capita availability of pulses, which are the main source of protein particularly for the poor, the same trend has been observed i.e. increasing upto 1990-91 to the level of 31.90 gm/capita/day and declining to 21gm/capita/day in 2000-01. The national figures per availability of pulses was 37 gm/ capita/day in 1995 which compares favourably with the stare of Sikkim during 1990-91.

Per capita food grain availability in China has been reported as 883 gm/day, 783 gm per day in Indonesia and 583 gm/day in Egypt. In a developed country, per capita foodgrain availability of more than one kilogram is not uncommon. In accordance with the norms fixed by Indian Council of Medial Research, per capita requirement of 520 gm for cereals and 50 gm for pulses has been recommended from the nutritional viewpoint for an individual. As regards the food consumption patterns in India, dramatic changes have taken place in post-green revolution period. At all India level, per capita cereal consumption has declined from 510 gm/day in 1972-73 to 447 gm/day in 1993-94 in rural areas. In urban areas, the decline was more modest from 376 gm/day to 353 gm/day over the same period. At the same time, the consumption of milk & milk products has increased. Such changes have happened as one of the outcomes of the process of economic development.

With the projected figures of population, and increased levels of irrigation development coupled with improved agriculture practices, per capita availability of foodgrains for the state of Sikkim has been projected as 400 gm/day and 355 gm/day for the years 2025 and 2050 respectively. The details are given in Table 11.9.

**Table 11.9 Per capita availability of foodgrains and oil seeds**

**(in gram/day)**

| | | Actual | | | | Projected | |
|---|---|---|---|---|---|---|---|
| | **Year** | **1975-76** | **1980-81** | **1990-91** | **2000-01** | **2025** | **2050** |
| | Population (Lakh) | 2.62 | 3.16 | 4.06 | 5.40 | 9.68 | 14.14 |
| 1. | Total Cereals | 180.39 | 174.84 | 199.52 | 156.36 | 378.55 | 336.65 |
| 2. | Total Pulses | 5.86 | 22.03 | 31.9 | 21.00 | 21.23 | 18.90 |
| | **Total food grains** | 186.25 | 196.87 | 231.42 | 177.36 | 399.78 | 355.55 |
| 3. | Total Oilseeds | 1.17 | 6.02 | 6.16 | 5.99 | 21.93 | 21.31 |

From the above discussions, it is abundantly clear that though ample surface water resources are available in the state, the same can not be utilized to their optimal levels, primarily due to land constraints and the lack of development through major and medium irrigation schemes. In such a scenario, very limited developmental options are available which primarily pertain to better water management practices through drip and sprinkler irrigation systems and diversification of cropping pattern with major thrust being given to growing of cash crops, development of floriculture and horticulture which are more remunerative in nature.

# CHAPTER - 12
# FINDINGS AND STRATEGIC RECOMMENDATIONS

# FINDINGS AND STRATEGIC RECOMMENDATIONS

## 12.1 Salient characteristics

- Sikkim covers a geographical area of 7096 sq km. The altitude above mean sea level varies from 300 m in the south to about 8600 m in the north and the hill slope generally ranges between 4% in the flat valleys to 90%, characterised by undulating surface features. The habitable areas exist only up to the altitude of 2100 m constituting only 20% of the total area of the state. (Para 2.3)

- River Teesta, than Main River of the state originates from the glacier at an altitude of 6200 m and traverses a length of 151 km in Silkkim. Its main tributaries are Lachen, Lachung, Dik Chhu, Rongni Chhu, Rongpo, Great Rangit, etc. (Para 2.4)

## 12.2 HYDROMETEOROLOGY

- At present there are 19 ordinary rain gauge stations in Teesta basin in Sikkim, as per the WMO guidelines, it would be desirable to have about 21 rain gauges. Accordingly, additional four rain gauge stations should be installed in the valley preferably at

Donkung on the Lachen Chhu, Namchi – South, Rangpo – East, Naya Bazaar – West. It is also suggested that three additional self recording rain gauges may be installed at Lachen, Gyalzing and Gangtok stations. (Para 3.4.1)

- In addition to these rain gauge stations, snow gauges are also required to be established for measurement of snowfall at the higher altitudes. It is suggested to establish snow gauge stations at Thangu, Yumthang Chhu, Nathu La, Jambong on Zemu Chhu, Lampharam. (Para 3.4.2)

- Average annual normal rainfall in Sikkim is about 2534 mm. It is observed that the month of July receives maximum rainfall of the order of 480 mm and minimum normal rainfall of 19 mm is recorded in the month of December for the Sikkim as a whole. (Para 3.5.1)

- The altitude of the station also influences the coefficient of variation ($C_V$). The coefficient of variation is generally found to increase with higher altitude. (Para 3.5.2)

- Monthly rainfall values are available for the 19 rain gauge stations in the state of Sikkim as obtained from IMD for varying time periods. The 75 per cent dependable rainfall in the basin in Sikkim works out to 2478 mm. (Para 3.5.4)

## 12.3 HYDROLOGY

- There are at present 11 G&D stations, maintained by Central Water Commission. Additional set up of seven hydrological stations is suggested taking into account the terrain conditions, and availability of suitable places for locating the headquarters for the positioning of staff. Gauge and discharge observations at the existing stations shall be continued. (Para 4.3.1 and 4.3.3)

- Average annual runoff at Chungthang, Sanklang, Dikchu and Khanitar is 4332 Mcm, 7860 Mcm, 9580 Mcm and 11569 Mcm respectively. (Para 4.3.4)

- 100 year return period flood at Khanitar site is 5779 cumec (Para 4.4.6)

- Maximum silt load is carried in the month of July and minimum in the month of October during monsoon period. (Para 4.5.3)

- Average sediment load during monsoon increases from the upstream to the downstream sites from 0.29 th cum/sq km to 1.53 th cum/ sq km. (Para 4.5.3)

- Coarse silt load is higher in upper reaches of the river while fine silt is more for downstream reaches. (Para 4.5.3)

- Average rate of sedimentation is the highest at Dikchu at 0.95 mm/ year, followed by Sankalang while it is minimum at chungthang at 0.32 mm/year. (Para 4.5.3)

## 12.4 IRRIGATION

- Ultimate irrigation potential through minor irrigation schemes is 50 th ha, out of which 32.10 th ha has been created upto March, 2004 (Para 5.2)

- Utilization of the created potential need to be improved from the level of 77% in March 2002.

- The feasibility of developing irrigation potential through major and medium schemes, which has been identified as 20,000 ha, should be re-ascertained. In case the possibility of the same does not exist, scope for alternative strategy, as deemed relevant with respect to physiographical characteristics of terrain should be investigated and pursued for implementation.

- Status of Minor Irrigation (M.I.) Census (1995-96) of the state shows that all the 854 M.I. schemes jointly serve about 17106 ha of CCA with irrigation potential of 20010 ha. However, actual annual irrigation upto 1993-94 has been indicated as only 12493 in the above census. It means that even though utilization of created potential has been shown as 77% of the created potential, there is still a sizeable lag between the potential utilized and actual irrigation, which should be reconciled appropriately. (Para 5.4)

- Although the status of M.I. Census (1995-96) shows that out of total 854 schemes, only 88 are not working, the Master Plan for Irrigation Development (1995), prepared during the same period reports that 419 schemes need appropriate measures according to their stage of functioning i.e. 119 are defunct, 105 are partially functioning, 142 need special repair and 50 need improvement. This needs to be reconciled at present level so that a realistic picture may emerge. (Para 5.4 and 5.5)

- A total of 17106 ha of CCA are covered by all the 854 M.I. schemes as per the Census. However, CCA of 14566 ha is found to be covered by 419 schemes in the Master Plan, leaving only 2540 ha for remaining 435 schemes which does not appear reasonable and hence need to be reconciled. (Para 5.4 and 5.5)

- The implementation of M.I. Schemes as contained in the Master Plan (1995) was planned for a period of 10 years. Nine years have since passed. However, from the perusal of physical achievements as brought out in Table 5.1, it does not appear that the implementation of schemes *vis*-à-*vis* creation of irrigation potential is progressing in a planned way. This should be attended to with adequate emphasis since the state is substantially deficit in reaching self-sufficiency stage in food grain production.

- As per information available, 1176 minor irrigation schemes have been constructed upto March, 2003 with 972.38 km length of channels. (Para 5.6)

## 12.5 LAND RESOURCE MANAGEMENT

- Net sown area of the state was 62.04 th ha with total cultivable area 108.89 th ha (15% of geographical area) as per 1995-96 land use statistics. (Para 6.2)

- Though cultivable area has marginally increased from 97.52 th ha to 108.89 th ha during 1980-81 to 1995-96, the net sown area has decreased from 78.38 th ha to 62.04 th ha during the same period, primarily due to substantial increase in fallow land which is other than current fallow. (Para 6.2)

- Effort should be made for possible appropriate use of cultivable waste land (CWL), which is quite sizable in the state. The possible use of such land could be its inclusion in net sown area (NSA) after undertaking appropriate soil conservation & improvement measures. (Para 6.5)

- Similarly possible use of barren and Un-cultural land (BUL) may be coverage by forest, area under non – agricultural uses, permanent pastures and other grazing lands for which meticulous planning and implementation strategy need to be formulated. (Para 6.5)

- For implementation of above land resource management strategies, use of efforts by Govt. of India, especially in regard to the funding of such schemes by GOI should be utilized. (Para 6.6)

## 12.6 AGRICULTURE

- Distribution of land holding in Sikkim is skewed. Marginal holders represent about 50% of land holding and hold 10.3% of total operated land area.

- Agro-climatological data along with average normal rainfall values has been used to work out net irrigation requirement for paddy and wheat crops. (Para 7.7)

- Overall efficiencies of 73% for paddy and 56% for other crops have been used to work out gross irrigation water requirement. (Para 7.8.4)

- Introduction of new crops (including wheat, rajmah, rape seed and mustard), extension of more areas under high-yielding and improved varieties of seeds, increased use of fertilizers and pesticides and expansion of area under double or multiple cropping would be helpful in overcoming subsistence farming to economically viable venture and it should be pursued more vigorously.

- Since horticulture development involves substantial scope of increased economic activity in the state, an appropriate mechanism need to be evolved to give adequate thrust on this front. (Para 7.13)

- Crops, which are not under organized sector(s) such as fruits and vegetables, are more liable to reporting of unrealistic figures in respect of cropped area and production. Therefore, this anomaly between the reported figures from various sources needs to be verified and reconciled. (Para 7.11)

- Strategies *viz*. adequate investment in land development and water harvesting structure, strengthening the government farms, encouraging private seed farms as joint venture undertakings, mechanized farming, large scale demonstration on packaging technology involving HYV, fertilizer and Integrated Pest Management (IPM), development of human resources, post-harvest storage, processing, packaging including consumption, etc. with respect to agriculture development during tenth five year plan be rigorously pursued. (Para 7.13)

- Any scientific system of harvesting the rainfall during monsoon period and utilization during the Rabi season has not yet been established, although some of such structures constructed during recent years have been quite useful. Proper investigation needs to be done for development of rain water harvesting structures, at least for meeting drinking water needs.

- It is much cheaper to import fertilizer than the food itself and every unit of fertilizer being used increases the food production by two or more units. This is especially relevant due to very high transportation cost in hills and hence use of fertilizer should be encouraged.

- Except the paddy field, more than 50% of other lands are either improperly terraced or untraced due to which plant nutrients are lost by run off and leaching, whenever there is high intensity rain during monsoon. Besides, cultivation is also difficult due to sloppy terrain. This issue of providing bench terraces need to be attended to promptly.

- To develop the state as model 'horticulture state' steps need to be taken to have intensive agriculture so that food grain requirement is met from lesser area so as to divert maximum area to horticulture.

- Apart from unfavorable geographical and socio-economic aspects, absence of adequate number of other industries and high literacy rate, more and more unemployed youth may have to seek employment in agriculture and agro-based industries. Under the broad strategies of mechanization of agriculture coupled with higher levels of inputs and technology, agriculture should be developed as a potential business enterprise in the state.

- For addressing the above issues relating to agriculture development, there would be a need to substantially jack up investment pattern in this sector.

## 12.7 HORTICULTURE AND OTHER ALLIED AGRICULTURAL ACTIVITIES

- Taking cognizance of strengths, weakness and hi-tech horticulture available in the state and the objectives set forth for Xth five year plan to achieve an annual growth rate of 10% should be vigorously pursued. Some important objectives include sustainable horticulture production, persuading hobby and kitchen garden / back-yard cultivation of horticulture crops to explore commercial cultivation of plant bio-diversity, develop marketing infrastructure, create vital linkages of post-harvest management etc. (Para 8.2.2.).

- Special emphasis need to be given to two important cash crops in the state i.e. large cardamom and ginger on which the agriculture economy of the state largely depends. Re- plantation of old orchards, providing planting material for gap filling and shade tree sapling are few basis needs for development. In case of ginger, awareness of ginger diseases to farmer, disease-free seed production and providing the same in mini kits, IPM activity to combat pests and diseases are same of the important activities for improvement.

- Strategies suggested to strengthen the floriculture sub-sector should be meticulously planned and implemented. These comprise of checking the outflow of quality planting materials from the state, large scale tissue culture, transfer of technology to farmers and infrastructure facility for marketing transport, packaging and handling etc. (Para 8.3)

- Detailed survey, documentation and identification of medicinal and aromatic plants and setting up herbal gardens at low, mid, high and alpine hills for development of cultural practices and commercial exploitation are few core strategies to streamline this sub-sector. (Para 8.4)

- Nucleus beekeeping centers in government farm need to be established. Bee species should be improved to have pollinizer effect on crops especially large cardamom and several varieties of vegetables. (Para 8.5)

- Considering the fact that livestock rearing is a way of life and a tradition which for centuries has substantially strengthened the economic life of the people in the state, it needs to be addressed with adequate emphasis, in terms of provision of veterinary services and animal health, cattle development, poultry development, sheep and wool development and piggery and other live stock development as well as diary development etc. (Para 8.7)

- Since encouragement to take up fish farming is needed for economic growth and generates employment, special emphasis is needed for trout fish and carps and cat fish seed production, propagation of Mahaseer and development of inland fisheries etc.

## 12.8 DROUGHT PRONE AREAS

- Identification of drought prone areas in the entire state as per the norm spelt out for local conditions of the state (250 mm to 350 mm rainfall during winter and 500 mm in summer) need to be done for a realistic assessment of the measures to be taken in this regard. (Para 9.1)

- Package of schemes for implementation in five years need to be pursued in a time bound manner with a priority to water conservation works. (Para 9.4)

## 12.9 LAND SLIDES AND FLOOD MANAGEMENT

- Continuous monitoring and review of identified zones of landslides and soil erosion to be done and necessary measures be adopted to maintain such areas. Besides the above, if there are indications of such developments in other areas, diagnostic measures should be planned in advance lest these should grow in dimension and extent. (Para 11.3).

- Evaluation of flood management works is necessary from time to time to appreciate techno-economic viability of the implemented schemes and assess their performance vis-à-vis the intended purpose.

## 12.10 IRRIGATION AND WATER MANAGEMENT – PERSPECTIVE PLANNING

- The ultimate irrigation potential of the state has been considered as 70,000 ha, out of which 20,000 ha is through major and medium irrigation schemes and 50,000 ha through minor irrigation schemes. For the purpose of perspective planning, whole of the ultimate potential of 70,000 ha has been considered to be developed through minor irrigation schemes by the year 2025. (Para 13.1)

- Typical design features of the following schemes have been included in the report:

- Restoration / modernisation of Bathung Khola Minor Irrigation Scheme at Village Pastanga-Gaucharan in East District, Sikkim. (Para 13.5.1)
- Chalamthang Minor Irrigation Scheme, South Sikkim (Para 13.5.2)

- Upto March 2002 i.e. end of IXth Plan, irrigation potential of 31.30 th ha was created, out of which 23.68 th ha was utilized. Considering the criteria of proving Rs.225/- and Rs.75/- per hectare of utilised and unutilised irrigation potential, O&M funds of Rs.59 lakh per annum would be required. However, at ultimate stage of development with utilized irrigation potential of 70 th ha, O&M funds of the order of Rs.1.58 crore would be required at present price level.

- Voluntary Health Association of Sikkim (VHAS) has organised the efforts in water resources development besides handling the environmental issues in a very professional and methodological manner. The association has sought public participation in identifying the schemes and has embarked upon ‘Ahlay Pokhari Water Harvesting Programme’ near Asang Thang in West Sikkim for drinking purposes catering to 140 households in five villages.

## 12.11 CARRYING CAPACITY – PERPECTIVE PLANNING

- Optional planning of available land and water resources in the state of Sikkim has been done considering the following three strategies:

- Maximise production per unit of area through multiple cropping, high yielding varieties etc.
- Maximise the area served with available water through protective irrigation to supplement rainfall and using drought-resistant varieties.
- Exploring the possibilities of lifting of surface water. (Para 14.1)

- For management of land resources in the state of Sikkim, it is considered appropriate that the area under 'other fallow land' is reduced by about 50% to a level of 14.78 th ha and this area is brought under 'net sown area' category. This would increase the net sown area from 62.04 th ha to 76.82 th ha for the purpose of perspective planning. Cropping intensity of 180% has been projected for the years 2025 & 2050, thus gross cropped area works out 138.30 th ha. (Para 14.3)

- Adopting the norm of 40 lpcd for rural and 100 lpcd for urban population, domestic water requirement for the state as whole have been worked out for the years 2025 and 2050 which is of the order of 18.49 Mcm and 33.41 Mcm respectively. (Para 14.4)

- Irrigation water requirement for the gross irrigated area of 70 th ha has been worked out as 328 Mcm. (Para 14.5)

- Agriculture production of food crops has been projected as 149 th tonne and 194.50 th tonne for the years 2025 & 2050 respectively. (Para 14.7.1)

- Per capita availability of foodgrains for the state of Sikkim has been reported as 177.36 gm/ day which has been projected as 400 gm/ day and 355 gm/ day for the years 2025 and 2050 respectively. (Para 14.7.2)

# PLATES

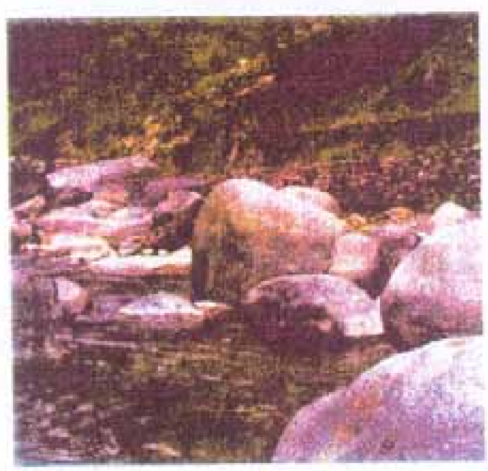

**Location of Restoration / Modernisation Scheme at Bathung Khola - Pastanga Village, East Sikkim (Reference: Para 14.5.1)**

Jhora training works at Bojoghari

AEW/JTW/CWD at Kabi Tingda

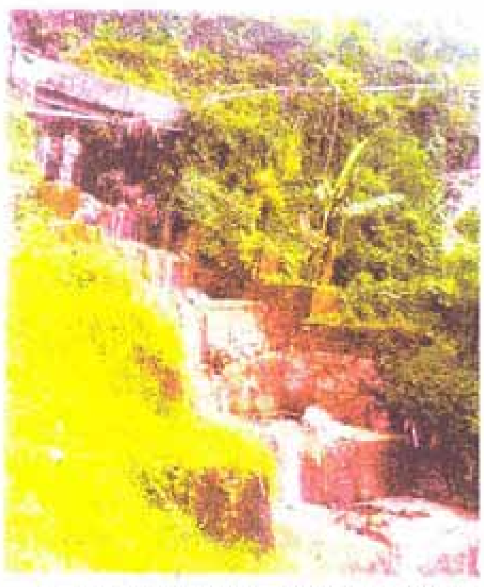
Jhora Training Works of Rafong Khola

A.E.W below 16$^{th}$ km Sombarey Hilley Road



River Training Works at Kalej Khola, Dentam

Jhora Training Works Near Rumtek School



Jhora Training works at Lower Sichey

# ANNEXURES

## Annexure- 3.1

**Monthly / Annual Rainfall Normals for the period 1941-90 for the State of Sikkim**

| S No. | STATION | Alt. (m) | No of Yrs | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | Jun-Sept | Oct-May |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **North District** | | | | | | | | | | | | | | | | | |
| 1 | DIKCHU | 869 | 17 | 36.3 | 71.4 | 141.2 | 218.3 | 487.5 | 654.6 | 565.8 | 488.7 | 421.1 | 216.0 | 47.9 | 15.4 | 3364.2 | 2130.2 | 1234.0 |
| 2 | SINGHIK | 1402 | 17 | 56.0 | 128.4 | 171.0 | 253.9 | 395.8 | 599.4 | 428.7 | 439.3 | 312.4 | 245.0 | 64.4 | 39.9 | 3134.2 | 1779.8 | 1354.4 |
| 3 | CHUNGTHANG | 1631 | 29 | 39.7 | 72.2 | 164.9 | 193.6 | 307.9 | 476.1 | 537.8 | 480.4 | 305.6 | 194.7 | 32.1 | 22.6 | 2827.6 | 1799.9 | 1027.7 |
| 4 | LACHUNG | 2633 | 16 | 19.9 | 55.9 | 130.2 | 141.9 | 209.9 | 280.3 | 298.2 | 281.2 | 198.9 | 133.2 | 36.2 | 21.5 | 1807.3 | 1058.6 | 748.7 |
| 5 | YUMTHANG | 3673 | 17 | 18.3 | 31.7 | 64.4 | 73.7 | 145.5 | 230.6 | 283.4 | 278.5 | 188.6 | 100.6 | 13.2 | 9.6 | 1438.1 | 981.1 | 457.0 |
| 6 | LACHEN | 2697 | 19 | 66.9 | 59.2 | 155.2 | 106.1 | 176.5 | 259.9 | 265.3 | 296.8 | 243.1 | 117.2 | 26.3 | 22.9 | 1795.4 | 1065.1 | 730.3 |
| 7 | THANGU | 3834 | 16 | 58.4 | 61.3 | 82.6 | 49.4 | 66.0 | 91.1 | 115.0 | 124.1 | 119.8 | 77.8 | 22.6 | 36.0 | 904.1 | 450.0 | 454.1 |
| 8 | MANGAN | 1310 | 22 | 73.4 | 91.5 | 163.2 | 191.4 | 359.8 | 639.7 | 525.5 | 456.3 | 410.0 | 184.9 | 38.0 | 44.4 | 3178.1 | 2031.5 | 1146.6 |
| **Average North** | | **2256.1** | **19.1** | **46.1** | **71.5** | **134.1** | **153.5** | **268.6** | **404.0** | **377.5** | **355.7** | **274.9** | **158.7** | **35.1** | **26.5** | **2306.1** | **1412.0** | **894.1** |
| | **South district** | | | | | | | | | | | | | | | | | |
| 9 | DAMTHANG | 1981 | 16 | 13.6 | 26.6 | 30.5 | 94.7 | 262.0 | 418.7 | 553.7 | 430.6 | 278.7 | 95.4 | 14.6 | 5.4 | 2224.5 | 1681.7 | 542.8 |
| **Average south** | | **1981** | **16** | **13.6** | **26.6** | **30.5** | **94.7** | **262** | **418.7** | **553.7** | **430.6** | **278.7** | **95.4** | **14.6** | **5.4** | **2224.5** | **1681.7** | **542.8** |
| | **East district** | | | | | | | | | | | | | | | | | |
| 10 | GANGTOK | 1756 | 22 | 47.2 | 54.7 | 137.9 | 284.5 | 559.7 | 677.2 | 711.6 | 613.1 | 467.6 | 191.6 | 38.6 | 19.9 | 3803.6 | 2469.5 | 1334.1 |
| 11 | CHHANGU | 3841 | 10 | 23.1 | 35.0 | 121.0 | 151.1 | 428.1 | 503.6 | 489.3 | 517.2 | 333.4 | 151.3 | 12.2 | 3.5 | 2768.8 | 1843.5 | 925.3 |
| 12 | RONGLI | 823 | 16 | 15.0 | 30.1 | 43.2 | 172.2 | 296.7 | 543.7 | 817.3 | 677.4 | 439.3 | 144.3 | 20.3 | 7.7 | 3207.2 | 2477.7 | 729.5 |
| **Average East** | | **2140.0** | **16.0** | **28.4** | **39.9** | **100.7** | **202.6** | **428.2** | **574.8** | **672.7** | **602.6** | **413.4** | **162.4** | **23.7** | **10.4** | **3259.9** | **2263.6** | **996.3** |
| | **West District** | | | | | | | | | | | | | | | | | |
| 13 | DENTAM | 132 | 16 | 18.0 | 21.5 | 43.9 | 128.1 | 202.4 | 383.5 | 530.3 | 489.6 | 338.6 | 129.5 | 18.5 | 8.0 | 2311.9 | 1742.0 | 569.9 |
| 14 | YOKSUM | 1780 | 16 | 36.3 | 35.7 | 56.4 | 107.3 | 220.4 | 461.7 | 532.8 | 584.2 | 486.3 | 193.0 | 51.9 | 15.1 | 2781.1 | 2065.0 | 716.1 |
| 15 | GEZING | 1524 | 22 | 33.4 | 19.3 | 56.4 | 108.6 | 195.2 | 421.1 | 547.1 | 443.9 | 433.7 | 165.9 | 24.3 | 14.2 | 2463.1 | 1845.8 | 617.3 |
| **Average West** | | **1145.3** | **18.0** | **29.2** | **25.5** | **52.2** | **114.7** | **206.0** | **422.1** | **536.7** | **505.9** | **419.5** | **162.8** | **31.6** | **12.4** | **2518.7** | **1884.3** | **634.4** |
| | **Average** | | | **35.8** | **51.8** | **101.5** | **151.4** | **292.9** | **446.6** | **489.2** | **443.9** | **330.2** | **153.2** | **29.7** | **18.2** | **2544.4** | **1709.9** | **834.5** |

## Annexure- 3.2

**Monthly / Annual Rainy Days for the period 1941-90 for the State of Sikkim**

| S No. | STATION | Altitude(m) | No of Yrs | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANNUAL | Jun- Sept | Oct- May |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **North District** | | | | | | | | | | | | | | | | | |
| 1 | DIKCHU | 869 | 17 | 2.7 | 5.9 | 8.4 | 13.5 | 20.4 | 21.6 | 24.0 | 21.9 | 17.1 | 8.8 | 2.9 | 1.7 | 148.9 | 84.6 | 64.3 |
| 2 | SINGHIK | 1402 | 17 | 4.3 | 9.7 | 12.1 | 15.6 | 20.0 | 24.6 | 25.5 | 23.5 | 18.6 | 12.3 | 4.3 | 2.2 | 172.7 | 92.2 | 80.5 |
| 3 | CHUNGTHANG | 1631 | 29 | 3.3 | 6.4 | 10.3 | 11.2 | 16.4 | 23.1 | 26.7 | 23.6 | 19.3 | 10.2 | 3.0 | 1.8 | 155.3 | 92.7 | 62.6 |
| 4 | LACHUNG | 2633 | 16 | 2.7 | 6.9 | 10.9 | 12.3 | 17.8 | 21.5 | 25.3 | 24.3 | 18.4 | 10.8 | 4.3 | 2.2 | 157.4 | 89.5 | 67.9 |
| 5 | YUMTHANG | 3673 | 17 | 2.2 | 4.1 | 8.2 | 9.8 | 16.8 | 22.1 | 27.1 | 26.2 | 20.8 | 10.2 | 1.9 | 1.0 | 150.4 | 96.2 | 54.2 |
| 6 | LACHEN | 2697 | 19 | 5.1 | 6.9 | 12.6 | 10.9 | 17.1 | 22.4 | 24.3 | 26.5 | 22.1 | 10.9 | 2.7 | 2.6 | 164.1 | 95.3 | 68.8 |
| 7 | THANGU | 3834 | 16 | 4.1 | 6.1 | 8.1 | 5.9 | 8.1 | 11.6 | 15.5 | 15.7 | 14.5 | 7.9 | 2.3 | 4.0 | 103.8 | 57.3 | 46.5 |
| 8 | MANGAN | 1310 | 22 | 4.7 | 7.2 | 11.0 | 13.1 | 18.6 | 22.1 | 23.1 | 23.1 | 19.0 | 9.6 | 3.1 | 3.1 | 157.7 | 87.3 | 70.4 |
| **Average North** | | **2256.1** | **19.1** | **3.6** | **6.7** | **10.2** | **11.5** | **16.9** | **21.1** | **23.9** | **23.1** | **18.7** | **10.1** | **3.1** | **2.3** | **151.3** | **86.9** | **64.4** |
| | **South District** | | | | | | | | | | | | | | | | | |
| 9 | DAMTHANG | 1981 | 16 | 2.0 | 2.3 | 4.5 | 9.7 | 17.3 | 23.9 | 25.4 | 24.1 | 17.5 | 6.4 | 1.9 | 0.7 | 135.7 | 90.9 | 44.8 |
| **Average south** | | **1981** | **16** | **2** | **2.3** | **4.5** | **9.7** | **17.3** | **23.9** | **25.4** | **24.1** | **17.5** | **6.4** | **1.9** | **0.7** | **135.7** | **90.9** | **44.8** |
| | **East District** | | | | | | | | | | | | | | | | | |
| 10 | GANGTOK | 1756 | 22 | 3.3 | 5.1 | 8.1 | 13.8 | 22.4 | 24.7 | 27.0 | 26.4 | 21.0 | 8.8 | 3.2 | 2.0 | 165.8 | 99.1 | 66.7 |
| 11 | CHHANGU | 3841 | 10 | 1.9 | 4.6 | 10.3 | 10.0 | 23.4 | 24.3 | 27.5 | 27.1 | 22.0 | 10.6 | 1.7 | 0.4 | 163.8 | 100.9 | 62.9 |
| 12 | RONGLI | 823 | 16 | 1.6 | 3.1 | 3.6 | 10.6 | 17.5 | 23.3 | 27.9 | 26.8 | 20.1 | 8.0 | 1.9 | 0.6 | 145.0 | 98.1 | 46.9 |
| **Average East** | | **2140.0** | **16.0** | **2.3** | **4.3** | **7.3** | **11.5** | **21.1** | **24.1** | **27.5** | **26.8** | **21.0** | **9.1** | **2.3** | **1.0** | **158.2** | **99.4** | **58.8** |
| | **West District** | | | | | | | | | | | | | | | | | |
| 13 | DENTAM | 132 | 16 | 1.8 | 2.9 | 4.4 | 10.6 | 18.7 | 20.6 | 23.7 | 22.9 | 17.9 | 9.5 | 1.7 | 1.0 | 135.7 | 85.1 | 50.6 |
| 14 | YOKSUM | 1780 | 16 | 3.4 | 3.9 | 5.6 | 8.9 | 17.5 | 21.6 | 23.4 | 24.5 | 20.1 | 10.5 | 3.7 | 1.7 | 144.8 | 89.6 | 55.2 |
| 15 | GEZING | 1524 | 22 | 1.9 | 2.4 | 5.1 | 9.4 | 14.6 | 19.9 | 21.7 | 19.7 | 17.0 | 8.6 | 2.3 | 1.4 | 124.0 | 78.3 | 45.7 |
| **Average West** | | 1946.5 | 17.3 | 2.7 | 4.2 | 6.9 | 10.4 | 17.8 | 21.8 | 24.3 | 23.7 | 18.9 | 8.8 | 2.4 | 1.6 | 143.5 | 88.6 | 54.8 |
| **Average State** | | | | **2.9** | **5.0** | **8.1** | **11.0** | **17.9** | **22.0** | **24.7** | **23.9** | **19.0** | **9.4** | **2.7** | **1.7** | **148.3** | **89.7** | **58.7** |

## Annexure-3.3 (a)

**MONTHLY RAINFALL VALUES FOR DIKCHU STATION IN SIKKIM**

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 29.2 | 174.7 | 144.3 | 461.7 | 654.2 | 677.9 | 515.5 | 496.5 | 186.8 | 0 | 67.1 | 3407.9 |
| 1958 | 44.9 | 45.4 | 124.3 | 333.2 | 339.7 | 685.1 | 594.8 | 817.1 | 135.2 | 172.1 | 91.5 | 11.7 | 3395 |
| 1959 | 113.8 | 116.5 | 160.5 | 175.8 | 442.6 | 770.3 | 568.5 | 301 | 464.5 | 231.8 | 51.4 | 0 | 3396.7 |
| 1960 | 0 | 110.9 | 202.7 | 103.7 | 414 | 795.9 | 422.8 | 268.7 | 536.7 | 2.6 | 0.5 | 1.8 | 2860.3 |
| 1961 | 11.4 | 47.5 | 204.2 | 111.5 | 632.7 | 668.2 | 617.4 | 588.5 | 514.6 | 214.7 | 42.9 | 71.5 | 3725.1 |
| 1962 | 59.3 | 48.8 | 97.2 | 126.8 | 729.9 | 532.4 | 378.3 | 999.6 | 414.6 | 21.6 | 2.4 | 18.6 | 3429.5 |
| 1963 | 23.4 | 75.8 | 227 | 201.6 | 327.4 | 514.4 | 653.8 | 649.2 | 391.2 | 244.2 | 63.8 | 9 | 3380.8 |
| 1971 | 46.8 | 62.2 | 217.3 | 233.6 | 518.8 | 847.4 | 658.2 | 442.6 | 455.6 | 488 | 11.4 | 0.4 | 3982.3 |
| 1972 | 17.4 | 34.8 | 53.4 | 325 | 569.4 | 658.8 | 536.4 | 257.2 | 166.6 | 105.2 | 20.8 | 0 | 2745 |
| 1973 | 36.7 | 120.4 | 214.2 | 143.4 | 611.8 | 510.4 | 398.4 | 278 | 222.6 | 294.6 | 4.8 | 0 | 2835.3 |
| 1974 | 1.8 | 0.2 | 66.4 | 306.8 | 395.4 | 695.8 | 685.8 | 397.2 | 375.2 | 149.8 | 0 | 19.6 | 3094 |
| 1975 | 28 | 55.2 | 0.8 | 93.2 | 512 | 505.4 | 695 | 215.6 | 636.4 | 317.8 | 2.8 | NA | NA |
| 1976 | 24.8 | 83.8 | 50.2 | 132.4 | 585.6 | 885.2 | 367.2 | 498.6 | 215.8 | 191.6 | 64.2 | 0.2 | 3099.6 |
| 1977 | 20 | 38.8 | 195.2 | 469.6 | 470.7 | 692.2 | 445.4 | 654.2 | 512.6 | 352.2 | 207 | 0 | 4057.7 |
| 1978 | 87.8 | 75.2 | 178.4 | 277.6 | 677.8 | 636.4 | 638.4 | 372.8 | 572 | 144 | 186 | 16.8 | 3863.2 |
| 1979 | 12.4 | 50 | 34.2 | 172.6 | 251.6 | 420.4 | 717.8 | 561.8 | 626.8 | 334 | 7.4 | NA | NA |
| 1980 | 38.2 | 197.8 | 202.2 | 358.4 | 347.2 | NA | 713..4 | 568.8 | 536.2 | 130.8 | 0 | 11.2 | NA |
| 1992 | 33 | 98.8 | NA | 168.8 | 2591 | 464.2 | 795 | 441.8 | NA | 249.1 | 2 | 11 | NA |
| 1993 | 65.5 | 65.7 | 166 | 178.7 | 589.5 | 602.7 | 475.3 | 450.2 | 296.1 | 164.2 | 56.2 | 11.8 | 3121.9 |
| 1994 | 41.8 | 81.8 | 1478 | 209.2 | 357 | 450.8 | 337.8 | 494.6 | 238 | 181.9 | 12.6 | 3.2 | 3886.8 |
| 1996 | 56 | 63.6 | 158.6 | 970.8 | 370.8 | 370.6 | 776 | 416.6 | 321.2 | 326.4 | 4.2 | 2 | 3836.8 |
| 1997 | 30.6 | 122.4 | 103.6 | 300.4 | 399.4 | 856.2 | 253.2 | 461.4 | 620.4 | 91.6 | 23.8 | 79 | 3342 |
| 1998 | NA | 61.8 | 236.8 | 169.2 | 318.8 | 717.6 | 698 | 712.2 | 448.8 | 353.2 | 5.2 | 7.8 | NA |
| 1999 | 28 | 0.2 | 74.8 | 433.8 | 391 | 645.6 | 615.5 | 556.2 | 253 | NA | 15.6 | 11.8 | NA |
| **Avr** | **35.7** | **70.3** | **200.9** | **255.9** | **554.4** | **633.9** | **565.5** | **496.6** | **410.9** | **215.1** | **36.5** | **16.1** | **3414.4** |

**Annexure-3.3 ( b )**

# MONTHLY RAINFALL VALUES FOR SINGHIK STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 21.6 | 194.2 | 142.4 | 267.7 | 692.3 | 593.6 | 323.5 | 297.5 | 237.7 | 37.5 | 33.8 | 2841.8 |
| 1958 | 91.1 | 89.3 | 129.3 | 385.6 | 471.2 | 830.7 | 425.5 | 941.6 | 134.4 | 498.4 | 68.7 | 2.1 | 4067.9 |
| 1959 | 96.5 | 193.5 | 186.8 | 201 | 464.5 | 770.1 | 376.2 | 117.8 | 48.6 | 105.6 | 107 | 1.3 | 2668.7 |
| 1960 | 0 | 195.8 | 224.4 | 66 | 267.3 | 829.4 | 250.5 | 45.6 | 127.2 | 39.6 | 0.6 | 2.9 | 2049.3 |
| 1961 | 38.9 | 75.5 | 162.5 | 255.8 | 484.6 | 424.6 | 541.5 | 534.9 | 316 | 249.7 | 31.1 | 304 | 3419.1 |
| 1962 | 5.4 | 267.6 | 166 | 162 | 543.8 | 573.6 | 266.1 | 942 | 415 | 105.4 | 47.6 | 63.4 | 3557.9 |
| 1963 | 46.6 | 98.4 | 170.6 | 351.2 | 309.4 | 392.2 | 526 | 674.6 | 353.6 | 253.8 | 91.6 | 62 | 3330 |
| 1971 | 164.4 | 124 | 181.6 | 311.4 | 203.8 | 366.6 | 219.4 | 226.4 | 178 | 0 | 25.8 | 0 | 2001.4 |
| 1972 | 23 | 80.9 | 237.2 | 426.8 | 548.4 | 760.6 | 214.2 | 262.2 | 278.2 | 86.2 | 14.4 | 0 | 2932.1 |
| 1973 | 15.2 | 117.4 | 33.8 | 193.2 | 342.8 | 658.3 | 232.8 | 205.6 | 196.2 | 311.8 | 10.4 | 2.2 | 2319.7 |
| 1974 | 28.2 | 28 | 179.7 | 231.8 | 567.4 | NA | 517 | 422.8 | 458.4 | 353.9 | 3.9 | 39.4 | 2830.5 |
| 1975 | 82 | 185.5 | 82.7 | 198 | 314.1 | 491 | 580.6 | 339.4 | 488 | 270 | 12 | 26 | 3069.3 |
| 1976 | 0 | 152.1 | 123.2 | 349.8 | 613.1 | 812.3 | 460.8 | 544.5 | 215.3 | 222.3 | 111 | 0 | 3604.1 |
| 1977 | 32.2 | 21.4 | 213 | 285.8 | 468.5 | 394.2 | 480.4 | 519.5 | 160 | 365 | 160 | 0 | 3100.4 |
| 1978 | 150.3 | 233.8 | 383.6 | 330 | 314.1 | 691.6 | 156.6 | 434.2 | 503.6 | 85 | 226 | 19.8 | 3529 |
| 1979 | 6.4 | 84.2 | 63.4 | 170.8 | 279.6 | 260.8 | 745.8 | 209.2 | 653 | 490 | 82.8 | NA | NA |
| 1980 | 90.8 | 1340 | 0 | 209.4 | 266.6 | 405 | 668.2 | 1005.8 | 864.4 | 790.5 | 0 | 4.2 | 5645.1 |
| 1991 | 146 | 147 | 604.2 | 479 | 792.2 | 434.7 | 1600 | 1207 | 1042.6 | 171.2 | 196 | 186 | 7005.5 |
| 1992 | 54.8 | 277.8 | NA | 271.4 | 542.2 | 325.2 | 1021.8 | 399 | 336.1 | 437.2 | 6 | 14.4 | NA |
| 1993 | 181.8 | 119.6 | 321.6 | 136.8 | 380.4 | 507.8 | 584.6 | 568 | 552.2 | 206.4 | 253 | 207 | 4019 |
| 1994 | 333.1 | 255.5 | 925.4 | 335.6 | 504.6 | 382.1 | 279 | 556.8 | 308.5 | 79.8 | 3.8 | NA | NA |
| 1997 | NA | NA | NA | NA | 512.8 | 913.8 | 319.2 | 423.4 | 697.6 | 28.8 | 76.2 | 54 | NA |
| 1998 | 9.6 | 93 | 360.4 | 439 | 443 | 639.6 | 769.4 | 759.6 | 447.2 | 350.6 | 29.2 | 0 | 4331 |
| 1999 | 36.6 | 19.2 | NA | 497 | 331.5 | 489.4 | NA | 468.4 | NA | NA | 24.8 | 6.2 | NA |
| **Avr** | **71.0** | **183.5** | **235.4** | **279.6** | **426.4** | **567.2** | **514.3** | **505.5** | **394.4** | **249.5** | **67.5** | **46.8** | **3490.6** |

**Annexure-3.3 (c)**

# MONTHLY RAINFALL VALUES FOR CHUNGTHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 57.1 | 11.6 | 235 | 162.8 | 233.7 | 519.1 | 387.6 | 0 | 345.6 | 183.8 | 107 | 3 | 2246.7 |
| 1953 | 26.9 | 0 | 155.8 | 180.1 | 242.1 | 186.8 | 462.4 | 220.9 | 127.8 | 240.7 | 33.7 | 0 | 1877.2 |
| 1954 | 24.3 | 39.9 | 25.9 | 125.5 | 241.9 | 478.5 | 911.2 | 399.2 | 304.8 | 53.3 | 0 | 21.9 | 2626.4 |
| 1955 | 20.5 | 17.5 | 303 | 217.9 | 260.9 | 560.7 | 725.2 | 345.7 | 319.5 | 260.2 | 0 | 2.5 | 3033.6 |
| 1956 | 36 | 76.2 | 339.3 | 25.3 | 274.6 | 394.2 | 428.7 | 312 | 156.2 | 323.3 | 6.4 | 43.2 | 2415.4 |
| 1957 | 98.5 | 137.8 | 0 | 750.2 | 924.4 | 1021 | 1491.5 | 1100.1 | 375.3 | 348.5 | 7.9 | 111 | 6366.2 |
| 1958 | 46.5 | 78.7 | 30 | 191.5 | 500.6 | 401.3 | 350.9 | 992.6 | 118.4 | 162.1 | 9.8 | 0 | 2882.4 |
| 1959 | 99.4 | 88.4 | 210.2 | 284 | 271.6 | 510.6 | 470.5 | 236.4 | 239.2 | 265.8 | 39 | 0 | 2715.1 |
| 1960 | 0 | 129.8 | 221.8 | 52.6 | 271.7 | 493.5 | 596.7 | 494 | 516.6 | 128.2 | 0 | 0 | 2904.9 |
| 1961 | 25.2 | 57.8 | 250.3 | 186.2 | 383.4 | 288 | 435.1 | 597.5 | 346.9 | 177.2 | 22 | 62.2 | 2831.8 |
| 1962 | 69 | 78.5 | 200.6 | 123.6 | 343.3 | 431.1 | 370.8 | 531.2 | 295.2 | 55.2 | 16.8 | 28.2 | 2543.5 |
| 1963 | 13.6 | 86.6 | 141.6 | 240.6 | 230 | 341.6 | 476.9 | 600.8 | 365.8 | 237 | 70.8 | 7 | 2812.3 |
| 1964 | 12 | 49.8 | 169.3 | 160.9 | 294.4 | 487 | 491.8 | 339.4 | 212.7 | 77 | 22.2 | 0 | 2316.5 |
| 1965 | 6.6 | 146.4 | 166.5 | 175.6 | 71.8 | 172.6 | 497.8 | 494.2 | 304.6 | 58.4 | 102 | 0.4 | 2197.1 |
| 1966 | 90.8 | 62.7 | 42.5 | 190 | 221.3 | 520.5 | 616.2 | 520.1 | 313.4 | 85.7 | 20.9 | 13.4 | 2697.5 |
| 1967 | 34 | 99.7 | 218.9 | 111.5 | 179.9 | 674.4 | 0 | 540.2 | 326.2 | 110.7 | 37.4 | 16 | 2348.9 |
| 1969 | 52.6 | 33.6 | 93 | 193 | 280.8 | 456.6 | 377.4 | 471.3 | 273.8 | 76.6 | 33 | 0 | 2341.7 |
| 1971 | 64.2 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1972 | 11 | 98.4 | 197.5 | 0 | 512.8 | NA | 195.5 | NA | NA | NA | NA | NA | NA |
| 1973 | NA | NA | NA | 42.6 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1974 | NA | 3 | 50 | NA | NA | 498.6 | 557.4 | NA | 443.5 | 256.7 | NA | NA | NA |
| 1975 | 54 | 90 | 0 | 128.8 | 152.6 | 560.2 | 610.5 | NA | NA | NA | NA | NA | NA |
| 1976 | NA | NA | NA | NA | NA | 464.7 | 320.3 | 492 | 286.2 | 96.4 | 20 | 0 | NA |
| 1977 | 21.7 | 19.6 | 280.6 | 487.3 | 328.9 | 311.1 | 577.2 | 452.9 | 149.2 | 453.6 | 109 | 108 | 3299.5 |
| 1978 | 8 | 25.4 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1979 | NA | NA | 104.8 | 165.7 | 123.4 | NA | 639 | 267.7 | 382.4 | 451.5 | NA | NA | NA |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 9.6 | 140.5 | 180.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1983 | 22.7 | 155.4 | NA | 263.1 | 309.6 | 592 | 349.1 | 333.8 | 569 | 80.6 | 17.4 | 14.4 | NA |
| 1984 | 26.8 | 23.6 | 170.6 | 175.3 | 215 | 391.4 | 540.7 | 238.3 | 245 | 234.8 | 0 | 16.2 | 2277.7 |
| **Avr** | **37.2** | **70.0** | **157.8** | **193.1** | **298.6** | **467.6** | **515.2** | **453.7** | **305.1** | **192.1** | **32.2** | **21.3** | **2775.5** |

**Annexure-3.3(d )**

# MONTHLY RAINFALL VALUES FOR LACHUNG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 0 | 0 | 0 | 116.6 | 366.7 | 279.8 | 103.4 | 73.3 | 73.9 | 42.5 | 1056.2 |
| 1958 | 43.3 | 60 | 171.3 | 263.9 | 312.6 | 266.3 | 281 | 437.7 | 103.2 | 129.1 | 13 | 1.3 | 2082.7 |
| 1959 | 37.8 | 66.3 | 235.2 | 207.8 | 187.2 | 209.4 | 306.2 | 220.9 | 150.5 | 166.8 | 8.1 | 0 | 1796.2 |
| 1960 | 1.8 | 148.7 | 165.9 | 59.9 | 122.6 | 327.4 | 315.7 | 224 | 231.9 | 57.3 | 2 | 0 | 1657.2 |
| 1961 | 17.8 | 34.1 | 118.3 | 77.6 | 127.6 | 194.7 | 270.7 | 368.8 | 196.7 | 167.5 | 8.1 | 13.8 | 1595.7 |
| 1962 | 0 | 53.8 | 122.7 | 15.6 | 99 | 172.2 | 173.3 | 453 | 200.8 | 46.6 | 0 | 15.8 | 1352.8 |
| 1963 | 14.8 | 21 | 66.2 | 118.7 | 144.8 | 230.4 | 254 | 350.2 | 234.6 | 116.6 | 54 | 4.2 | 1609.5 |
| | | | | | | | | | | | | | |
| 1971 | 43.8 | 43.9 | 126 | 107.2 | 164.9 | 364.2 | 226.4 | 178.3 | 140.8 | 105.2 | 24.6 | 0.4 | 1525.7 |
| 1972 | 3.4 | 36.4 | 110 | 205.6 | 151.4 | 165.2 | 252.8 | 181.8 | 237.1 | 117 | 20 | 0 | 1480.7 |
| 1973 | 29.2 | 108 | 90.6 | 127.2 | 197.3 | 285.8 | 167 | 235 | 263.4 | 396.4 | 0 | 28.6 | 1928.5 |
| 1974 | 16.5 | 3.6 | 125.5 | 111.6 | 481 | 442.1 | 432.6 | 210.6 | 232.4 | 137.6 | 11 | 20.6 | 2225.1 |
| 1975 | 38.6 | 71 | 124.8 | 70.6 | 161.4 | 268 | 291 | 170.2 | 287.2 | 125.5 | 2 | NA | 1610.3 |
| 1976 | 19.4 | 94.3 | 162.6 | 224.2 | 212.9 | 282.7 | 241 | 249 | 191 | 89.2 | 21 | 0 | 1787.3 |
| 1977 | 5 | 27.6 | 157 | 271.4 | 211.4 | 313.6 | 317.4 | 295.2 | 116.5 | 261.4 | 106 | 84.4 | 2166.9 |
| 1978 | 0 | 13.3 | 45 | NA | 316 | 358 | 431 | 310 | 248 | 8.2 | 122 | 89.4 | NA |
| 1979 | 10.4 | 88.8 | NA | 124.8 | NA | 285.7 | 442.3 | 332 | 232 | NA | 111 | NA | NA |
| | | | | | | | | | | | | | |
| 1990 | NA | NA | NA | NA | NA | NA | 765.5 | 511.4 | NA | 119.4 | 0 | 53.6 | NA |
| 1992 | 7.1 | 71.2 | 109.4 | 109.4 | 170.8 | 166.2 | 235.9 | 273.2 | 150.1 | 128 | 4.7 | 28.6 | 1454.6 |
| 1993 | 19.3 | 51.2 | 132.2 | 122.3 | 105.2 | 242.6 | 292.3 | 308 | 176.3 | 92.5 | 21.4 | 5.2 | 1568.5 |
| 1994 | 22.7 | 76.6 | 214.1 | 159 | 171.1 | 289.6 | 204.1 | 199.1 | 220.7 | 76.6 | 9 | 1.5 | 1644.1 |
| 1995 | 29 | 36 | 61.2 | 125 | 143.9 | 631.3 | 303.5 | 284 | 219.6 | 97.6 | 15 | 19 | 1965.1 |
| 1996 | 21.4 | 144.3 | 207.2 | 198.6 | 287.6 | 308 | 311 | 177.8 | 216.9 | 128 | 2 | 2 | 2004.8 |
| 1997 | 23 | 62 | 403 | 123 | 186 | 379 | 300 | 217 | 449 | 94 | 24 | 39 | 2299 |
| 1998 | 11 | 90 | 227 | 97 | 225 | 230.3 | NA | 468 | NA | 174.8 | 6.6 | NA | NA |
| 1999 | 0 | 87 | 98 | NA | NA | 335.2 | NA | NA | NA | NA | NA | NA | NA |
| **Avr** | **17.3** | **62.0** | **142.3** | **132.7** | **190.0** | **286.0** | **312.2** | **289.0** | **209.2** | **126.5** | **27.5** | **21.4** | **1740.5** |

<u>**Annexure-3.3 ( e )**</u>

## MONTHLY RAINFALL VALUES FOR YUMTHANG STATION IN SIKKIM

**( Unit : mm )**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 0 | 0 | 0 | 41.4 | 292.7 | 233.9 | 165.6 | 112.7 | 0 | 0 | 846.3 |
| 1958 | 0 | 0 | 0 | 0 | 212.6 | 203.3 | 323.2 | 432.8 | 141.3 | 139.2 | 7.4 | 0 | 1459.8 |
| 1959 | 0 | 0 | 0 | 0 | 170.6 | 227.8 | 391.7 | 290.6 | 115.7 | 166.5 | 2.2 | 1.5 | 1366.6 |
| 1960 | 14.8 | 92.5 | 105.6 | 62.8 | 143.5 | 261.9 | 301.5 | 292.2 | 263.6 | 53.2 | 3.1 | 0 | 1594.7 |
| 1961 | 26.9 | 29.4 | 44.3 | 57.7 | 95.6 | 177.8 | 295.1 | 334.3 | 241.6 | 158.5 | 26.5 | 36.2 | 1523.9 |
| 1962 | 21 | 55.2 | 89 | 83.8 | 135 | 276.4 | 202.4 | 274.8 | 216.8 | 37.4 | 6.2 | 16.6 | 1414.6 |
| 1963 | 9 | 16.2 | 75.2 | 159.2 | 165.4 | 168.4 | 323.4 | 331.3 | 180.8 | 97.4 | 23.6 | 5 | 1554.9 |
| 1971 | 36.2 | 54.4 | 59.6 | 89.8 | 173.5 | 337.6 | 279 | 223.4 | 181.6 | 113 | 14.6 | 0 | 1562.7 |
| 1972 | 7.2 | 16.8 | 28.6 | 105.1 | 192.2 | 172.5 | NA | 220 | 226.2 | 106.4 | 7.8 | 0 | NA |
| 1973 | NA | 21.8 | 15.6 | 18.2 | 130.6 | 336.2 | 194.8 | 232 | NA | NA | 0 | 0 | NA |
| 1974 | 8.6 | 15 | 54.8 | 60.8 | 204.4 | 318.6 | 370.8 | NA | 190.4 | 113.6 | 8.6 | 16.8 | NA |
| 1975 | 27 | 67.8 | 115.2 | 50.2 | 97 | 215.6 | 268.4 | 169.8 | 286.1 | 84.6 | 1.4 | 4.2 | 1387.3 |
| 1976 | 12.3 | 37.4 | 61.4 | 53.2 | 181.8 | 109.6 | 222.6 | 332 | 171.8 | 66.7 | 14 | 1 | 1263.8 |
| 1977 | 14 | 15 | 55.4 | 139.8 | 180 | 268.7 | 259.4 | 379.2 | 73.6 | 45.6 | 34.6 | 36 | 1501.3 |
| 1978 | 45.4 | 23.7 | 82.4 | 58 | 93.4 | 192.4 | 233.2 | 180.6 | 165.8 | 87.6 | 36.6 | 7.6 | 1206.7 |
| 1979 | 3 | 36 | 64.4 | 16.4 | 60.2 | 193.4 | 222.6 | 187.6 | 173.6 | 45.8 | 10.2 | 10.8 | 1024 |
| 1980 | 4.2 | 24.6 | 23.3 | 17.2 | 89 | NA | NA | NA | NA | NA | NA | NA | NA |
| 1985 | 614.8 | 27 | 60.2 | 53.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1987 | 32.5 | 11 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Avr** | **48.7** | **28.6** | **51.9** | **57.0** | **136.8** | **218.9** | **278.7** | **274.3** | **186.3** | **95.2** | **12.3** | **8.5** | **1362.0** |

Annexure-3.3 ( f )

# MONTHLY RAINFALL VALUES FOR LACHEN STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 16.5 | 28.2 | 194.2 | 171.6 | 125.4 | 258.2 | 203.8 | 0 | 293.4 | 66 | 49 | 0 | 1406.3 |
| 1952 | 42.2 | 76 | 177.8 | 85.8 | 197.5 | 255.1 | 267.4 | 339.8 | 243.4 | 48.5 | 20.4 | 24.4 | 1778.3 |
| 1953 | 6.3 | 0 | 114.7 | 125.7 | 119.2 | 316.2 | 272.8 | 266 | 372 | 137.4 | 40.6 | 5.8 | 1776.7 |
| 1954 | 230.9 | 35.4 | 152.5 | 95.4 | 154.5 | 285 | 250.9 | 272.4 | 206.2 | 105.8 | 0 | 70.2 | 1859.2 |
| 1955 | 49.4 | 40 | 112.8 | 149.1 | 191.1 | 227.5 | 295.5 | 327.5 | 292.2 | 140.5 | 3.8 | 5.3 | 1834.7 |
| 1956 | 76 | 51.6 | 227 | 91.4 | 234.8 | 212.2 | 270.7 | 217.7 | 148.3 | 177 | 5.8 | 52.5 | 1765 |
| 1957 | 407.7 | 118.9 | 260.2 | 191.8 | 272 | 517.3 | 528.3 | 611.9 | 366.9 | 131.9 | 21.4 | 97.4 | 3525.7 |
| 1958 | 145.8 | 112.8 | 122.6 | 147.3 | 153.9 | 190.5 | 320.6 | 324 | 97.8 | 209.4 | 0 | 9 | 1833.7 |
| 1959 | 13.9 | 40.1 | 0 | 0 | 0 | 266.2 | 213.2 | 119.6 | 134 | 159.4 | 12.4 | 0 | 958.8 |
| 1960 | 21.8 | 68.2 | 184.5 | 46.4 | 147.1 | 340.4 | 285.6 | 213.2 | 340.4 | 118.5 | 12 | 1 | 1779.1 |
| 1961 | 28.2 | 5.2 | 132.4 | 104.4 | 123.2 | 187.8 | 213.7 | 287.4 | 257.4 | 195.6 | 22.4 | 18 | 1575.7 |
| 1962 | 0 | 4.5 | 30 | 56.2 | 120.1 | 207.4 | 209 | 329.5 | 216.9 | 52 | 45.8 | 16.2 | 1287.6 |
| 1963 | 2.1 | 45.4 | 208 | 60.4 | 228.2 | 237.2 | 252 | 296.4 | 345.1 | 149.6 | 52 | 23.2 | 1899.6 |
| 1964 | 17.9 | 128 | 128.2 | 114.2 | 229.4 | 229.4 | 276 | 259.2 | 171 | 62.8 | 4 | 7.2 | 1627.3 |
| 1965 | 23 | 0 | 146.1 | 111.1 | 169.1 | 243 | 125.6 | 0 | 189.9 | 71.7 | 89.2 | 5 | 1173.7 |
| 1966 | 36.6 | 46.9 | 128 | 38.5 | 267.8 | 179.7 | 283.8 | 289.6 | 215 | 48.1 | 26.6 | 31.4 | 1592 |
| 1967 | 26.1 | 85.9 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | | | | | | | | | | | | | |
| 1971 | NA | NA | NA | NA | 87.4 | NA | 106 | NA | NA | NA | NA | NA | NA |
| 1972 | NA | NA | 130.4 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1992 | NA | NA | NA | NA | NA | 200.2 | 318 | 856.2 | 168.3 | 93.1 | 24.2 | NA | NA |
| 1993 | 72.5 | 116.8 | 235.7 | NA | 116 | 227.3 | 329.5 | 292.5 | 199.4 | 105.6 | 6.6 | 3.1 | NA |
| 1994 | 53 | 28 | 124.7 | 172.4 | 131.3 | 223.3 | 582.6 | 199.8 | 142 | 102.7 | 54.9 | 0 | 1083.8 |
| 1997 | 129 | 116.8 | 224.8 | 110.5 | 153.5 | 334.1 | 178.9 | 252.8 | 300.4 | 68.6 | 153 | 124 | 974.4 |
| 1998 | 7.4 | 151.6 | 320.7 | 69.6 | 109.7 | 444 | 370 | 384 | 128.9 | 240.7 | NA | 23.1 | NA |
| 1999 | 27.3 | 85 | NA | 58.3 | 235.5 | 335.2 | 273.7 | 350.7 | 187.8 | 280.6 | 4 | 12.8 | NA |
| **Avr** | **65.2** | **63.0** | **159.8** | **100.0** | **162.1** | **269.0** | **279.5** | **295.0** | **228.0** | **125.7** | **30.8** | **25.2** | **1651.8** |

**<u>Annexure-3.3 (g)</u>**

## MONTHLY RAINFALL VALUES FOR THANGU STATION IN SIKKIM

**( Unit : mm )**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 50.2 | 22.7 | 134.2 | 37.6 | 74.3 | 106.2 | 104.7 | 0 | 109.6 | 79.5 | 54.4 | 0 | 773.4 |
| 1953 | 25.4 | 0 | 37.6 | 72.4 | 39.1 | 89.4 | 109.6 | 110.8 | 159.2 | 104.7 | 13.6 | 18.2 | 780 |
| 1954 | 0 | 50.8 | 86.4 | 37.7 | 148.4 | 111.8 | 141.4 | 147.3 | 77.5 | 26 | 0 | 30.4 | 857.7 |
| 1955 | 8.1 | 25.1 | 33.2 | 44.9 | 54.6 | 80.3 | 167.8 | 168.9 | 150 | 84 | 0 | 2.3 | 819.2 |
| 1956 | 10.4 | 68.6 | 36.7 | 35.4 | 45.1 | 83.4 | 130.5 | 73.1 | 93.9 | 74.8 | 1.3 | 13.1 | 666.3 |
| 1957 | 450.9 | 40.7 | 170.9 | 5.9 | 88.6 | 184.2 | 124.5 | 0 | 135.3 | 57.6 | 97.5 | 194 | 1549.8 |
| 1958 | 68.5 | 64.2 | 94.5 | 0 | 0 | 23.7 | 93.3 | 147.5 | 0 | 0 | 0 | 0 | 491.7 |
| 1959 | 0 | 40.4 | 40.8 | 72.2 | 73.4 | 35 | 50.4 | 75 | 42.6 | 36.6 | 1.2 | 0 | 467.6 |
| 1960 | 10.2 | 34.6 | 144.2 | 60 | 54 | 59 | 137.4 | 124.2 | 150.4 | 85.2 | 0 | 0 | 859.2 |
| 1961 | 72.8 | 280.5 | 137 | 76.4 | 68 | 142.5 | 133 | 109.3 | 166.2 | 200.3 | 42.2 | 92.9 | 1521.1 |
| 1962 | 60.6 | 87.1 | 47.3 | 32.6 | 50 | 72.2 | 60.8 | 171.1 | 134.4 | 45.8 | 6.2 | 27 | 795.1 |
| 1963 | 27.2 | 61.4 | 87.6 | 87.8 | 108.2 | 127.7 | 144.2 | 124.2 | 175.9 | 88.3 | 44 | 19 | 1095.5 |
| 1966 | 30.4 | 4.3 | 59.1 | 8 | 38.1 | 81.7 | 131.3 | 131.5 | 91.9 | 0 | 0 | 0 | 576.3 |
| 1967 | 0 | 14 | 99 | 47 | 18.9 | 92.4 | 61.8 | 106.7 | 70.1 | 49.1 | 30.5 | 13.7 | 603.2 |
| 1969 | 9.4 | 11.1 | 31.5 | 63.7 | 60.8 | 79.6 | 0 | 0 | 0 | 0 | 0 | 0 | 256.1 |
| 1980 | 54.4 | 110.2 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Avr** | **54.9** | **57.2** | **82.7** | **45.4** | **61.4** | **91.3** | **106.0** | **99.3** | **103.8** | **62.1** | **19.4** | **27.4** | **807.5** |

**Annexure-3.3 (h)**

## MONTHLY RAINFALL VALUES FOR DAMTHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 69.6 | 54 | 179.9 | 450.6 | 731.5 | 465.6 | 192.8 | 84.5 | 22.9 | 12.4 | 2263.8 |
| 1958 | 0 | 64.2 | 2.5 | 81.8 | 68.8 | 427.4 | 325.2 | 606.8 | 472.8 | 78.2 | 56.1 | 17.8 | 2201.6 |
| 1959 | 17.9 | 102.5 | 54.5 | 31.5 | 14.7 | 665.7 | 1589.9 | 682.2 | 771.7 | 178 | 0.3 | 0.3 | 4109.2 |
| 1960 | 0 | 2.6 | 26.2 | 23.2 | 108 | 281.4 | 457 | 520.6 | 64.3 | 31.5 | 0 | 10.6 | 1525.4 |
| 1961 | 7.1 | 120.8 | 3.1 | 123 | 409.3 | 152.6 | 109.8 | 142 | 122.6 | 35.8 | 0.2 | 0 | 1226.3 |
| 1962 | 12 | 1.5 | 6 | 21.5 | 161.8 | 172.6 | 151.6 | 159.6 | 89.8 | 0 | 0 | 0 | 776.4 |
| 1963 | 0.2 | 0.4 | 13.4 | 69 | 150 | 105.9 | 246.2 | 332 | 228.2 | 75.4 | 30.8 | 27.5 | 1279 |
| **Avr** | **5.3** | **41.7** | **25.0** | **57.7** | **156.1** | **322.3** | **515.9** | **415.5** | **277.5** | **69.1** | **15.8** | **9.8** | **1911.7** |

**Annexure-3.3 ( i )**

# MONTHLY RAINFALL VALUES FOR YOKSUM STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 58.4 | 24.4 | 43.8 | 221.4 | 160.2 | 474.6 | 641 | 879.1 | 274 | 212.1 | 116 | 0 | 3105 |
| 1959 | 82.6 | 126.2 | 94.1 | 127.1 | 264.8 | 634.9 | 783.4 | 487.1 | 446.7 | 344.8 | 47.5 | 0 | 3439.2 |
| 1960 | 0 | 86.1 | 100.3 | 42.4 | 224.2 | 682.1 | 581.3 | 714.4 | 544.7 | 96.4 | 0 | 0 | 3071.9 |
| 1961 | 19 | 46 | 16.3 | 18.2 | 310.7 | 554.4 | 483.9 | 754.3 | 669.7 | 196.3 | 0 | 18.7 | 3087.5 |
| 1962 | 38 | 32.6 | 89.6 | 83.2 | 234.5 | 650.4 | 357 | 883.1 | 357.5 | 65.9 | 0 | 29.5 | 2821.3 |
| 1963 | 41.5 | 33.8 | 49.1 | 156.1 | 213.5 | 555.9 | 505.5 | 708.1 | 469.1 | 224.6 | 124 | 22 | 3103.5 |
| 1971 | 16 | NA | NA | 151 | 367.7 | 536.7 | 584.2 | NA | NA | NA | NA | NA | NA |
| 1972 | NA | 0.8 | 13 | NA | 124.2 | NA | NA | NA | NA | NA | 12 | 37.2 | NA |
| 1973 | 36.8 | 22.9 | 53.8 | 16.8 | NA | 271.2 | 215.8 | 231.3 | 155.6 | 176.8 | 16.8 | 4.2 | NA |
| 1974 | 20.4 | 4.2 | 89.4 | 204.1 | 253.8 | 274.2 | 192 | 138.6 | 245 | 22.2 | 16.4 | 33.2 | 1493.5 |
| 1975 | 55.4 | 34.4 | 0 | 35.2 | 167.3 | 267.4 | 261.7 | 109.7 | 757.6 | 431.4 | 0.4 | 0 | 2120.5 |
| 1976 | 35.8 | 50.6 | 79.6 | 157.2 | 294.4 | 488.2 | 772.5 | 428.9 | 337.3 | 177 | 211 | 12 | 3044.9 |
| 1977 | 74.8 | 33.2 | 35.8 | 171.8 | 84.8 | 160.8 | 438.1 | 1082.8 | 499 | 286.6 | 85.6 | 39 | 2992.3 |
| 1978 | 0 | 0 | 99 | 75.8 | 349.5 | 708.6 | 841.6 | 376.6 | 793 | 65.6 | 66.8 | 0 | 3376.5 |
| 1979 | 16.9 | 9.2 | 16.2 | 13.4 | 35.7 | 201.1 | 799 | 799.6 | 772.5 | 153 | 10.2 | NA | NA |
| 1980 | NA | 28.7 | 65.1 | 67.6 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1991 | 7.6 | 22.5 | 39.8 | 137.7 | 382.8 | 739 | 481.8 | 354.3 | 393.6 | 49.2 | 1.5 | 10.9 | 2620.7 |
| 1992 | 10.9 | 27.8 | 33.5 | 163 | NA | 674.3 | 701.6 | 342.8 | 278.8 | 59 | 10.2 | 15.5 | NA |
| 1993 | 17.6 | 57 | 77 | 169.8 | 498.8 | 739.9 | 599.8 | 307.1 | 248.8 | 50.2 | 53.1 | 16.2 | 2835.3 |
| 1994 | 8.4 | 25.9 | 115.3 | 165.4 | 178.9 | 469.9 | 520.9 | 325 | 156 | 84.8 | 37 | 2.1 | 2089.6 |
| 1995 | 2.2 | 15.6 | 30.7 | 108 | 290.3 | 367.9 | 478.7 | 324.3 | 228.6 | 90.2 | 30.7 | 20.1 | 1987.3 |
| 1996 | 15.6 | 43.6 | 95.4 | 214 | 359 | 436.7 | 561.3 | 266 | 180.2 | 85.6 | nil | 3 | 2260.4 |
| **Avr** | **27.9** | **34.5** | **58.9** | **119.0** | **252.4** | **494.4** | **540.1** | **500.7** | **410.9** | **151.1** | **44.2** | **13.9** | **2715.6** |

**Annexure-3.3( j )**

## MONTHLY RAINFALL VALUES FOR DENTAM STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 30.9 | 13.5 | 30.2 | 151.4 | 114.8 | 409.5 | 548.3 | 317.1 | 289.7 | 32.6 | 7.6 | 0 | 1945.6 |
| 1959 | 67.2 | 37 | 123.6 | 76.9 | 269.4 | 272.1 | 677.3 | 447.6 | 292.4 | 325.4 | 16.8 | 0 | 2605.7 |
| 1960 | 2.5 | 36.2 | 93 | 40.4 | 235.3 | 345.5 | 581.1 | 402.5 | 494.1 | 81.8 | 0 | 6.1 | 2318.5 |
| 1961 | 6.2 | 42.2 | 27.4 | 56 | 164.9 | 347.8 | 484.4 | 719.3 | 277.8 | 96.1 | 14.2 | 15 | 2251.3 |
| 1962 | 49.2 | 30.4 | 53.6 | 97.6 | 222.6 | 521.8 | 373.3 | 582.9 | 222.6 | 65.7 | 0 | 0 | 2219.7 |
| 1963 | 19.6 | 3.9 | 69.2 | 120.9 | 144.5 | 330 | 471 | 573.2 | 353 | 100.7 | 30 | 0 | 2216 |
| | | | | | | | | | | | | | |
| 1971 | 1 | 2 | 32.4 | 168.7 | 164 | 557.2 | 527 | 555.6 | 218 | 298.2 | 13.4 | 0 | 2537.5 |
| 1972 | 0.2 | 30.2 | 17.6 | 137.6 | 177 | 226 | NA | NA | 396.2 | NA | 4 | 0 | NA |
| 1973 | 6.4 | 29.4 | 43.6 | NA | NA | NA | 315 | 450.5 | 288.6 | NA | 8 | 0 | NA |
| 1974 | 15 | 2.4 | 29 | 172.8 | 215.6 | 358.9 | 594 | 459.3 | 290 | 97 | 0 | 6.6 | 2240.6 |
| 1975 | 20.8 | 6.4 | 2.2 | 51.2 | 267.2 | 490 | 648.5 | 235.2 | 608 | NA | 0 | 6.6 | NA |
| 1976 | 18.6 | 40.6 | 4.6 | 68.8 | 243.9 | 359.8 | 526.4 | 631.6 | 214 | 57.2 | 3.6 | 0 | 2169.1 |
| 1977 | 14.2 | 8.2 | 41 | 276.1 | 244.4 | 244.9 | 469 | 732.9 | 367.7 | 175 | 57.8 | 67.2 | 2698.4 |
| 1978 | 7 | 20.4 | 44 | 98.8 | 244.6 | 457.4 | 480.4 | 357.3 | 380.1 | 100.8 | 43 | 11.4 | 2245.2 |
| 1979 | 0 | 26.9 | 0 | 81.7 | 77.2 | 448.7 | 727.2 | 389.2 | 385.9 | 122.6 | 77.6 | NA | NA |
| 1980 | 0 | 0 | 90.4 | 289.8 | 248.8 | NA | NA | NA | NA | NA | NA | NA | NA |
| | | | | | | | | | | | | | |
| 1992 | 5 | NA | 6 | 24 | 34.3 | 41.1 | NA | 433.3 | NA | 0 | 0 | 2 | NA |
| 1993 | NA | 0 | 23 | 43 | 137 | 457.4 | NA | 195 | NA | NA | NA | NA | NA |
| 1994 | NA | 82.3 | 60.1 | 123.8 | 115.5 | 195 | 233.4 | 588 | 420.4 | 0 | 13 | 5 | NA |
| | | | | | | | | | | | | | |
| 1997 | NA | 29.4 | 54.8 | 99 | 114.2 | 707.2 | 480.4 | 422 | 456 | 25.8 | 0 | 81.6 | NA |
| 1998 | 4.6 | 13 | 49.2 | 57.2 | 235.6 | NA | 766.2 | NA | NA | 61.6 | 8.2 | 1.6 | NA |
| 1999 | 7.6 | 0 | 14.2 | NA | 336.2 | 591 | 744.6 | 596.8 | 291.2 | 359.6 | 0 | 29.2 | NA |
| **Avr** | **14.5** | **21.6** | **41.3** | **111.8** | **190.8** | **387.4** | **536.0** | **478.4** | **347.0** | **117.7** | **14.9** | **12.2** | **2313.4** |

**Annexure-3.3 ( k )**

## MONTHLY RAINFALL VALUES FOR CHHANGU STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 69.8 | 73.4 | 251.1 | 317.5 | 515.3 | 519.1 | 486.8 | 806.5 | 220.4 | 81.6 | 43.6 | 0.3 | 3385.4 |
| 1959 | 67.8 | 48.9 | 125.9 | 262.2 | 461.7 | 658.7 | 531.9 | 412.5 | 307.7 | 262.9 | 13 | 0.5 | 3153.7 |
| 1960 | 0 | 77.4 | 172 | 27.4 | 322.7 | 565.1 | 490.7 | 196.1 | 574.9 | 47 | 0 | 0.5 | 2473.8 |
| 1961 | 10.2 | 35.4 | 144.4 | 160.3 | 823.6 | 361.1 | 482.7 | 587.4 | 450.4 | 79.3 | 30.1 | 10 | 3174.9 |
| 1962 | 38 | 53.1 | 149.1 | 227.4 | 543.4 | 533.6 | 454.2 | 739.4 | 283.4 | 100 | 0 | 12.6 | 3134.2 |
| 1963 | 2.1 | 1.6 | 0 | 0 | 0 | 129.2 | 0 | 0 | 141.9 | 99.6 | 0 | 0 | 374.4 |
| 1969 | 0 | 0 | 1 | 20 | 287.6 | 548.4 | 532.6 | 566.4 | 310.3 | 0 | 0 | 0 | 2266.3 |
| 1971 | NA | 27 | 115.9 | 187.1 | 296.7 | 724.8 | 473.1 | 581.2 | 181.8 | 387.4 | 0 | 0 | NA |
| 1972 | 0 | NA | NA | NA | NA | 491.9 | NA | 418.1 | 351.9 | NA | NA | NA | NA |
| 1978 | NA | 2.4 | 9 | 0.1 | 171.3 | NA | 461.1 | 348 | 268 | NA | NA | NA | NA |
| 1992 | NA | NA | 0 | NA | 2591 | NA | 1199.7 | NA | NA | NA | NA | NA | NA |
| **Avr** | **23.5** | **35.5** | **96.8** | **133.6** | **601.3** | **503.5** | **511.3** | **465.6** | **309.1** | **132.2** | **10.8** | **3.0** | **2566.1** |

**Annexure-3.3 ( I )**

## MONTHLY RAINFALL VALUES FOR RONGLI STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 56.1 | 73.6 | 122.5 | 461 | 802.7 | 616.3 | 307.2 | 62.3 | 5.1 | 14.5 | 2521.3 |
| 1958 | 20.3 | 48.5 | 5.1 | 177.8 | 250.4 | 327 | 736.7 | 374.4 | 272.9 | 25.4 | 27.4 | 18.5 | 2284.4 |
| 1959 | 35.3 | 24.5 | 64.3 | 231.9 | 332.7 | 315.5 | 618.2 | 620.6 | 528.9 | 253.8 | 18.2 | 0 | 3043.9 |
| 1960 | 0 | 97.1 | 144.2 | 57.9 | 424.3 | 418.3 | 897.6 | 918.6 | 606.2 | 151.8 | 0 | 2.1 | 3718.1 |
| 1961 | 9.3 | 50.1 | 53.3 | 75.3 | 184.4 | 465.4 | 936.2 | 857.9 | 572.1 | 75.4 | 10.9 | 7 | 3297.3 |
| 1962 | 50.5 | 17.7 | 67 | 129.5 | 261.4 | 734.2 | 862.8 | 686 | 404.8 | 63 | 0 | 0 | 3276.9 |
| 1963 | 12 | 0.2 | 55 | 332.6 | 230.8 | 402.8 | 722.8 | 674.2 | 259 | 71.8 | 40.4 | 15.2 | 2816.8 |
| 1971 | 3 | 11.6 | 43.6 | 211.4 | 306.1 | 1213 | 1012.5 | 998.4 | 392.2 | 381.2 | 3.6 | 5.2 | 4581.8 |
| 1972 | 33.4 | 29.2 | 20 | 361.8 | 483.2 | 423.2 | 914.6 | 1087.6 | 591.8 | 60.8 | 50.4 | 0 | 4056 |
| 1973 | 9 | 41.6 | 21.2 | 163 | 303.6 | 536.8 | 634.8 | 570.2 | 593.4 | 395.8 | 5.4 | 0 | 3274.8 |
| 1974 | 36.2 | 6.2 | 50.9 | 191.2 | 300.2 | 279.2 | 1012.2 | 432 | 381 | 109.6 | 0 | 5.2 | 2803.9 |
| 1975 | 14.8 | 0.8 | 19.2 | 126.4 | 361.8 | 641.8 | 866.6 | 304.4 | 607.4 | 244.6 | 0 | 16 | 3203.8 |
| 1976 | 0.2 | 50.4 | 0 | 102.4 | 333.6 | 729.8 | 849.6 | 681.2 | 453.2 | 58.6 | 0 | 1.4 | 3260.4 |
| 1977 | 0 | 0 | 17.6 | 273.2 | 325.2 | 472.8 | 760.9 | 932.6 | 379.1 | 156.6 | 56.2 | 21.4 | 3395.6 |
| 1978 | 15.8 | 8.6 | 65 | 75 | 231.8 | 738 | 748.4 | 257.8 | 422.8 | 34.4 | 89 | NA | NA |
| 1979 | 4 | 68 | 0 | NA | NA | NA | 698 | 527 | 256 | NA | NA | NA | NA |
| 1992 | 12.4 | 35.6 | 0 | 181.4 | 172 | 597 | 772.6 | 733.2 | 442.2 | 83.4 | 4.6 | 9.6 | 3044 |
| 1993 | 24.1 | 58.8 | 10.2 | 105.6 | NA | 239.8 | NA | NA | 334.2 | 65 | 14.8 | 0 | NA |
| 1994 | 26 | 3.2 | 152.4 | 182.3 | 337.8 | 210.6 | 257.8 | 261 | 257.2 | 0 | NA | NA | NA |
| 1997 | 0 | 80.4 | 13.6 | 253.2 | 145.2 | 233.2 | 219.8 | NA | NA | NA | NA | NA | NA |
| 1998 | NA | NA | NA | 82.6 | 92.2 | 282.4 | NA | 303.8 | 314 | 52 | 0 | NA | NA |
| 1999 | NA | NA | 0 | 135.6 | 378.4 | 312.4 | NA | 319.4 | NA | NA | NA | NA | NA |
| **Avr** | **15.3** | **31.6** | **40.9** | **167.8** | **278.9** | **477.8** | **753.9** | **607.8** | **418.8** | **123.4** | **18.1** | **7.3** | **3238.6** |

**Annexure-3.3 (m)**

## MONTHLY RAINFALL VALUES FOR GEZING STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 240.0 | 25.2 | 139.3 | 135.3 | 430.3 | 864.6 | 1414.7 | 1075.1 | 1682.0 | 381.5 | 67.7 | 45.0 | 6500.7 |
| 1958 | 34.5 | 22.1 | 20.3 | 179.8 | 148.5 | 422.8 | 439.5 | 591.3 | 252.4 | 120.2 | 48.4 | 0.0 | 2279.8 |
| 1959 | 57.8 | 18.2 | 76.8 | 119.6 | 196.9 | 283.9 | 508.1 | 272.5 | 306.4 | 272.0 | 34.4 | 0.0 | 2146.6 |
| 1960 | 0.0 | 61.8 | 87.3 | 78.6 | 240.8 | 306.0 | 542.9 | 331.2 | 522.7 | 87.4 | 0.0 | 1.2 | 2259.9 |
| 1961 | 9.2 | 44.9 | 27.7 | 91.1 | 189.8 | 538.5 | 690.3 | 626.5 | 313.0 | 140.2 | 12.6 | 12.4 | 2696.2 |
| 1962 | 45.6 | 20.7 | 66.1 | 60.2 | 207.3 | 605.9 | 340.8 | 654.0 | 221.4 | 68.0 | 0.0 | 10.7 | 2300.7 |
| 1963 | 12.5 | 4.5 | 74.0 | 175.2 | 227.2 | 501.6 | 450.4 | 552.7 | 414.0 | 232.0 | 40.1 | 34.5 | 2718.7 |
| 1964 | 0.0 | 0.0 | 45.5 | 76.7 | 134.0 | 332.8 | 801.4 | 514.8 | 319.2 | 79.0 | 10.7 | 0.0 | 2314.1 |
| 1965 | 0.9 | 3.7 | 42.0 | 89.4 | 188.3 | 301.3 | 545.8 | 773.2 | 296.3 | 143.7 | 81.6 | 0.0 | 2466.2 |
| 1966 | 99.2 | 4.6 | 10.2 | 80.9 | 145.9 | 234.7 | 515.0 | 564.8 | 348.3 | 52.5 | 0.0 | 0.0 | 2056.1 |
| 1967 | 0.0 | 0.0 | 0.0 | 129.0 | 205.9 | 415.1 | 528.2 | 210.7 | 367.0 | 114.6 | 52.9 | 23.2 | 2046.6 |
| 1968 | 15.1 | 8.2 | 142.9 | 58.8 | 177.6 | 305.3 | 646.7 | 486.4 | 533.3 | 409.2 | 0.4 | 0.0 | 2783.9 |
| 1969 | 8.7 | 4.1 | 87.8 | 50.3 | 197.5 | 245.5 | 662.1 | 423.5 | 451.5 | 59.1 | 1.7 | 2.1 | 2193.9 |
| 1970 | 19.3 | 33.0 | 19.5 | 125.7 | 129.4 | 468.2 | 787.0 | 430.5 | 336.1 | 0.0 | 10.6 | 0.0 | 2359.3 |
| 1971 | 9.4 | 5.8 | 38.3 | 206.3 | 158.8 | 720.3 | 481.6 | 555.6 | 364.9 | 268.5 | 28.4 | 11.2 | 2849.1 |
| 1972 | 25.8 | 31.2 | 41.9 | 131.5 | 194.7 | 254.4 | 521.2 | 272.0 | 312.3 | 56.3 | 29.5 | 46.6 | 1917.4 |
| 1973 | 10.2 | 29.9 | 58.8 | 138.3 | 309.5 | 1039.8 | 409.0 | 404.5 | 71.8 | 366.2 | 5.6 | 0.0 | 2843.6 |
| 1974 | 27.2 | 7.5 | 0.1 | 35.0 | 216.9 | 261.2 | 488.6 | 166.2 | 499.6 | 179.7 | 5.9 | 16.4 | 1904.3 |
| 1975 | 27.2 | 7.5 | 0.1 | 35.0 | 216.9 | 261.2 | 496.1 | 166.2 | 499.6 | 179.7 | 3.5 | 16.4 | 1909.4 |
| 1976 | 5.8 | 40.1 | 2.4 | 1.9 | 27.6 | 106.7 | 27.8 | 115.7 | 166.5 | 68.1 | 18.3 | 5.0 | 585.9 |
| 1977 | 2.0 | 0.0 | 197.6 | 303.6 | 136.3 | 133.2 | 350.4 | 470.8 | 627.4 | 199.5 | NA | 89.6 | 2510.4 |
| 1978 | 38.4 | 26.7 | 7.6 | 84.4 | 191.9 | 665.5 | 386.9 | 93.8 | 633.0 | 9.3 | 58.9 | 0.0 | 2196.4 |
| **Avr** | **31.3** | **18.2** | **53.9** | **108.5** | **194.2** | **421.3** | **547.0** | **443.3** | **433.6** | **158.5** | **24.3** | **14.3** | **2447.2** |

**Annexure-3.3 (n)**

# MONTHLY RAINFALL VALUES FOR GANGTOK STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 224.8 | 186.2 | 390.4 | 504.3 | 901.4 | 972.4 | 1639.2 | 1259.4 | 1387.4 | 398 | 96 | 98.6 | 8058.1 |
| 1958 | 102.7 | 76.7 | 65 | 378 | 348.5 | 726.4 | 687.9 | 768.3 | 289.9 | 110.2 | 71.8 | 16.2 | 3641.6 |
| 1959 | 81.8 | 87.6 | 137.6 | 242.9 | 620.8 | 636.4 | 717.3 | 316.5 | 501.2 | 352.7 | 37.1 | 0.4 | 3732.3 |
| 1960 | 0.4 | 92.4 | 198.7 | 204.4 | 560.3 | 837.3 | 607.7 | 464.5 | 633.9 | 126.5 | 0 | 8 | 3734.1 |
| 1961 | 26.7 | 99.7 | 174.5 | 159.2 | 455.2 | 654.8 | 690.1 | 588.5 | 505.7 | 88.3 | 22.6 | 33.8 | 3499.1 |
| 1962 | 60.5 | 36.2 | 102.5 | 133.6 | 609.1 | 564.8 | 528.8 | 779 | 296.5 | 51.8 | 0 | 11.8 | 3174.6 |
| 1963 | 15 | 41.5 | 130.5 | 424.5 | 442 | 691.7 | 709.4 | 710.1 | 439.8 | 156.4 | 67.7 | 31.5 | 3860.1 |
| 1964 | 5.8 | 17.8 | 96.7 | 333.4 | 380.1 | 683.4 | 825.5 | 571.5 | 374.3 | 85.7 | 37.2 | 17.5 | 3428.9 |
| 1965 | 8.4 | 34 | 91.6 | 217.8 | 476.3 | 692.2 | 507.2 | 698.5 | 413.6 | 39.7 | 123 | 0 | 3302 |
| 1966 | 110.2 | 38.5 | 126.4 | 119.6 | 435 | 920.4 | 571.5 | 589.6 | 392.2 | 166.6 | 3.5 | 9.4 | 3482.9 |
| 1967 | 0.2 | 39.5 | 226.5 | 81.3 | 566.7 | 550.1 | 788.5 | 492.6 | 345.8 | 89.1 | 20.2 | 34.2 | 3234.7 |
| 1968 | 34.1 | 21.7 | 263.9 | 112.7 | 670.1 | 415.5 | 645.2 | 582.1 | 600.9 | 403 | 4.3 | 0 | 3753.5 |
| 1969 | 36.5 | 12.2 | 235.6 | 264.7 | 492.9 | 631.6 | 752.3 | 560.4 | 337.2 | 222.1 | 15.2 | 9.4 | 3570.1 |
| 1970 | 40.6 | 98.3 | 82 | 237.9 | 309.6 | 563.5 | 605.2 | 645.7 | 239.7 | 17.3 | 35.2 | 1.6 | 2876.6 |
| 1971 | 36.6 | 22 | 133 | 329 | 422.4 | 912.1 | 694.3 | 641.9 | 421.1 | 468.3 | 26.8 | 11.2 | 4118.7 |
| 1972 | 52.6 | 46.8 | 123 | 453.8 | 758.7 | 685.1 | 625.7 | 482.1 | 591.9 | 75.4 | 31.8 | 1.7 | 3928.6 |
| 1973 | 25.9 | 69.9 | 106.6 | 185.2 | 601.3 | 691.5 | 468.8 | 566.8 | 302.8 | 461 | 11.8 | 0.4 | 3492 |
| 1974 | 24.3 | 4.6 | 154.1 | 687.8 | 530.1 | 510.3 | 861.1 | 658.5 | 457.2 | 139.9 | 0.2 | 32 | 4060.1 |
| 1975 | 21.7 | 61.6 | 10.3 | 113.8 | 662 | 570.3 | 852.9 | 326.7 | 541 | 325.4 | 3.7 | 32 | 3521.4 |
| 1976 | 28.3 | 89.1 | 45.9 | 210.1 | 638.9 | 587.3 | 553.4 | 714.6 | 287.4 | 135.9 | 46.3 | 1.7 | 3338.9 |
| 1977 | 22.8 | 6 | 69.4 | 680.1 | 784.1 | 694.9 | 629.1 | 630.1 | 382.9 | 260.2 | 168 | 73.9 | 4401.1 |
| 1978 | 65.4 | 35.9 | 69.3 | 183.7 | 645.3 | 707.4 | 694.5 | 436.6 | 543.1 | 34.3 | 25.1 | 12.9 | 3453.5 |
| | | | | | | | | | | | | | |
| 1990 | NA | NA | NA | NA | NA | NA | 700.7 | 551.5 | 453.6 | 41.5 | 0.5 | 2.7 | NA |
| 1991 | NA | NA | NA | NA | NA | NA | 502 | 734.3 | 793.5 | 48.5 | 1.2 | 34.9 | NA |
| 1992 | 26.9 | 97.8 | 39.5 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1993 | 62.3 | 101 | 77.1 | 269.8 | 498.8 | 739.9 | 599.3 | 633.4 | 348.8 | 250.2 | 53.1 | 16.2 | 3649.9 |
| 1994 | 48.2 | 50.9 | 218 | 265.4 | 306.4 | 659.3 | 369.4 | 625.2 | 356 | 342.7 | 37.2 | 2.1 | 3280.8 |
| 1995 | 21.9 | 79 | 70.7 | 208 | 489.5 | 467.6 | 778.7 | 594.3 | 562.3 | 100.7 | 174 | 47.3 | 3593.5 |
| 1996 | 73.6 | 46.4 | 185.6 | 214 | 951.7 | 436.7 | 622.1 | 766 | 382.8 | 488 | 0.2 | 0.3 | 4167.4 |
| 1997 | 34.5 | 125.4 | 101.7 | 297.2 | 400.9 | 1281.3 | 518.4 | 600.7 | 565.6 | 101.8 | 3.5 | 75.8 | 4106.8 |
| 1998 | 23.4 | 58.6 | NA | 228.2 | 340 | 1120.8 | 669.4 | 555.9 | 372.8 | 233.6 | 7 | 0.1 | NA |
| 1999 | 25.5 | 1.2 | 41.4 | 523.2 | 370.5 | 713.3 | 771.1 | 585 | 487.1 | 351.2 | 44.6 | 21 | 3935.1 |
| **Avr** | **44.7** | **59.3** | **129.9** | **285.0** | **540.3** | **700.6** | **683.4** | **617.1** | **471.2** | **198.9** | **37.7** | **20.6** | **3799.9** |

**Annexure-3.3 (o)**

## MONTHLY RAINFALL VALUES FOR MANGAN STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 399.7 | 174.8 | 534.7 | 403.2 | 548.8 | 1782.3 | 1675.5 | 1111.5 | 1132.5 | 700.2 | 129 | 296 | 8888.3 |
| 1960 | 0 | 199.2 | 237.3 | 95 | 412.2 | 897 | 453.4 | 292.6 | 524.4 | 205.6 | 12.4 | 4.2 | 3333.3 |
| 1961 | 62.2 | 86.4 | 286.2 | 224 | 582.6 | 450.6 | 638.8 | 461.9 | 460.6 | 207.9 | 35 | 106 | 3602.2 |
| 1962 | 86.8 | 59.8 | 261 | 80.8 | 463.2 | 566.6 | 309.8 | 986 | 416.8 | 88.8 | 40 | 76.4 | 3436 |
| 1963 | 51.2 | 91 | 156.5 | 242.4 | 299.2 | 549 | 503.6 | 642 | 342.6 | 236 | 81.4 | 48.4 | 3243.3 |
| 1964 | 4 | 59 | 186.2 | 254.2 | 351.2 | 303.5 | 742.7 | 423.2 | 236 | 118.2 | 25.7 | 2 | 2705.9 |
| 1965 | 16 | 144.1 | 212.8 | 179.1 | 190.4 | 419.1 | 471.8 | 525.8 | 495 | 91.2 | 134 | 2.2 | 2881.5 |
| 1966 | 100.8 | 63.3 | 21.6 | 188.9 | 380.1 | 729.7 | 706.2 | 389.8 | 370 | 112.6 | 5.8 | 28.5 | 3097.3 |
| 1967 | 0 | 0 | 203.2 | 122.3 | 502.9 | 1616.2 | 635.5 | 377.8 | 222.5 | 98.2 | 38.7 | 24.4 | 3841.7 |
| 1968 | 61.8 | 128.8 | 176.6 | 200 | 353.5 | 360.2 | 705.2 | 513.7 | 519.6 | 338 | 44.8 | 1.6 | 3403.8 |
| 1969 | 84.6 | 28.2 | 157 | 194.5 | 397.2 | 752.4 | 392.2 | 455.1 | 253.7 | 76.4 | 35.8 | 6 | 2833.1 |
| 1970 | 78.8 | 131.8 | 158.6 | 204.9 | 367.4 | 651.9 | 488.1 | 461 | 864 | 56.4 | 0 | 0 | 3462.9 |
| 1971 | 116.8 | 117.2 | 133.9 | 233.2 | 282.2 | 800.7 | 474.2 | 278.9 | 355.2 | 283.4 | 26.4 | 4 | 3106.1 |
| 1972 | 19.4 | 122.9 | 261.9 | 278.8 | 611.4 | 701.6 | 448.8 | 304.5 | 279.7 | 117.7 | 22.2 | 0 | 3168.9 |
| 1973 | 38.4 | 155.1 | 51 | 142.9 | 501.8 | 947.3 | 395.6 | 333.7 | 190.3 | 200.7 | 9.3 | 8.2 | 2974.3 |
| 1974 | 31.2 | 36.1 | 101 | 267.4 | 257.3 | NA | NA | 717 | 768.2 | 330.2 | 7.8 | 43.8 | NA |
| 1975 | 55.2 | 210.6 | 60.8 | 185.8 | 276.9 | 154.4 | NA | NA | 377.2 | 244.2 | NA | NA | NA |
| 1976 | 10 | 30.9 | 44 | 59.3 | 112.2 | 81.2 | 136.4 | 159.3 | 151.4 | 79.5 | 35.5 | 12.2 | 911.9 |
| 1977 | 36.2 | 31.6 | 83.2 | 121.2 | 143.8 | 209.4 | 188.7 | 136.8 | 145.2 | 87.3 | NA | 129 | 1312 |
| 1978 | 83.8 | 34 | 84.6 | 145.6 | 160.8 | 125.6 | 92 | 98.5 | 94.6 | 21.2 | 0 | NA | NA |
| 1979 | NA | 10 | 22.2 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1980 | 79.8 | 95.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Avr** | **67.5** | **91.4** | **163.5** | **191.2** | **359.8** | **636.8** | **525.5** | **456.3** | **410.0** | **184.7** | **38.0** | **44.1** | **3306.0** |

**Annexure-3.3 ( p )**

## MONTHLY RAINFALL VALUES FOR SERRATHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 74.6 | 22.4 | 89.8 | 265.7 | 521.5 | 370.2 | 422.7 | 691.3 | 147.8 | 104.2 | 10.2 | 5.1 | 2725.5 |
| 1959 | 30.6 | 32.9 | 96.4 | 267.9 | 436 | 562.9 | 420.4 | 433.7 | 378.4 | 231.8 | 20.3 | 0 | 2911.3 |
| 1960 | 1.8 | 163.6 | 247.4 | 71 | 291.9 | 393.7 | 394.5 | 298.3 | 398.7 | 105.2 | 0 | 0 | 2366.1 |
| 1961 | 39.2 | 44.3 | 176.4 | 54.5 | 528.6 | 365 | 454.7 | 464.7 | 351.7 | 98.9 | 47 | 67.2 | 2692.2 |
| 1962 | 55.9 | 60.8 | 128.1 | 141.2 | 493.2 | 317.2 | 326.6 | 345.7 | 240.1 | 29.1 | 0 | 44.4 | 2182.3 |
| 1963 | 6 | 105.5 | 47.9 | 48.1 | 71 | 155.8 | 62.4 | 93.8 | 124.7 | 33.8 | 19.8 | 4.5 | 773.3 |
| 1993 | NA | NA | NA | NA | 18 | NA | NA | NA | 89 | 24 | NA | NA | NA |
| **Avr** | **34.7** | **71.6** | **131.0** | **141.4** | **337.2** | **360.8** | **346.9** | **387.9** | **247.2** | **89.6** | **16.2** | **20.2** | **2275.1** |

**Annexure-3.3 ( q )**

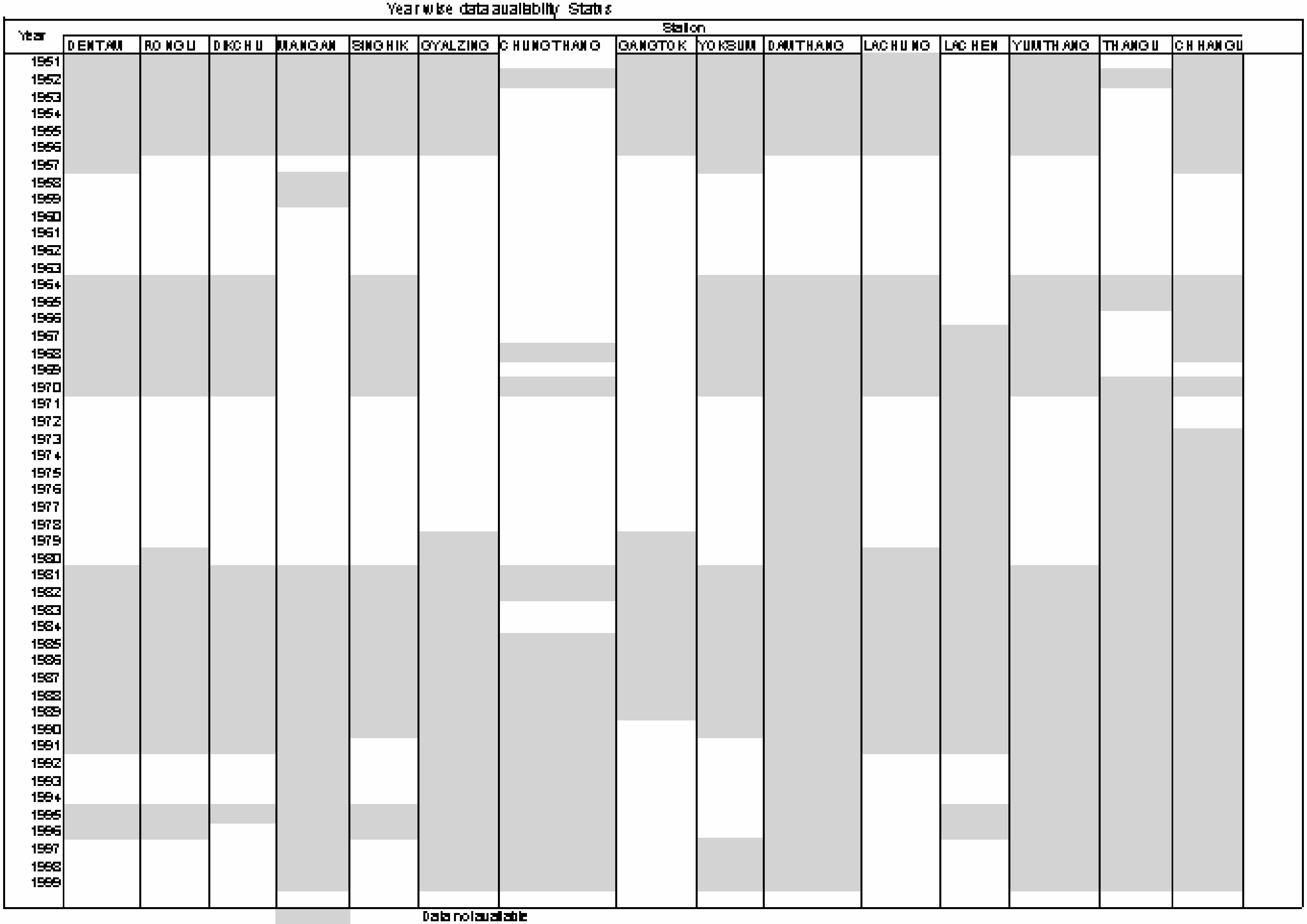
## MONTHLY RAINFALL VALUES FOR GNATHANG STATION IN SIKKIM

**( Unit : mm )**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | NA | NA | NA | NA | NA | 191.8 | 351.7 | 590 | 419.1 | 148 | 0 | NA | NA |
| 1975 | NA | NA | NA | NA | 457.5 | NA | NA | NA | 643 | NA | NA | NA | NA |
| 1976 | 0 | 0 | 0 | 0 | 452 | 749.4 | 651 | 723 | 355 | 137 | 30 | 0 | 3097.4 |
| 1977 | 0 | 35 | 10 | 0 | 0 | 652 | 627 | 382.5 | 272.9 | 0 | NA | 0 | NA |
| 1978 | NA | 0 | 0 | 31 | 296 | 1344 | 0 | 273 | NA | NA | NA | NA | NA |
| 1979 | NA | NA | 0 | NA | NA | NA | NA | NA | 351.5 | NA | NA | NA | NA |
| **Avr** | **0.0** | **11.7** | **2.5** | **10.3** | **301.4** | **734.3** | **407.4** | **492.1** | **408.3** | **95.0** | **15.0** | **0.0** | **3097.4** |

Annexure-3.3 ( r )

Year wise data availability Status



**Annexure-3.4 (a)**

# FILLED UP VALUES

## MONTHLY RAINFALL VALUES FOR DIKCHU STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 29.2 | 174.7 | 144.3 | 461.7 | 654.2 | 677.9 | 515.5 | 496.5 | 186.8 | 0 | 67.1 | 3407.9 |
| 1958 | 44.9 | 45.4 | 124.3 | 333.2 | 339.7 | 685.1 | 594.8 | 817.1 | 135.2 | 172.1 | 91.5 | 11.7 | 3395 |
| 1959 | 113.8 | 116.5 | 160.5 | 175.8 | 442.6 | 770.3 | 568.5 | 301 | 464.5 | 231.8 | 51.4 | 0 | 3396.7 |
| 1960 | 0 | 110.9 | 202.7 | 103.7 | 414 | 795.9 | 422.8 | 268.7 | 536.7 | 2.6 | 0.5 | 1.8 | 2860.3 |
| 1961 | 11.4 | 47.5 | 204.2 | 111.5 | 632.7 | 668.2 | 617.4 | 588.5 | 514.6 | 214.7 | 42.9 | 71.5 | 3725.1 |
| 1962 | 59.3 | 48.8 | 97.2 | 126.8 | 729.9 | 532.4 | 378.3 | 999.6 | 414.6 | 21.6 | 2.4 | 18.6 | 3429.5 |
| 1963 | 23.4 | 75.8 | 227 | 201.6 | 327.4 | 514.4 | 653.8 | 649.2 | 391.2 | 244.2 | 63.8 | 9 | 3380.8 |
| 1971 | 46.8 | 62.2 | 217.3 | 233.6 | 518.8 | 847.4 | 658.2 | 442.6 | 455.6 | 488 | 11.4 | 0.4 | 3982.3 |
| 1972 | 17.4 | 34.8 | 53.4 | 325 | 569.4 | 658.8 | 536.4 | 257.2 | 166.6 | 105.2 | 20.8 | 0 | 2745 |
| 1973 | 36.7 | 120.4 | 214.2 | 143.4 | 611.8 | 510.4 | 398.4 | 278 | 222.6 | 294.6 | 4.8 | 0 | 2835.3 |
| 1974 | 1.8 | 0.2 | 66.4 | 306.8 | 395.4 | 695.8 | 685.8 | 397.2 | 375.2 | 149.8 | 0 | 19.6 | 3094 |
| 1975 | 28 | 55.2 | 0.8 | 93.2 | 512 | 505.4 | 695 | 215.6 | 636.4 | 317.8 | 2.8 | 15.4 | 3077.6 |
| 1976 | 24.8 | 83.8 | 50.2 | 132.4 | 585.6 | 885.2 | 367.2 | 498.6 | 215.8 | 191.6 | 64.2 | 0.2 | 3099.6 |
| 1977 | 20 | 38.8 | 195.2 | 469.6 | 470.7 | 692.2 | 445.4 | 654.2 | 512.6 | 352.2 | 207 | 0 | 4057.7 |
| 1978 | 87.8 | 75.2 | 178.4 | 277.6 | 677.8 | 636.4 | 638.4 | 372.8 | 572 | 144 | 186 | 16.8 | 3863.2 |
| 1979 | 12.4 | 50 | 34.2 | 172.6 | 251.6 | 420.4 | 717.8 | 561.8 | 626.8 | 334 | 7.4 | 15.4 | 3204.4 |
| 1980 | 38.2 | 197.8 | 202.2 | 358.4 | 347.2 | NA | 713..4 | 568.8 | 536.2 | 130.8 | 0 | 11.2 | NA |
| 1992 | 33 | 98.8 | 141.2 | 168.8 | 2591 | 464.2 | 795 | 441.8 | 421.1 | 249.1 | 2 | 11 | 5417 |
| 1993 | 65.5 | 65.7 | 166 | 178.7 | 589.5 | 602.7 | 475.3 | 450.2 | 296.1 | 164.2 | 56.2 | 11.8 | 3121.9 |
| 1994 | 41.8 | 81.8 | 1478 | 209.2 | 357 | 450.8 | 337.8 | 494.6 | 238 | 181.9 | 12.6 | 3.2 | 3886.8 |
| 1995 | 16.8 | 103.1 | 72.4 | 159.6 | 426.4 | 452.0 | 619.2 | 473.7 | 506.4 | 113.5 | 215.3 | 36.6 | 3195.0 |
| 1996 | 56 | 63.6 | 158.6 | 970.8 | 370.8 | 370.6 | 776 | 416.6 | 321.2 | 326.4 | 4.2 | 2 | 3836.8 |
| 1997 | 30.6 | 122.4 | 103.6 | 300.4 | 399.4 | 856.2 | 253.2 | 461.4 | 620.4 | 91.6 | 23.8 | 79 | 3342 |
| 1998 | 18.0 | 61.8 | 236.8 | 169.2 | 318.8 | 717.6 | 698 | 712.2 | 448.8 | 353.2 | 5.2 | 7.8 | 3747.4 |
| 1999 | 28 | 0.2 | 74.8 | 433.8 | 391 | 645.6 | 615.5 | 556.2 | 253 | 395.9 | 15.6 | 11.8 | 3421.4 |
| **Avr** | **34.3** | **71.6** | **193.4** | **252.0** | **549.3** | **626.3** | **567.8** | **495.7** | **415.1** | **218.3** | **43.7** | **16.9** | **3480.1** |

**Annex-3.4 ( b )**

**MONTHLY RAINFALL VALUES FOR SINGHIK STATION IN SIKKIM**

**( Unit : mm )**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 21.6 | 194.2 | 142.4 | 267.7 | 692.3 | 593.6 | 323.5 | 297.5 | 237.7 | 37.5 | 33.8 | 2841.8 |
| 1958 | 91.1 | 89.3 | 129.3 | 385.6 | 471.2 | 830.7 | 425.5 | 941.6 | 134.4 | 498.4 | 68.7 | 2.1 | 4067.9 |
| 1959 | 96.5 | 193.5 | 186.8 | 201 | 464.5 | 770.1 | 376.2 | 117.8 | 48.6 | 105.6 | 106.8 | 1.3 | 2668.7 |
| 1960 | 0 | 195.8 | 224.4 | 66 | 267.3 | 829.4 | 250.5 | 45.6 | 127.2 | 39.6 | 0.6 | 2.9 | 2049.3 |
| 1961 | 38.9 | 75.5 | 162.5 | 255.8 | 484.6 | 424.6 | 541.5 | 534.9 | 316 | 249.7 | 31.1 | 304 | 3419.1 |
| 1962 | 5.4 | 267.6 | 166 | 162 | 543.8 | 573.6 | 266.1 | 942 | 415 | 105.4 | 47.6 | 63.4 | 3557.9 |
| 1963 | 46.6 | 98.4 | 170.6 | 351.2 | 309.4 | 392.2 | 526 | 674.6 | 353.6 | 253.8 | 91.6 | 62 | 3330 |
| | | | | | | | | | | | | | |
| 1971 | 164.4 | 124 | 181.6 | 311.4 | 203.8 | 366.6 | 219.4 | 226.4 | 178 | 0 | 25.8 | 0 | 2001.4 |
| 1972 | 23 | 80.9 | 237.2 | 426.8 | 548.4 | 760.6 | 214.2 | 262.2 | 278.2 | 86.2 | 14.4 | 0 | 2932.1 |
| 1973 | 15.2 | 117.4 | 33.8 | 193.2 | 342.8 | 658.3 | 232.8 | 205.6 | 196.2 | 311.8 | 10.4 | 2.2 | 2319.7 |
| 1974 | 28.2 | 28 | 179.7 | 231.8 | 567.4 | 599.4 | 517 | 422.8 | 458.4 | 353.9 | 3.9 | 39.4 | 2830.5 |
| 1975 | 82 | 185.5 | 82.7 | 198 | 314.1 | 491 | 580.6 | 339.4 | 488 | 270 | 12 | 26 | 3069.3 |
| 1976 | 0 | 152.1 | 123.2 | 349.8 | 613.1 | 812.3 | 460.8 | 544.5 | 215.3 | 222.3 | 110.7 | 0 | 3604.1 |
| 1977 | 32.2 | 21.4 | 213 | 285.8 | 468.5 | 394.2 | 480.4 | 519.5 | 160 | 365 | 160.4 | 0 | 3100.4 |
| 1978 | 150.3 | 233.8 | 383.6 | 330 | 314.1 | 691.6 | 156.6 | 434.2 | 503.6 | 85 | 226.4 | 19.8 | 3529 |
| 1979 | 6.4 | 84.2 | 63.4 | 170.8 | 279.6 | 260.8 | 745.8 | 209.2 | 653 | 490 | 82.8 | 39.9 | 3085.9 |
| 1980 | 90.8 | 1340.2 | 0 | 209.4 | 266.6 | 405 | 668.2 | 1005.8 | 864.4 | 790.5 | 0 | 4.2 | 5645.1 |
| | | | | | | | | | | | | | |
| 1991 | 146 | 147 | 604.2 | 479 | 792.2 | 434.7 | 1600 | 1207 | 1042.6 | 171.2 | 195.8 | 185.8 | 7005.5 |
| 1992 | 54.8 | 277.8 | 171 | 271.4 | 542.2 | 325.2 | 1021.8 | 399 | 336.1 | 437.2 | 6 | 14.4 | 3842.5 |
| 1993 | 181.8 | 119.6 | 321.6 | 136.8 | 380.4 | 507.8 | 584.6 | 568 | 552.2 | 206.4 | 252.6 | 207.2 | 3811.8 |
| 1994 | 333.1 | 255.5 | 925.4 | 335.6 | 504.6 | 382.1 | 279 | 556.8 | 308.5 | 79.8 | 3.8 | 39.9 | 3964.2 |
| 1995 | 26.0 | 185.4 | 87.7 | 185.6 | 346.2 | 413.9 | 469.1 | 425.8 | 375.7 | 128.8 | 289.5 | 94.8 | 2933.6 |
| 1996 | 86.4 | 114.4 | 192.1 | 1129.1 | 301.1 | 339.3 | 588.0 | 374.5 | 238.3 | 370.2 | 5.6 | 5.2 | 3739.0 |
| 1997 | 47.2 | 220.1 | 125.5 | 349.4 | 512.8 | 913.8 | 319.2 | 423.4 | 697.6 | 28.8 | 76.2 | 54 | 3714.0 |
| 1998 | 9.6 | 93 | 360.4 | 439 | 443 | 639.6 | 769.4 | 759.6 | 447.2 | 350.6 | 29.2 | 0 | 4340.6 |
| 1999 | 36.6 | 19.2 | 90.6 | 497 | 331.5 | 489.4 | 466.4 | 468.4 | 187.7 | 449.1 | 24.8 | 6.2 | 3060.6 |
| **Avr** | **68.9** | **182.4** | **215.8** | **311.3** | **418.5** | **553.8** | **513.6** | **497.4** | **379.7** | **257.2** | **73.6** | **46.5** | **3479.4** |

**Annexure-3.4 (c)**

# MONTHLY RAINFALL VALUES FOR CHUNGTHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 57.1 | 11.6 | 235 | 162.8 | 233.7 | 519.1 | 387.6 | 0 | 345.6 | 183.8 | 107 | 3 | 2246.7 |
| 1952 | 84.2 | 98.2 | 225.2 | 117.1 | 289.7 | 433.3 | 482.3 | 580.5 | 374.0 | 70.9 | 18.1 | 25.6 | 2799.0 |
| 1953 | 26.9 | 0 | 155.8 | 180.1 | 242.1 | 186.8 | 462.4 | 220.9 | 127.8 | 240.7 | 33.7 | 0 | 1877.2 |
| 1954 | 24.3 | 39.9 | 25.9 | 125.5 | 241.9 | 478.5 | 911.2 | 399.2 | 304.8 | 53.3 | 0 | 21.9 | 2626.4 |
| 1955 | 20.5 | 17.5 | 303 | 217.9 | 260.9 | 560.7 | 725.2 | 345.7 | 319.5 | 260.2 | 0 | 2.5 | 3033.6 |
| 1956 | 36 | 76.2 | 339.3 | 25.3 | 274.6 | 394.2 | 428.7 | 312 | 156.2 | 323.3 | 6.4 | 43.2 | 2415.4 |
| 1957 | 98.5 | 137.8 | 0 | 750.2 | 924.4 | 1021 | 1491.5 | 1100.1 | 375.3 | 348.5 | 7.9 | 111 | 6366.2 |
| 1958 | 46.5 | 78.7 | 30 | 191.5 | 500.6 | 401.3 | 350.9 | 992.6 | 118.4 | 162.1 | 9.8 | 0 | 2882.4 |
| 1959 | 99.4 | 88.4 | 210.2 | 284 | 271.6 | 510.6 | 470.5 | 236.4 | 239.2 | 265.8 | 39 | 0 | 2715.1 |
| 1960 | 0 | 129.8 | 221.8 | 52.6 | 271.7 | 493.5 | 596.7 | 494 | 516.6 | 128.2 | 0 | 0 | 2904.9 |
| 1961 | 25.2 | 57.8 | 250.3 | 186.2 | 383.4 | 288 | 435.1 | 597.5 | 346.9 | 177.2 | 22 | 62.2 | 2831.8 |
| 1962 | 69 | 78.5 | 200.6 | 123.6 | 343.3 | 431.1 | 370.8 | 531.2 | 295.2 | 55.2 | 16.8 | 28.2 | 2543.5 |
| 1963 | 13.6 | 86.6 | 141.6 | 240.6 | 230 | 341.6 | 476.9 | 600.8 | 365.8 | 237 | 70.8 | 7 | 2812.3 |
| 1964 | 12 | 49.8 | 169.3 | 160.9 | 294.4 | 487 | 491.8 | 339.4 | 212.7 | 77 | 22.2 | 0 | 2316.5 |
| 1965 | 6.6 | 146.4 | 166.5 | 175.6 | 71.8 | 172.6 | 497.8 | 494.2 | 304.6 | 58.4 | 102 | 0.4 | 2197.1 |
| 1966 | 90.8 | 62.7 | 42.5 | 190 | 221.3 | 520.5 | 616.2 | 520.1 | 313.4 | 85.7 | 20.9 | 13.4 | 2697.5 |
| 1967 | 34 | 99.7 | 218.9 | 111.5 | 179.9 | 674.4 | 0 | 540.2 | 326.2 | 110.7 | 37.4 | 16 | 2348.9 |
| 1968 | 33.4 | 101.6 | 178.4 | 202.3 | 302.5 | 268.1 | 721.7 | 540.8 | 387.3 | 355.9 | 37.8 | 0.8 | 3130.8 |
| 1969 | 52.6 | 33.6 | 93 | 193 | 280.8 | 456.6 | 377.4 | 471.3 | 273.8 | 76.6 | 33 | 0 | 2341.7 |
| 1970 | 42.6 | 104.0 | 160.3 | 207.3 | 314.4 | 485.2 | 499.5 | 485.3 | 644.0 | 59.4 | 0.0 | 0.0 | 3002.0 |
| 1971 | 64.2 | 92.5 | 135.3 | 235.9 | 241.5 | 595.9 | 485.3 | 293.6 | 264.8 | 298.4 | 22.3 | 2.0 | 2731.7 |
| 1972 | 11 | 98.4 | 197.5 | 0 | 512.8 | 522.2 | 195.5 | 320.6 | 208.5 | 123.9 | 18.8 | 0.0 | 2209.1 |
| 1973 | 20.8 | 122.4 | 51.5 | 42.6 | 429.4 | 705.0 | 404.9 | 351.3 | 141.8 | 211.3 | 7.9 | 4.2 | 2493.1 |
| 1974 | 16.9 | 3 | 50 | 270.5 | 220.2 | 498.6 | 557.4 | 754.9 | 443.5 | 256.7 | 6.6 | 22.3 | 3100.5 |
| 1975 | 54 | 90 | 0 | 128.8 | 152.6 | 560.2 | 610.5 | 291.5 | 281.2 | 257.1 | 3.9 | 18.7 | 2448.5 |
| 1976 | 5.4 | 24.4 | 44.5 | 60.0 | 96.0 | 464.7 | 320.3 | 492 | 286.2 | 96.4 | 20 | 0 | 1909.8 |
| 1977 | 21.7 | 19.6 | 280.6 | 487.3 | 328.9 | 311.1 | 577.2 | 452.9 | 149.2 | 453.6 | 109 | 108 | 3299.5 |
| 1978 | 8 | 25.4 | 85.5 | 147.3 | 137.6 | 93.5 | 94.2 | 103.7 | 70.5 | 22.3 | 0.0 | 17.9 | 805.9 |
| 1979 | 9.0 | 7.9 | 104.8 | 165.7 | 123.4 | 256.5 | 639 | 267.7 | 382.4 | 451.5 | 23.1 | 22.6 | 2453.6 |
| 1980 | 9.6 | 140.5 | 180.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | | | | | | | | | | | | | |
| 1983 | 22.7 | 155.4 | NA | 263.1 | 309.6 | 592 | 349.1 | 333.8 | 569 | 80.6 | 17.4 | 14.4 | NA |
| 1984 | 26.8 | 23.6 | 170.6 | 175.3 | 215 | 391.4 | 540.7 | 238.3 | 245 | 234.8 | 0 | 16.2 | 2277.7 |
| **Avr** | **35.7** | **71.9** | **150.6** | **189.5** | **287.1** | **455.3** | **502.2** | **442.0** | **302.9** | **187.6** | **26.3** | **18.1** | **2660.6** |

## MONTHLY RAINFALL VALUES FOR LACHUNG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 0 | 0 | 0 | 116.6 | 366.7 | 279.8 | 103.4 | 73.3 | 73.9 | 42.5 | 1056 |
| 1958 | 43.3 | 60 | 171.3 | 263.9 | 312.6 | 266.3 | 281 | 437.7 | 103.2 | 129.1 | 13 | 1.3 | 2083 |
| 1959 | 37.8 | 66.3 | 235.2 | 207.8 | 187.2 | 209.4 | 306.2 | 220.9 | 150.5 | 166.8 | 8.1 | 0 | 1796 |
| 1960 | 1.8 | 148.7 | 165.9 | 59.9 | 122.6 | 327.4 | 315.7 | 224 | 231.9 | 57.3 | 2 | 0 | 1657 |
| 1961 | 17.8 | 34.1 | 118.3 | 77.6 | 127.6 | 194.7 | 270.7 | 368.8 | 196.7 | 167.5 | 8.1 | 13.8 | 1596 |
| 1962 | 0 | 53.8 | 122.7 | 15.6 | 99 | 172.2 | 173.3 | 453 | 200.8 | 46.6 | 0 | 15.8 | 1353 |
| 1963 | 14.8 | 21 | 66.2 | 118.7 | 144.8 | 230.4 | 254 | 350.2 | 234.6 | 116.6 | 54 | 4.2 | 1610 |
| | | | | | | | | | | | | | |
| 1971 | 43.8 | 43.9 | 126 | 107.2 | 164.9 | 364.2 | 226.4 | 178.3 | 140.8 | 105.2 | 24.6 | 0.4 | 1526 |
| 1972 | 3.4 | 36.4 | 110 | 205.6 | 151.4 | 165.2 | 252.8 | 181.8 | 237.1 | 117 | 20 | 0 | 1481 |
| 1973 | 29.2 | 108 | 90.6 | 127.2 | 197.3 | 285.8 | 167 | 235 | 263.4 | 396.4 | 0 | 28.6 | 1929 |
| 1974 | 16.5 | 3.6 | 125.5 | 111.6 | 481 | 442.1 | 432.6 | 210.6 | 232.4 | 137.6 | 11 | 20.6 | 2225 |
| 1975 | 38.6 | 71 | 124.8 | 70.6 | 161.4 | 268 | 291 | 170.2 | 287.2 | 125.5 | 2 | 9.4 | 1620 |
| 1976 | 19.4 | 94.3 | 162.6 | 224.2 | 212.9 | 282.7 | 241 | 249 | 191 | 89.2 | 21 | 0 | 1787 |
| 1977 | 5 | 27.6 | 157 | 271.4 | 211.4 | 313.6 | 317.4 | 295.2 | 116.5 | 261.4 | 106 | 84.4 | 2167 |
| 1978 | 0 | 13.3 | 45 | 111.7 | 316 | 358 | 431 | 310 | 248 | 8.2 | 122 | 89.4 | 2053 |
| 1979 | 10.4 | 88.8 | 130.2 | 124.8 | 86.8 | 285.7 | 442.3 | 332 | 232 | 60.6 | 111 | 24.2 | 1929 |
| | | | | | | | | | | | | | |
| 1990 | NA | NA | NA | NA | NA | NA | 765.5 | 511.4 | NA | 119.4 | 0 | 53.6 | NA |
| 1992 | 7.1 | 71.2 | 109.4 | 109.4 | 170.8 | 166.2 | 235.9 | 273.2 | 150.1 | 128 | 4.7 | 28.6 | 1455 |
| 1993 | 19.3 | 51.2 | 132.2 | 122.3 | 105.2 | 242.6 | 292.3 | 308 | 176.3 | 92.5 | 21.4 | 5.2 | 1569 |
| 1994 | 22.7 | 76.6 | 214.1 | 159 | 171.1 | 289.6 | 204.1 | 199.1 | 220.7 | 76.6 | 9 | 1.5 | 1644 |
| 1995 | 29 | 36 | 61.2 | 125 | 143.9 | 631.3 | 303.5 | 284 | 219.6 | 97.6 | 15 | 19 | 1965 |
| 1996 | 21.4 | 144.3 | 207.2 | 198.6 | 287.6 | 308 | 311 | 177.8 | 216.9 | 128 | 2 | 2 | 2005 |
| 1997 | 23 | 62 | 403 | 123 | 186 | 379 | 300 | 217 | 449 | 94 | 24 | 39 | 2299 |
| 1998 | 11 | 90 | 227 | 97 | 225 | 230.3 | 415.9 | 468 | 105.5 | 174.8 | 6.6 | 21.7 | 2072.7 |
| 1999 | 0 | 87 | 98 | 78.0 | 280.1 | 335.2 | 307.6 | 332.3 | 153.7 | 318.9 | 5.5 | 12.0 | 2008.2 |
| **Avr** | **17.3** | **62.0** | **141.8** | **129.6** | **189.4** | **286.0** | **316.2** | **290.7** | **202.6** | **131.5** | **26.6** | **20.7** | **1786.8** |

**Annex-3.4 ( e )**

## MONTHLY RAINFALL VALUES FOR YUMTHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 0 | 0 | 0 | 41.4 | 292.7 | 233.9 | 165.6 | 112.7 | 0 | 0 | 846.3 |
| 1958 | 0 | 0 | 0 | 0 | 212.6 | 203.3 | 323.2 | 432.8 | 141.3 | 139.2 | 7.4 | 0 | 1459.8 |
| 1959 | 0 | 0 | 0 | 0 | 170.6 | 227.8 | 391.7 | 290.6 | 115.7 | 166.5 | 2.2 | 1.5 | 1366.6 |
| 1960 | 14.8 | 92.5 | 105.6 | 62.8 | 143.5 | 261.9 | 301.5 | 292.2 | 263.6 | 53.2 | 3.1 | 0 | 1594.7 |
| 1961 | 26.9 | 29.4 | 44.3 | 57.7 | 95.6 | 177.8 | 295.1 | 334.3 | 241.6 | 158.5 | 26.5 | 36.2 | 1523.9 |
| 1962 | 21 | 55.2 | 89 | 83.8 | 135 | 276.4 | 202.4 | 274.8 | 216.8 | 37.4 | 6.2 | 16.6 | 1414.6 |
| 1963 | 9 | 16.2 | 75.2 | 159.2 | 165.4 | 168.4 | 323.4 | 331.3 | 180.8 | 97.4 | 23.6 | 5 | 1554.9 |
| 1971 | 36.2 | 54.4 | 59.6 | 89.8 | 173.5 | 337.6 | 279 | 223.4 | 181.6 | 113 | 14.6 | 0 | 1562.7 |
| 1972 | 7.2 | 16.8 | 28.6 | 105.1 | 192.2 | 172.5 | 283.4 | 220 | 226.2 | 106.4 | 7.8 | 0 | 1366.2 |
| 1973 | 18.3 | 21.8 | 15.6 | 18.2 | 130.6 | 336.2 | 283.4 | 232 | 188.6 | 100.6 | 0 | 0 | 1345.3 |
| 1974 | 8.6 | 15 | 54.8 | 60.8 | 204.4 | 318.6 | 370.8 | 278.5 | 190.4 | 113.6 | 8.6 | 16.8 | 1640.9 |
| 1975 | 27 | 67.8 | 115.2 | 50.2 | 97 | 215.6 | 268.4 | 169.8 | 286.1 | 84.6 | 1.4 | 4.2 | 1387.3 |
| 1976 | 12.3 | 37.4 | 61.4 | 53.2 | 181.8 | 109.6 | 222.6 | 332 | 171.8 | 66.7 | 14 | 1 | 1263.8 |
| 1977 | 14 | 15 | 55.4 | 139.8 | 180 | 268.7 | 259.4 | 379.2 | 73.6 | 45.6 | 34.6 | 36 | 1501.3 |
| 1978 | 45.4 | 23.7 | 82.4 | 58 | 93.4 | 192.4 | 233.2 | 180.6 | 165.8 | 87.6 | 36.6 | 7.6 | 1206.7 |
| 1979 | 3 | 36 | 64.4 | 16.4 | 60.2 | 193.4 | 222.6 | 187.6 | 173.6 | 45.8 | 10.2 | 10.8 | 1024 |
| 1980 | 4.2 | 24.6 | 23.3 | 17.2 | 89 | NA | NA | NA | NA | NA | NA | NA | NA |
| 1985 | 614.8 | 27 | 60.2 | 53.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1987 | 32.5 | 11 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Avr** | **47.1** | **28.6** | **51.9** | **57.0** | **136.8** | **218.9** | **284.6** | **274.6** | **186.4** | **95.6** | **12.3** | **8.5** | **1378.7** |

**Annexure-3.4 ( f )**

## MONTHLY RAINFALL VALUES FOR LACHEN STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 16.5 | 28.2 | 194.2 | 171.6 | 125.4 | 258.2 | 203.8 | 0 | 293.4 | 66 | 49 | 0 | 1406.3 |
| 1952 | 42.2 | 76 | 177.8 | 85.8 | 197.5 | 255.1 | 267.4 | 339.8 | 243.4 | 48.5 | 20.4 | 24.4 | 1778.3 |
| 1953 | 6.3 | 0 | 114.7 | 125.7 | 119.2 | 316.2 | 272.8 | 266 | 372 | 137.4 | 40.6 | 5.8 | 1776.7 |
| 1954 | 230.9 | 35.4 | 152.5 | 95.4 | 154.5 | 285 | 250.9 | 272.4 | 206.2 | 105.8 | 0 | 70.2 | 1859.2 |
| 1955 | 49.4 | 40 | 112.8 | 149.1 | 191.1 | 227.5 | 295.5 | 327.5 | 292.2 | 140.5 | 3.8 | 5.3 | 1834.7 |
| 1956 | 76 | 51.6 | 227 | 91.4 | 234.8 | 212.2 | 270.7 | 217.7 | 148.3 | 177 | 5.8 | 52.5 | 1765 |
| 1957 | 407.7 | 118.9 | 260.2 | 191.8 | 272 | 517.3 | 528.3 | 611.9 | 366.9 | 131.9 | 21.4 | 97.4 | 3525.7 |
| 1958 | 145.8 | 112.8 | 122.6 | 147.3 | 153.9 | 190.5 | 320.6 | 324 | 97.8 | 209.4 | 0 | 9 | 1833.7 |
| 1959 | 13.9 | 40.1 | 0 | 0 | 0 | 266.2 | 213.2 | 119.6 | 134 | 159.4 | 12.4 | 0 | 958.8 |
| 1960 | 21.8 | 68.2 | 184.5 | 46.4 | 147.1 | 340.4 | 285.6 | 213.2 | 340.4 | 118.5 | 12 | 1 | 1779.1 |
| 1961 | 28.2 | 5.2 | 132.4 | 104.4 | 123.2 | 187.8 | 213.7 | 287.4 | 257.4 | 195.6 | 22.4 | 18 | 1575.7 |
| 1962 | 0 | 4.5 | 30 | 56.2 | 120.1 | 207.4 | 209 | 329.5 | 216.9 | 52 | 45.8 | 16.2 | 1287.6 |
| 1963 | 2.1 | 45.4 | 208 | 60.4 | 228.2 | 237.2 | 252 | 296.4 | 345.1 | 149.6 | 52 | 23.2 | 1899.6 |
| 1964 | 17.9 | 128 | 128.2 | 114.2 | 229.4 | 229.4 | 276 | 259.2 | 171 | 62.8 | 4 | 7.2 | 1627.3 |
| 1965 | 23 | 0 | 146.1 | 111.1 | 169.1 | 243 | 125.6 | 0 | 189.9 | 71.7 | 89.2 | 5 | 1173.7 |
| 1966 | 36.6 | 46.9 | 128 | 38.5 | 267.8 | 179.7 | 283.8 | 289.6 | 215 | 48.1 | 26.6 | 31.4 | 1592 |
| 1967 | 26.1 | 85.9 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| | | | | | | | | | | | | | |
| 1971 | NA | NA | NA | NA | 87.4 | NA | 106 | NA | NA | NA | NA | NA | NA |
| 1972 | NA | NA | 130.4 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 1992 | 23.9 | 75.4 | 130.4 | 81.8 | 143.6 | 200.2 | 318 | 856.2 | 168.3 | 93.1 | 24.2 | 30.5 | 2145.6 |
| 1993 | 72.5 | 116.8 | 235.7 | 106.1 | 116 | 227.3 | 329.5 | 292.5 | 199.4 | 105.6 | 6.6 | 3.1 | NA |
| 1994 | 53 | 28 | 124.7 | 172.4 | 131.3 | 223.3 | 582.6 | 199.8 | 142 | 102.7 | 54.9 | 0 | 1083.8 |
| 1995 | 97.5 | 38.1 | 73.0 | 93.5 | 121.0 | 585.4 | 270.0 | 299.8 | 268.4 | 85.9 | 10.9 | 20.2 | |
| 1996 | 71.9 | 152.8 | 247.0 | 148.5 | 241.8 | 285.6 | 276.7 | 187.7 | 265.1 | 112.6 | 1.5 | 2.1 | |
| 1997 | 129 | 116.8 | 224.8 | 110.5 | 153.5 | 334.1 | 178.9 | 252.8 | 300.4 | 68.6 | 153 | 124 | 974.4 |
| 1998 | 7.4 | 151.6 | 320.7 | 69.6 | 109.7 | 444 | 370 | 384 | 128.9 | 240.7 | 26.3 | 23.1 | NA |
| 1999 | 27.3 | 85 | 155.2 | 58.3 | 235.5 | 335.2 | 273.7 | 350.7 | 187.8 | 280.6 | 4 | 12.8 | NA |
| **Avr** | **65.1** | **66.1** | **158.4** | **101.2** | **162.9** | **282.8** | **279.0** | **290.7** | **231.3** | **123.5** | **28.6** | **24.2** | **1677.7** |

**Annex-3.4 (g)**

## MONTHLY RAINFALL VALUES FOR THANGU STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 50.2 | 22.7 | 134.2 | 37.6 | 74.3 | 106.2 | 104.7 | 0 | 109.6 | 79.5 | 54.4 | 0 | 773.4 |
| 1952 | 80.3 | 81.0 | 103.7 | 34.9 | 68.0 | 86.2 | 109.5 | 146.0 | 133.3 | 30.3 | 15.1 | 39.6 | 927.9 |
| 1953 | 25.4 | 0 | 37.6 | 72.4 | 39.1 | 89.4 | 109.6 | 110.8 | 159.2 | 104.7 | 13.6 | 18.2 | 780 |
| 1954 | 0 | 50.8 | 86.4 | 37.7 | 148.4 | 111.8 | 141.4 | 147.3 | 77.5 | 26 | 0 | 30.4 | 857.7 |
| 1955 | 8.1 | 25.1 | 33.2 | 44.9 | 54.6 | 80.3 | 167.8 | 168.9 | 150 | 84 | 0 | 2.3 | 819.2 |
| 1956 | 10.4 | 68.6 | 36.7 | 35.4 | 45.1 | 83.4 | 130.5 | 73.1 | 93.9 | 74.8 | 1.3 | 13.1 | 666.3 |
| 1957 | 450.9 | 40.7 | 170.9 | 5.9 | 88.6 | 184.2 | 124.5 | 0 | 135.3 | 57.6 | 97.5 | 193.7 | 1549.8 |
| 1958 | 68.5 | 64.2 | 94.5 | 0 | 0 | 23.7 | 93.3 | 147.5 | 0 | 0 | 0 | 0 | 491.7 |
| 1959 | 0 | 40.4 | 40.8 | 72.2 | 73.4 | 35 | 50.4 | 75 | 42.6 | 36.6 | 1.2 | 0 | 467.6 |
| 1960 | 10.2 | 34.6 | 144.2 | 60 | 54 | 59 | 137.4 | 124.2 | 150.4 | 85.2 | 0 | 0 | 859.2 |
| 1961 | 72.8 | 280.5 | 137 | 76.4 | 68 | 142.5 | 133 | 109.3 | 166.2 | 200.3 | 42.2 | 92.9 | 1521.1 |
| 1962 | 60.6 | 87.1 | 47.3 | 32.6 | 50 | 72.2 | 60.8 | 171.1 | 134.4 | 45.8 | 6.2 | 27 | 795.1 |
| 1963 | 27.2 | 61.4 | 87.6 | 87.8 | 108.2 | 127.7 | 144.2 | 124.2 | 175.9 | 88.3 | 44 | 19 | 1095.5 |
| 1964 | 16.6 | 87.4 | 76.5 | 47.1 | 74.4 | 86.8 | 112.4 | 98.0 | 83.8 | 36.2 | 9.5 | 5.7 | 734.6 |
| 1965 | 14.9 | 62.1 | 80.6 | 48.3 | 39.3 | 59.1 | 80.4 | 63.8 | 106.5 | 35.5 | 74.3 | 4.2 | 669.1 |
| 1966 | 30.4 | 4.3 | 59.1 | 8 | 38.1 | 81.7 | 131.3 | 131.5 | 91.9 | 0 | 0 | 0 | 576.3 |
| 1967 | 0 | 14 | 99 | 47 | 18.9 | 92.4 | 61.8 | 106.7 | 70.1 | 49.1 | 30.5 | 13.7 | 603.2 |
| 1968 | 24.6 | 43.1 | 44.7 | 25.8 | 32.4 | 25.6 | 77.2 | 69.9 | 75.9 | 71.1 | 13.3 | 0.6 | 504.3 |
| 1969 | 9.4 | 11.1 | 31.5 | 63.7 | 60.8 | 79.6 | 0 | 0 | 0 | 0 | 0 | 0 | 256.1 |
| 1970 | 77.4 | 28.5 | 46.6 | 49.2 | 60.2 | 87.4 | 80.7 | 121.7 | 107.3 | 30.6 | 23.2 | 0.0 | 712.9 |
| 1980 | 54.4 | 110.2 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Avr | **52.0** | **58.0** | **79.6** | **44.3** | **59.8** | **85.7** | **102.5** | **99.5** | **103.2** | **56.8** | **21.3** | **23.0** | **783.1** |

Annex-3.4 (h)

## MONTHLY RAINFALL VALUES FOR DAMTHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 69.6 | 54 | 179.9 | 450.6 | 731.5 | 465.6 | 192.8 | 84.5 | 22.9 | 12.4 | 2263.8 |
| 1958 | 0 | 64.2 | 2.5 | 81.8 | 68.8 | 427.4 | 325.2 | 606.8 | 472.8 | 78.2 | 56.1 | 17.8 | 2201.6 |
| 1959 | 17.9 | 102.5 | 54.5 | 31.5 | 14.7 | 665.7 | 1589.9 | 682.2 | 771.7 | 178 | 0.3 | 0.3 | 4109.2 |
| 1960 | 0 | 2.6 | 26.2 | 23.2 | 108 | 281.4 | 457 | 520.6 | 64.3 | 31.5 | 0 | 10.6 | 1525.4 |
| 1961 | 7.1 | 120.8 | 3.1 | 123 | 409.3 | 152.6 | 109.8 | 142 | 122.6 | 35.8 | 0.2 | 0 | 1226.3 |
| 1962 | 12 | 1.5 | 6 | 21.5 | 161.8 | 172.6 | 151.6 | 159.6 | 89.8 | 0 | 0 | 0 | 776.4 |
| 1963 | 0.2 | 0.4 | 13.4 | 69 | 150 | 105.9 | 246.2 | 332 | 228.2 | 75.4 | 30.8 | 27.5 | 1279 |
| Avr | **5.3** | **41.7** | **25.0** | **57.7** | **156.1** | **322.3** | **515.9** | **415.5** | **277.5** | **69.1** | **15.8** | **9.8** | **1911.7** |

**Annex-3.4 ( i )**

**MONTHLY RAINFALL VALUES FOR YOKSUM STATION IN SIKKIM**

**( Unit : mm )**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 260.8 | 46.6 | 139.3 | 133.7 | 485.9 | 948.0 | 1377.7 | 1414.9 | 1886.0 | 443.8 | 144.6 | 47.9 | 7329.1 |
| 1958 | 58.4 | 24.4 | 43.8 | 221.4 | 160.2 | 474.6 | 641 | 879.1 | 274 | 212.1 | 116 | 0 | 3105 |
| 1959 | 82.6 | 126.2 | 94.1 | 127.1 | 264.8 | 634.9 | 783.4 | 487.1 | 446.7 | 344.8 | 47.5 | 0 | 3439.2 |
| 1960 | 0 | 86.1 | 100.3 | 42.4 | 224.2 | 682.1 | 581.3 | 714.4 | 544.7 | 96.4 | 0 | 0 | 3071.9 |
| 1961 | 19 | 46 | 16.3 | 18.2 | 310.7 | 554.4 | 483.9 | 754.3 | 669.7 | 196.3 | 0 | 18.7 | 3087.5 |
| 1962 | 38 | 32.6 | 89.6 | 83.2 | 234.5 | 650.4 | 357 | 883.1 | 357.5 | 65.9 | 0 | 29.5 | 2821.3 |
| 1963 | 41.5 | 33.8 | 49.1 | 156.1 | 213.5 | 555.9 | 505.5 | 708.1 | 469.1 | 224.6 | 124.3 | 22 | 3103.5 |
| | | | | | | | | | | | | | |
| 1971 | 16 | 3.3 | 41.6 | 151 | 367.7 | 536.7 | 584.2 | 663.0 | 313.1 | 444.4 | 37.6 | 0.0 | NA |
| 1972 | 0.4 | 0.8 | 13 | 115.3 | 124.2 | 272.1 | 507.6 | 358.0 | 569.0 | 65.5 | 12 | 37.2 | NA |
| 1973 | 36.8 | 22.9 | 53.8 | 16.8 | 349.5 | 271.2 | 215.8 | 231.3 | 155.6 | 176.8 | 16.8 | 4.2 | NA |
| 1974 | 20.4 | 4.2 | 89.4 | 204.1 | 253.8 | 274.2 | 192 | 138.6 | 245 | 22.2 | 16.4 | 33.2 | 1493.5 |
| 1975 | 55.4 | 34.4 | 0 | 35.2 | 167.3 | 267.4 | 261.7 | 109.7 | 757.6 | 431.4 | 0.4 | 0 | 2120.5 |
| 1976 | 35.8 | 50.6 | 79.6 | 157.2 | 294.4 | 488.2 | 772.5 | 428.9 | 337.3 | 177 | 211.4 | 12 | 3044.9 |
| 1977 | 74.8 | 33.2 | 35.8 | 171.8 | 84.8 | 160.8 | 438.1 | 1082.8 | 499 | 286.6 | 85.6 | 39 | 2992.3 |
| 1978 | 0 | 0 | 99 | 75.8 | 349.5 | 708.6 | 841.6 | 376.6 | 793 | 65.6 | 66.8 | 0 | 3376.5 |
| 1979 | 16.9 | 9.2 | 16.2 | 13.4 | 35.7 | 201.1 | 799 | 799.6 | 772.5 | 153 | 10.2 | 15.1 | 2841.9 |
| 1980 | 0 | 28.7 | 65.1 | 67.6 | 270.9 | 461.7 | 532.8 | 584.2 | 486.3 | 193.0 | 51.9 | 15.1 | 2757.326 |
| 1991 | 7.6 | 22.5 | 39.8 | 137.7 | 382.8 | 739 | 481.8 | 354.3 | 393.6 | 49.2 | 1.5 | 10.9 | 2620.7 |
| 1992 | 10.9 | 27.8 | 33.5 | 163 | NA | 674.3 | 701.6 | 342.8 | 278.8 | 59 | 10.2 | 15.5 | NA |
| 1993 | 17.6 | 57 | 77 | 169.8 | 498.8 | 739.9 | 599.8 | 307.1 | 248.8 | 50.2 | 53.1 | 16.2 | 2835.3 |
| 1994 | 8.4 | 25.9 | 115.3 | 165.4 | 178.9 | 469.9 | 520.9 | 325 | 156 | 84.8 | 37 | 2.1 | 2089.6 |
| 1995 | 2.2 | 15.6 | 30.7 | 108 | 290.3 | 367.9 | 478.7 | 324.3 | 228.6 | 90.2 | 30.7 | 20.1 | 1987.3 |
| 1996 | 15.6 | 43.6 | 95.4 | 214 | 359 | 436.7 | 561.3 | 266 | 180.2 | 85.6 | nil | 3 | 2260.4 |
| **Avr** | **25.4** | **33.1** | **58.1** | **118.8** | **257.9** | **482.8** | **538.2** | **505.4** | **417.1** | **162.5** | **44.3** | **13.4** | **2724.9** |

**Annex-3.4 ( j )**

## MONTHLY RAINFALL VALUES FOR DENTAM STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 129.3 | 28.1 | 108.4 | 159.6 | 446.2 | 787.4 | 1371.3 | 1185.8 | 1313.2 | 297.8 | 51.5 | 25.4 | 5903.9 |
| 1958 | 30.9 | 13.5 | 30.2 | 151.4 | 114.8 | 409.5 | 548.3 | 317.1 | 289.7 | 32.6 | 7.6 | 0 | 1945.6 |
| 1959 | 67.2 | 37 | 123.6 | 76.9 | 269.4 | 272.1 | 677.3 | 447.6 | 292.4 | 325.4 | 16.8 | 0 | 2605.7 |
| 1960 | 2.5 | 36.2 | 93 | 40.4 | 235.3 | 345.5 | 581.1 | 402.5 | 494.1 | 81.8 | 0 | 6.1 | 2318.5 |
| 1961 | 6.2 | 42.2 | 27.4 | 56 | 164.9 | 347.8 | 484.4 | 719.3 | 277.8 | 96.1 | 14.2 | 15 | 2251.3 |
| 1962 | 49.2 | 30.4 | 53.6 | 97.6 | 222.6 | 521.8 | 373.3 | 582.9 | 222.6 | 65.7 | 0 | 0 | 2219.7 |
| 1963 | 19.6 | 3.9 | 69.2 | 120.9 | 144.5 | 330 | 471 | 573.2 | 353 | 100.7 | 30 | 0 | 2216 |
| | | | | | | | | | | | | | |
| 1971 | 1 | 2 | 32.4 | 168.7 | 164 | 557.2 | 527 | 555.6 | 218 | 298.2 | 13.4 | 0 | 2537.5 |
| 1972 | 0.2 | 30.2 | 17.6 | 137.6 | 177 | 226 | 505.2 | 300.0 | 396.2 | 43.9 | 4 | 0 | 1837.945 |
| 1973 | 6.4 | 29.4 | 43.6 | 163.1 | 320.9 | 947.0 | 315 | 450.5 | 288.6 | 285.9 | 8 | 0 | 2858.357 |
| 1974 | 15 | 2.4 | 29 | 172.8 | 215.6 | 358.9 | 594 | 459.3 | 290 | 97 | 0 | 6.6 | 2240.6 |
| 1975 | 20.8 | 6.4 | 2.2 | 51.2 | 267.2 | 490 | 648.5 | 235.2 | 608 | 140.3 | 0 | 6.6 | 2240.6 |
| 1976 | 18.6 | 40.6 | 4.6 | 68.8 | 243.9 | 359.8 | 526.4 | 631.6 | 214 | 57.2 | 3.6 | 0 | 2169.1 |
| 1977 | 14.2 | 8.2 | 41 | 276.1 | 244.4 | 244.9 | 469 | 732.9 | 367.7 | 175 | 57.8 | 67.2 | 2698.4 |
| 1978 | 7 | 20.4 | 44 | 98.8 | 244.6 | 457.4 | 480.4 | 357.3 | 380.1 | 100.8 | 43 | 11.4 | 2245.2 |
| 1979 | 0 | 26.9 | 0 | 81.7 | 77.2 | 448.7 | 727.2 | 389.2 | 385.9 | 122.6 | 77.6 | 7.5 | 2344.488 |
| 1980 | 0 | 0 | 90.4 | 289.8 | 248.8 | 383.5 | 530.3 | 489.6 | 338.6 | 129.5 | 18.5 | 8 | 2527 |
| | | | | | | | | | | | | | |
| 1992 | 5 | 21.5 | 6 | 24 | 34.3 | 41.1 | 530.3 | 433.3 | 338.6 | 0 | 0 | 2 | 1436.1 |
| 1993 | 18 | 0 | 23 | 43 | 137 | 457.4 | 530.3 | 195 | 338.6 | 129.5 | 18.5 | 8 | 1898.3 |
| 1994 | 18 | 82.3 | 60.1 | 123.8 | 115.5 | 195 | 233.4 | 588 | 420.4 | 0 | 13 | 5 | 1854.5 |
| 1995 | 18 | 21.5 | 43.9 | 128.1 | 202.4 | 383.5 | 530.3 | 489.6 | 338.6 | 129.5 | 18.5 | 8 | 2311.9 |
| 1996 | 18 | 21.5 | 43.9 | 128.1 | 202.4 | 383.5 | 530.3 | 489.6 | 338.6 | 129.5 | 18.5 | 8 | 2311.9 |
| 1997 | 18 | 29.4 | 54.8 | 99 | 114.2 | 707.2 | 480.4 | 422 | 456 | 25.8 | 0 | 81.6 | 2488.4 |
| 1998 | 4.6 | 13 | 49.2 | 57.2 | 235.6 | 383.5 | 766.2 | 489.6 | 338.6 | 61.6 | 8.2 | 1.6 | 2408.9 |
| 1999 | 7.6 | 0 | 14.2 | 128.1 | 336.2 | 591 | 744.6 | 596.8 | 291.2 | 359.6 | 0 | 29.2 | 3098.5 |
| **Avr** | **15.3** | **21.6** | **41.5** | **116.0** | **197.2** | **410.1** | **533.5** | **472.8** | **344.9** | **124.5** | **15.5** | **11.3** | **2294.4** |

**Annex-3.4( k )**

## MONTHLY RAINFALL VALUES FOR CHHANGU STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 55.0 | 59.6 | 249.8 | 166.2 | 433.1 | 575.1 | 803.8 | 766.5 | 611.2 | 189.8 | 16.7 | 12.0 | 3938.8 |
| 1958 | 69.8 | 73.4 | 251.1 | 317.5 | 515.3 | 519.1 | 486.8 | 806.5 | 220.4 | 81.6 | 43.6 | 0.3 | 3385.4 |
| 1959 | 67.8 | 48.9 | 125.9 | 262.2 | 461.7 | 658.7 | 531.9 | 412.5 | 307.7 | 262.9 | 13 | 0.5 | 3153.7 |
| 1960 | 0 | 77.4 | 172 | 27.4 | 322.7 | 565.1 | 490.7 | 196.1 | 574.9 | 47 | 0 | 0.5 | 2473.8 |
| 1961 | 10.2 | 35.4 | 144.4 | 160.3 | 823.6 | 361.1 | 482.7 | 587.4 | 450.4 | 79.3 | 30.1 | 10 | 3174.9 |
| 1962 | 38 | 53.1 | 149.1 | 227.4 | 543.4 | 533.6 | 454.2 | 739.4 | 283.4 | 100 | 0 | 12.6 | 3134.2 |
| 1963 | 2.1 | 1.6 | 0 | 0 | 0 | 129.2 | 0 | 0 | 141.9 | 99.6 | 0 | 0 | 374.4 |
| 1969 | 0 | 0 | 1 | 20 | 287.6 | 548.4 | 532.6 | 566.4 | 310.3 | 0 | 0 | 0 | 2266.3 |
| 1971 | NA | 27 | 115.9 | 187.1 | 296.7 | 724.8 | 473.1 | 581.2 | 181.8 | 387.4 | 0 | 0 | NA |
| 1972 | 0 | NA | NA | NA | NA | 491.9 | NA | 418.1 | 351.9 | NA | NA | NA | NA |
| 1978 | NA | 2.4 | 9 | 0.1 | 171.3 | NA | 461.1 | 348 | 268 | NA | NA | NA | NA |
| 1992 | NA | NA | 0 | NA | 2591 | NA | 1199.7 | NA | NA | NA | NA | NA | NA |
| **Avr** | **23.5** | **35.5** | **96.8** | **133.6** | **601.3** | **503.5** | **511.3** | **465.6** | **309.1** | **132.2** | **10.8** | **3.0** | **2566.1** |

**Annex-3.4 ( I )**

## MONTHLY RAINFALL VALUES FOR RONGLI STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 0 | 0 | 56.1 | 73.6 | 122.5 | 461 | 802.7 | 616.3 | 307.2 | 62.3 | 5.1 | 14.5 | 2521.3 |
| 1958 | 20.3 | 48.5 | 5.1 | 177.8 | 250.4 | 327 | 736.7 | 374.4 | 272.9 | 25.4 | 27.4 | 18.5 | 2284.4 |
| 1959 | 35.3 | 24.5 | 64.3 | 231.9 | 332.7 | 315.5 | 618.2 | 620.6 | 528.9 | 253.8 | 18.2 | 0 | 3043.9 |
| 1960 | 0 | 97.1 | 144.2 | 57.9 | 424.3 | 418.3 | 897.6 | 918.6 | 606.2 | 151.8 | 0 | 2.1 | 3718.1 |
| 1961 | 9.3 | 50.1 | 53.3 | 75.3 | 184.4 | 465.4 | 936.2 | 857.9 | 572.1 | 75.4 | 10.9 | 7 | 3297.3 |
| 1962 | 50.5 | 17.7 | 67 | 129.5 | 261.4 | 734.2 | 862.8 | 686 | 404.8 | 63 | 0 | 0 | 3276.9 |
| 1963 | 12 | 0.2 | 55 | 332.6 | 230.8 | 402.8 | 722.8 | 674.2 | 259 | 71.8 | 40.4 | 15.2 | 2816.8 |
| 1971 | 3 | 11.6 | 43.6 | 211.4 | 306.1 | 1213 | 1012.5 | 998.4 | 392.2 | 381.2 | 3.6 | 5.2 | 4581.8 |
| 1972 | 33.4 | 29.2 | 20 | 361.8 | 483.2 | 423.2 | 914.6 | 1087.6 | 591.8 | 60.8 | 50.4 | 0 | 4056 |
| 1973 | 9 | 41.6 | 21.2 | 163 | 303.6 | 536.8 | 634.8 | 570.2 | 593.4 | 395.8 | 5.4 | 0 | 3274.8 |
| 1974 | 36.2 | 6.2 | 50.9 | 191.2 | 300.2 | 279.2 | 1012.2 | 432 | 381 | 109.6 | 0 | 5.2 | 2803.9 |
| 1975 | 14.8 | 0.8 | 19.2 | 126.4 | 361.8 | 641.8 | 866.6 | 304.4 | 607.4 | 244.6 | 0 | 16 | 3203.8 |
| 1976 | 0.2 | 50.4 | 0 | 102.4 | 333.6 | 729.8 | 849.6 | 681.2 | 453.2 | 58.6 | 0 | 1.4 | 3260.4 |
| 1977 | 0 | 0 | 17.6 | 273.2 | 325.2 | 472.8 | 760.9 | 932.6 | 379.1 | 156.6 | 56.2 | 21.4 | 3395.6 |
| 1978 | 15.8 | 8.6 | 65 | 75 | 231.8 | 738 | 748.4 | 257.8 | 422.8 | 34.4 | 89 | 7.7 | 2694.3 |
| 1979 | 4 | 68 | 0 | 136.2 | 153.1 | 349.2 | 698 | 527 | 256 | 223.1 | 3.1 | 7.7 | 2425.4 |
| 1992 | 12.4 | 35.6 | 0 | 181.4 | 172 | 597 | 772.6 | 733.2 | 442.2 | 83.4 | 4.6 | 9.6 | 3044.0 |
| 1993 | 24.1 | 58.8 | 10.2 | 105.6 | 264.4 | 239.8 | 688.3 | 699.8 | 334.2 | 65 | 14.8 | 0 | 2505.1 |
| 1994 | 26 | 3.2 | 152.4 | 182.3 | 337.8 | 210.6 | 257.8 | 261 | 257.2 | 0 | 19.6 | 0.8 | 1708.7 |
| 1995 | 7.0 | 43.5 | 22.1 | 125.9 | 259.5 | 375.4 | 894.4 | 656.6 | 528.3 | 75.8 | 91.2 | 18.3 | 3098.0 |
| 1996 | 23.4 | 25.5 | 58.1 | 129.5 | 504.5 | 350.6 | 714.5 | 846.3 | 359.6 | 367.5 | 0.1 | 0.1 | 3379.9 |
| 1997 | 0 | 80.4 | 13.6 | 253.2 | 145.2 | 233.2 | 219.8 | 663.7 | 531.4 | 76.7 | 1.8 | 29.3 | 2248.3 |
| 1998 | 7.4 | 32.2 | 96.0 | 82.6 | 92.2 | 282.4 | 768.8 | 303.8 | 314 | 52 | 0 | 0.0 | 2031.6 |
| 1999 | 8.1 | 0.7 | 0 | 135.6 | 378.4 | 312.4 | 885.6 | 319.4 | 457.6 | 264.5 | 23.5 | 8.1 | 2793.9 |
| Avr | **14.7** | **30.6** | **43.1** | **163.1** | **281.6** | **462.9** | **761.5** | **626.0** | **427.2** | **139.7** | **19.4** | **7.8** | **2977.7** |

**Annex-3.4 (m)**

## MONTHLY RAINFALL VALUES FOR GEZING STATION IN SIKKIM

**( Unit : mm )**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 240.0 | 25.2 | 139.3 | 135.3 | 430.3 | 864.6 | 1414.7 | 1075.1 | 1682.0 | 381.5 | 67.7 | 45.0 | 6500.7 |
| 1958 | 34.5 | 22.1 | 20.3 | 179.8 | 148.5 | 422.8 | 439.5 | 591.3 | 252.4 | 120.2 | 48.4 | 0.0 | 2279.8 |
| 1959 | 57.8 | 18.2 | 76.8 | 119.6 | 196.9 | 283.9 | 508.1 | 272.5 | 306.4 | 272.0 | 34.4 | 0.0 | 2146.6 |
| 1960 | 0.0 | 61.8 | 87.3 | 78.6 | 240.8 | 306.0 | 542.9 | 331.2 | 522.7 | 87.4 | 0.0 | 1.2 | 2259.9 |
| 1961 | 9.2 | 44.9 | 27.7 | 91.1 | 189.8 | 538.5 | 690.3 | 626.5 | 313.0 | 140.2 | 12.6 | 12.4 | 2696.2 |
| 1962 | 45.6 | 20.7 | 66.1 | 60.2 | 207.3 | 605.9 | 340.8 | 654.0 | 221.4 | 68.0 | 0.0 | 10.7 | 2300.7 |
| 1963 | 12.5 | 4.5 | 74.0 | 175.2 | 227.2 | 501.6 | 450.4 | 552.7 | 414.0 | 232.0 | 40.1 | 34.5 | 2718.7 |
| 1964 | 0.0 | 0.0 | 45.5 | 76.7 | 134.0 | 332.8 | 801.4 | 514.8 | 319.2 | 79.0 | 10.7 | 0.0 | 2314.1 |
| 1965 | 0.9 | 3.7 | 42.0 | 89.4 | 188.3 | 301.3 | 545.8 | 773.2 | 296.3 | 143.7 | 81.6 | 0.0 | 2466.2 |
| 1966 | 99.2 | 4.6 | 10.2 | 80.9 | 145.9 | 234.7 | 515.0 | 564.8 | 348.3 | 52.5 | 0.0 | 0.0 | 2056.1 |
| 1967 | 0.0 | 0.0 | 0.0 | 129.0 | 205.9 | 415.1 | 528.2 | 210.7 | 367.0 | 114.6 | 52.9 | 23.2 | 2046.6 |
| 1968 | 15.1 | 8.2 | 142.9 | 58.8 | 177.6 | 305.3 | 646.7 | 486.4 | 533.3 | 409.2 | 0.4 | 0.0 | 2783.9 |
| 1969 | 8.7 | 4.1 | 87.8 | 50.3 | 197.5 | 245.5 | 662.1 | 423.5 | 451.5 | 59.1 | 1.7 | 2.1 | 2193.9 |
| 1970 | 19.3 | 33.0 | 19.5 | 125.7 | 129.4 | 468.2 | 787.0 | 430.5 | 336.1 | 0.0 | 10.6 | 0.0 | 2359.3 |
| 1971 | 9.4 | 5.8 | 38.3 | 206.3 | 158.8 | 720.3 | 481.6 | 555.6 | 364.9 | 268.5 | 28.4 | 11.2 | 2849.1 |
| 1972 | 25.8 | 31.2 | 41.9 | 131.5 | 194.7 | 254.4 | 521.2 | 272.0 | 312.3 | 56.3 | 29.5 | 46.6 | 1917.4 |
| 1973 | 10.2 | 29.9 | 58.8 | 138.3 | 309.5 | 1039.8 | 409.0 | 404.5 | 71.8 | 366.2 | 5.6 | 0.0 | 2843.6 |
| 1974 | 27.2 | 7.5 | 0.1 | 35.0 | 216.9 | 261.2 | 488.6 | 166.2 | 499.6 | 179.7 | 5.9 | 16.4 | 1904.3 |
| 1975 | 27.2 | 7.5 | 0.1 | 35.0 | 216.9 | 261.2 | 496.1 | 166.2 | 499.6 | 179.7 | 3.5 | 16.4 | 1909.4 |
| 1976 | 5.8 | 40.1 | 2.4 | 1.9 | 27.6 | 106.7 | 27.8 | 115.7 | 166.5 | 68.1 | 18.3 | 5.0 | 585.9 |
| 1977 | 2.0 | 0.0 | 197.6 | 303.6 | 136.3 | 133.2 | 350.4 | 470.8 | 627.4 | 199.5 | 24.3 | 89.6 | 2534.7 |
| 1978 | 38.4 | 26.7 | 7.6 | 84.4 | 191.9 | 665.5 | 386.9 | 93.8 | 633.0 | 9.3 | 58.9 | 0.0 | 2196.4 |
| 1979 | 0.0 | 24.1 | 0.0 | 69.3 | 74.5 | 492.7 | 750.2 | 352.9 | 494.3 | 157.1 | 101.9 | 13.3 | 2530.2 |
| **Avr** | **29.9** | **18.4** | **51.6** | **106.8** | **189.0** | **424.4** | **555.9** | **439.3** | **436.2** | **158.4** | **27.7** | **14.2** | **2451.9** |

**Annex-3.4 (n)**

## MONTHLY RAINFALL VALUES FOR GANGTOK STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 224.8 | 186.2 | 390.4 | 504.3 | 901.4 | 972.4 | 1639.2 | 1259.4 | 1387.4 | 398 | 96 | 98.6 | 8058.1 |
| 1958 | 102.7 | 76.7 | 65 | 378 | 348.5 | 726.4 | 687.9 | 768.3 | 289.9 | 110.2 | 71.8 | 16.2 | 3641.6 |
| 1959 | 81.8 | 87.6 | 137.6 | 242.9 | 620.8 | 636.4 | 717.3 | 316.5 | 501.2 | 352.7 | 37.1 | 0.4 | 3732.3 |
| 1960 | 0.4 | 92.4 | 198.7 | 204.4 | 560.3 | 837.3 | 607.7 | 464.5 | 633.9 | 126.5 | 0 | 8 | 3734.1 |
| 1961 | 26.7 | 99.7 | 174.5 | 159.2 | 455.2 | 654.8 | 690.1 | 588.5 | 505.7 | 88.3 | 22.6 | 33.8 | 3499.1 |
| 1962 | 60.5 | 36.2 | 102.5 | 133.6 | 609.1 | 564.8 | 528.8 | 779 | 296.5 | 51.8 | 0 | 11.8 | 3174.6 |
| 1963 | 15 | 41.5 | 130.5 | 424.5 | 442 | 691.7 | 709.4 | 710.1 | 439.8 | 156.4 | 67.7 | 31.5 | 3860.1 |
| 1964 | 5.8 | 17.8 | 96.7 | 333.4 | 380.1 | 683.4 | 825.5 | 571.5 | 374.3 | 85.7 | 37.2 | 17.5 | 3428.9 |
| 1965 | 8.4 | 34 | 91.6 | 217.8 | 476.3 | 692.2 | 507.2 | 698.5 | 413.6 | 39.7 | 122.7 | 0 | 3302 |
| 1966 | 110.2 | 38.5 | 126.4 | 119.6 | 435 | 920.4 | 571.5 | 589.6 | 392.2 | 166.6 | 3.5 | 9.4 | 3482.9 |
| 1967 | 0.2 | 39.5 | 226.5 | 81.3 | 566.7 | 550.1 | 788.5 | 492.6 | 345.8 | 89.1 | 20.2 | 34.2 | 3234.7 |
| 1968 | 34.1 | 21.7 | 263.9 | 112.7 | 670.1 | 415.5 | 645.2 | 582.1 | 600.9 | 403 | 4.3 | 0 | 3753.5 |
| 1969 | 36.5 | 12.2 | 235.6 | 264.7 | 492.9 | 631.6 | 752.3 | 560.4 | 337.2 | 222.1 | 15.2 | 9.4 | 3570.1 |
| 1970 | 40.6 | 98.3 | 82 | 237.9 | 309.6 | 563.5 | 605.2 | 645.7 | 239.7 | 17.3 | 35.2 | 1.6 | 2876.6 |
| 1971 | 36.6 | 22 | 133 | 329 | 422.4 | 912.1 | 694.3 | 641.9 | 421.1 | 468.3 | 26.8 | 11.2 | 4118.7 |
| 1972 | 52.6 | 46.8 | 123 | 453.8 | 758.7 | 685.1 | 625.7 | 482.1 | 591.9 | 75.4 | 31.8 | 1.7 | 3928.6 |
| 1973 | 25.9 | 69.9 | 106.6 | 185.2 | 601.3 | 691.5 | 468.8 | 566.8 | 302.8 | 461 | 11.8 | 0.4 | 3492 |
| 1974 | 24.3 | 4.6 | 154.1 | 687.8 | 530.1 | 510.3 | 861.1 | 658.5 | 457.2 | 139.9 | 0.2 | 32 | 4060.1 |
| 1975 | 21.7 | 61.6 | 10.3 | 113.8 | 662 | 570.3 | 852.9 | 326.7 | 541 | 325.4 | 3.7 | 32 | 3521.4 |
| 1976 | 28.3 | 89.1 | 45.9 | 210.1 | 638.9 | 587.3 | 553.4 | 714.6 | 287.4 | 135.9 | 46.3 | 1.7 | 3338.9 |
| 1977 | 22.8 | 6 | 69.4 | 680.1 | 784.1 | 694.9 | 629.1 | 630.1 | 382.9 | 260.2 | 167.6 | 73.9 | 4401.1 |
| 1978 | 65.4 | 35.9 | 69.3 | 183.7 | 645.3 | 707.4 | 694.5 | 436.6 | 543.1 | 34.3 | 25.1 | 12.9 | 3453.5 |
| 1979 | 16.1 | 38.3 | 33.4 | 224.9 | 288.9 | 434.9 | 902.8 | 704.8 | 696.0 | 296.3 | 6.0 | 19.9 | 3662.3 |
| 1990 | NA | NA | NA | NA | NA | NA | 700.7 | 551.5 | 453.6 | 41.5 | 0.5 | 2.7 | NA |
| 1991 | NA | NA | NA | NA | NA | NA | 502 | 734.3 | 793.5 | 48.5 | 1.2 | 34.9 | NA |
| 1992 | 26.9 | 97.8 | 39.5 | 219.5 | 1985.0 | 453.4 | 1036.1 | 507.2 | 435.6 | 313.3 | 2.5 | 12.2 | 5128.989 |
| 1993 | 62.3 | 101 | 77.1 | 269.8 | 498.8 | 739.9 | 599.3 | 633.4 | 348.8 | 250.2 | 53.1 | 16.2 | 3649.9 |
| 1994 | 48.2 | 50.9 | 218 | 265.4 | 306.4 | 659.3 | 369.4 | 625.2 | 356 | 342.7 | 37.2 | 2.1 | 3280.8 |
| 1995 | 21.9 | 79 | 70.7 | 208 | 489.5 | 467.6 | 778.7 | 594.3 | 562.3 | 100.7 | 173.5 | 47.3 | 3593.5 |
| 1996 | 73.6 | 46.4 | 185.6 | 214 | 951.7 | 436.7 | 622.1 | 766 | 382.8 | 488 | 0.2 | 0.3 | 4167.4 |
| 1997 | 34.5 | 125.4 | 101.7 | 297.2 | 400.9 | 1281.3 | 518.4 | 600.7 | 565.6 | 101.8 | 3.5 | 75.8 | 4106.8 |
| 1998 | 23.4 | 58.6 | 306.4 | 228.2 | 340 | 1120.8 | 669.4 | 555.9 | 372.8 | 233.6 | 7 | 0.1 | 3916.247 |
| 1999 | 25.5 | 1.2 | 41.4 | 523.2 | 370.5 | 713.3 | 771.1 | 585 | 487.1 | 351.2 | 44.6 | 21 | 3935.1 |
| **Avr** | **43.8** | **58.6** | **132.5** | **280.9** | **578.8** | **684.1** | **700.8** | **616.4** | **477.0** | **205.3** | **35.6** | **20.3** | **3842.1** |

**Annex-3.4 (o)**

## MONTHLY RAINFALL VALUES FOR MANGAN STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 399.7 | 174.8 | 534.7 | 403.2 | 548.8 | 1782.3 | 1675.5 | 1111.5 | 1132.5 | 700.2 | 128.7 | 296.4 | 8888.3 |
| 1958 | 105.1 | 60.9 | 133.5 | 291.4 | 339.5 | 778.0 | 537.0 | 870.5 | 154.0 | 261.7 | 56.6 | 18.0 | 3606.3 |
| 1959 | 178.3 | 143.6 | 181.9 | 152.8 | 374.5 | 787.3 | 494.6 | 201.7 | 258.0 | 139.1 | 51.9 | 0.7 | 2964.4 |
| 1960 | 0 | 199.2 | 237.3 | 95 | 412.2 | 897 | 453.4 | 292.6 | 524.4 | 205.6 | 12.4 | 4.2 | 3333.3 |
| 1961 | 62.2 | 86.4 | 286.2 | 224 | 582.6 | 450.6 | 638.8 | 461.9 | 460.6 | 207.9 | 35 | 106 | 3602.2 |
| 1962 | 86.8 | 59.8 | 261 | 80.8 | 463.2 | 566.6 | 309.8 | 986 | 416.8 | 88.8 | 40 | 76.4 | 3436 |
| 1963 | 51.2 | 91 | 156.5 | 242.4 | 299.2 | 549 | 503.6 | 642 | 342.6 | 236 | 81.4 | 48.4 | 3243.3 |
| 1964 | 4 | 59 | 186.2 | 254.2 | 351.2 | 303.5 | 742.7 | 423.2 | 236 | 118.2 | 25.7 | 2 | 2705.9 |
| 1965 | 16 | 144.1 | 212.8 | 179.1 | 190.4 | 419.1 | 471.8 | 525.8 | 495 | 91.2 | 134 | 2.2 | 2881.5 |
| 1966 | 100.8 | 63.3 | 21.6 | 188.9 | 380.1 | 729.7 | 706.2 | 389.8 | 370 | 112.6 | 5.8 | 28.5 | 3097.3 |
| 1967 | 0 | 0 | 203.2 | 122.3 | 502.9 | 1616.2 | 635.5 | 377.8 | 222.5 | 98.2 | 38.7 | 24.4 | 3841.7 |
| 1968 | 61.8 | 128.8 | 176.6 | 200 | 353.5 | 360.2 | 705.2 | 513.7 | 519.6 | 338 | 44.8 | 1.6 | 3403.8 |
| 1969 | 84.6 | 28.2 | 157 | 194.5 | 397.2 | 752.4 | 392.2 | 455.1 | 253.7 | 76.4 | 35.8 | 6 | 2833.1 |
| 1970 | 78.8 | 131.8 | 158.6 | 204.9 | 367.4 | 651.9 | 488.1 | 461 | 864 | 56.4 | 0 | 0 | 3462.9 |
| 1971 | 116.8 | 117.2 | 133.9 | 233.2 | 282.2 | 800.7 | 474.2 | 278.9 | 355.2 | 283.4 | 26.4 | 4 | 3106.1 |
| 1972 | 19.4 | 122.9 | 261.9 | 278.8 | 611.4 | 701.6 | 448.8 | 304.5 | 279.7 | 117.7 | 22.2 | 0 | 3168.9 |
| 1973 | 38.4 | 155.1 | 51 | 142.9 | 501.8 | 947.3 | 395.6 | 333.7 | 190.3 | 200.7 | 9.3 | 8.2 | 2974.3 |
| 1974 | 31.2 | 36.1 | 101 | 267.4 | 257.3 | 659.8 | 635.3 | 717 | 768.2 | 330.2 | 7.8 | 43.8 | NA |
| 1975 | 55.2 | 210.6 | 60.8 | 185.8 | 276.9 | 154.4 | 678.6 | 276.9 | 377.2 | 244.2 | 4.7 | 36.7 | NA |
| 1976 | 10 | 30.9 | 44 | 59.3 | 112.2 | 81.2 | 136.4 | 159.3 | 151.4 | 79.5 | 35.5 | 12.2 | 911.9 |
| 1977 | 36.2 | 31.6 | 83.2 | 121.2 | 143.8 | 209.4 | 188.7 | 136.8 | 145.2 | 87.3 | 129.4 | 128.6 | 1312 |
| 1978 | 83.8 | 34 | 84.6 | 145.6 | 160.8 | 125.6 | 92 | 98.5 | 94.6 | 21.2 | 0 | 35.2 | NA |
| 1979 | 16.7 | 10 | 22.2 | 140.0 | 219.9 | 344.6 | 790.4 | 370.9 | 733.6 | 327.9 | 27.4 | 44.4 | NA |
| 1980 | 79.8 | 95.8 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Avr** | **71.5** | **92.3** | **163.0** | **191.6** | **353.4** | **637.8** | **547.6** | **451.7** | **406.3** | **192.3** | **41.4** | **40.3** | **3303.9** |

**Annex-3.4 ( p )**

## MONTHLY RAINFALL VALUES FOR SERRATHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 | 74.6 | 22.4 | 89.8 | 265.7 | 521.5 | 370.2 | 422.7 | 691.3 | 147.8 | 104.2 | 10.2 | 5.1 | 2725.5 |
| 1959 | 30.6 | 32.9 | 96.4 | 267.9 | 436 | 562.9 | 420.4 | 433.7 | 378.4 | 231.8 | 20.3 | 0 | 2911.3 |
| 1960 | 1.8 | 163.6 | 247.4 | 71 | 291.9 | 393.7 | 394.5 | 298.3 | 398.7 | 105.2 | 0 | 0 | 2366.1 |
| 1961 | 39.2 | 44.3 | 176.4 | 54.5 | 528.6 | 365 | 454.7 | 464.7 | 351.7 | 98.9 | 47 | 67.2 | 2692.2 |
| 1962 | 55.9 | 60.8 | 128.1 | 141.2 | 493.2 | 317.2 | 326.6 | 345.7 | 240.1 | 29.1 | 0 | 44.4 | 2182.3 |
| 1963 | 6 | 105.5 | 47.9 | 48.1 | 71 | 155.8 | 62.4 | 93.8 | 124.7 | 33.8 | 19.8 | 4.5 | 773.3 |
| 1993 | NA | NA | NA | NA | 18 | NA | NA | NA | 89 | 24 | NA | NA | NA |
| **Avr** | **34.7** | **71.6** | **131.0** | **141.4** | **337.2** | **360.8** | **346.9** | **387.9** | **247.2** | **89.6** | **16.2** | **20.2** | **2275.1** |

Annex-3.4 ( q )

## MONTHLY RAINFALL VALUES FOR GNATHANG STATION IN SIKKIM

( Unit : mm )

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | NA | NA | NA | NA | NA | 191.8 | 351.7 | 590 | 419.1 | 148 | 0 | NA | NA |
| 1975 | NA | NA | NA | NA | 457.5 | NA | NA | NA | 643 | NA | NA | NA | NA |
| 1976 | 0 | 0 | 0 | 0 | 452 | 749.4 | 651 | 723 | 355 | 137 | 30 | 0 | 3097.4 |
| 1977 | 0 | 35 | 10 | 0 | 0 | 652 | 627 | 382.5 | 272.9 | 0 | NA | 0 | NA |
| 1978 | NA | 0 | 0 | 31 | 296 | 1344 | 0 | 273 | NA | NA | NA | NA | NA |
| 1979 | NA | NA | 0 | NA | NA | NA | NA | NA | 351.5 | NA | NA | NA | NA |
| **Avr** | **0.0** | **11.7** | **2.5** | **10.3** | **301.4** | **734.3** | **407.4** | **492.1** | **408.3** | **95.0** | **15.0** | **0.0** | **3097.4** |

**Annexure-3.5**

## Thiessen Weights of Stations in Tessta Basin

| Year Range | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951-56 | | 1957-1963 | | 1964-1970 | | 1971-1979 | | 1980-1991 | | 1992-1999 | |
| Area(sq. km.) | Wt | Area(sq. km.) | Wt | Area(sq. km.) | Wt | Area(sq. km.) | Wt | Area(sq. km.) | Wt | Area(sq. km.) | Wt |
| | | 449 | 0.09 | | | 414 | 0.09 | | | 1277 | 0.26 |
| | | 331 | 0.07 | | | 496 | 0.10 | | | 638 | 0.13 |
| | | 319 | 0.07 | | | 378 | 0.08 | | | 591 | 0.12 |
| | | 124 | 0.03 | 910 | 0.19 | 142 | 0.03 | | | | |
| | | 272 | 0.06 | | | 449 | 0.09 | | | 615 | 0.13 |
| | | 142 | 0.03 | 1608 | 0.33 | 733 | 0.15 | | | | |
| 3050 | 0.628 | 260 | 0.05 | 851 | 0.18 | 378 | 0.08 | | | | |
| | | 225 | 0.05 | 1064 | 0.22 | 426 | 0.09 | | | 508 | 0.10 |
| | | 591 | 0.12 | | | 556 | 0.11 | | | | |
| | | 621 | 0.13 | | | | | | | | |
| | | 248 | 0.05 | | | 236 | 0.05 | | | 520 | 0.11 |
| 1619 | 0.333 | 591 | 0.12 | | | | | | | 709 | 0.15 |
| | | 219 | 0.05 | | | 651 | 0.13 | | | | |
| 189 | 0.039 | 124 | 0.03 | 426 | 0.09 | | | | | | |
| | | 343 | 0.07 | | | | | | | | |
| **4858.02** | **1** | **4858.02** | **1** | **4858** | **1** | **4858** | **1** | | | **4858** | **1** |

## Weighted Average Rainfall for Teesta Basin in Sikkim

**Annexure-3.6**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | TOTAL | | Annual rainfall in descending order | Dependabilty | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 43.3 | 17.6 | 217.5 | 160.9 | 191.4 | 416.1 | 315.3 | 0.0 | 319.0 | 140.5 | 85.9 | 1.9 | 3860.2 | 1 | 4502.76 | 2.63 | | |
| 1952 | 70.0 | 90.1 | 204.7 | 103.4 | 250.3 | 360.4 | 396.1 | 483.4 | 321.1 | 61.8 | 18.7 | 25.8 | 4337.9 | 2 | 4337.91 | 5.26 | | |
| 1953 | 20.0 | 0.0 | 137.5 | 157.8 | 193.2 | 226.1 | 385.5 | 231.6 | 210.4 | 201.0 | 35.2 | 2.6 | 3754.0 | 3 | 4255.81 | 7.89 | | |
| 1954 | 92.2 | 38.8 | 70.5 | 112.0 | 209.1 | 399.7 | 661.1 | 347.1 | 263.1 | 69.7 | 0.0 | 38.3 | 4255.8 | 4 | 4249.98 | 10.53 | | |
| 1955 | 29.7 | 25.3 | 229.1 | 188.2 | 229.6 | 430.9 | 560.3 | 332.8 | 303.8 | 213.4 | 1.3 | 3.4 | 4502.8 | 5 | 4086.51 | 13.16 | | |
| 1956 | 48.3 | 67.7 | 290.1 | 47.7 | 252.4 | 321.4 | 364.4 | 271.3 | 151.1 | 264.9 | 6.0 | 45.1 | 4086.5 | 6 | 3860.21 | 15.79 | | |
| 1957 | 141.6 | 52.3 | 151.5 | 173.3 | 360.6 | 645.2 | 916.1 | 765.4 | 711.9 | 227.9 | 47.9 | 56.2 | 4250.0 | 7 | 3753.99 | 18.42 | | |
| 1958 | 56.9 | 57.3 | 76.6 | 201.2 | 241.2 | 434.4 | 465.1 | 615.7 | 225.6 | 147.8 | 44.5 | 6.8 | 2573.1 | 8 | 2973.46 | 21.05 | | |
| 1959 | 57.6 | 77.7 | 101.7 | 130.0 | 247.0 | 488.5 | 645.4 | 366.8 | 352.7 | 230.1 | 27.1 | 0.3 | 2724.7 | 9 | 2933.69 | 23.68 | | |
| 1960 | 3.9 | 83.5 | 141.0 | 58.3 | 246.7 | 486.3 | 475.8 | 406.0 | 399.0 | 81.8 | 2.1 | 3.0 | 2387.5 | 10 | 2929.84 | 26.32 | | |
| 1961 | 19.9 | 60.3 | 98.5 | 108.1 | 334.2 | 361.3 | 434.6 | 505.8 | 364.4 | 143.7 | 17.7 | 41.4 | 2489.9 | 11 | 2917.90 | 28.95 | | |
| 1962 | 33.6 | 46.1 | 86.6 | 93.0 | 295.8 | 433.8 | 335.0 | 587.7 | 270.0 | 53.9 | 10.8 | 17.8 | 2264.0 | 12 | 2905.09 | 31.58 | | |
| 1963 | 17.2 | 33.0 | 96.4 | 161.2 | 205.4 | 334.4 | 404.3 | 477.4 | 319.4 | 151.9 | 55.3 | 19.1 | 2275.1 | 13 | 2894.74 | 34.21 | | |
| 1964 | 5.6 | 31.3 | 107.5 | 178.3 | 251.5 | 409.5 | 681.1 | 442.8 | 276.4 | 83.7 | 21.2 | 4.7 | 2493.7 | 14 | 2868.87 | 36.84 | | |
| 1965 | 7.6 | 66.8 | 110.0 | 145.8 | 218.3 | 365.2 | 474.3 | 599.5 | 344.0 | 86.7 | 103.4 | 0.9 | 2522.5 | 15 | 2821.58 | 39.47 | | |
| 1966 | 94.4 | 33.2 | 47.7 | 122.3 | 256.8 | 514.3 | 547.3 | 491.7 | 333.4 | 90.0 | 5.5 | 9.7 | 2546.3 | 16 | 2724.74 | 42.11 | | |
| 1967 | 6.0 | 27.3 | 134.7 | 107.1 | 319.6 | 686.8 | 471.9 | 352.3 | 302.1 | 99.5 | 38.4 | 23.7 | 2569.6 | 17 | 2659.38 | 44.74 | | |
| 1968 | 32.1 | 53.2 | 173.3 | 119.3 | 327.6 | 308.7 | 620.6 | 485.5 | 479.9 | 355.6 | 17.3 | 0.5 | 2973.5 | 18 | 2647.71 | 47.37 | | |
| 1969 | 36.8 | 16.2 | 129.1 | 150.4 | 302.2 | 447.5 | 523.4 | 430.7 | 318.7 | 95.9 | 16.4 | 3.9 | 2471.2 | 19 | 2573.12 | 50.00 | **2573** | 50 percent |
| 1970 | 44.3 | 77.9 | 86.3 | 172.7 | 239.8 | 493.1 | 579.0 | 465.9 | 447.8 | 27.4 | 13.3 | 0.4 | 2647.7 | 20 | 2569.60 | 52.63 | | |
| 1971 | 41.1 | 40.9 | 91.7 | 202.6 | 265.8 | 653.9 | 520.1 | 490.1 | 300.4 | 286.4 | 21.4 | 3.5 | 2917.8 | 21 | 2546.35 | 55.26 | | |
| 1972 | 18.0 | 39.9 | 80.4 | 218.4 | 360.4 | 405.9 | 468.1 | 377.3 | 363.1 | 81.7 | 21.2 | 11.4 | 2445.8 | 22 | 2530.86 | 57.89 | | |
| 1973 | 20.4 | 62.5 | 62.0 | 114.7 | 352.1 | 626.0 | 360.8 | 354.0 | 230.5 | 287.4 | 7.3 | 2.7 | 2480.3 | 23 | 2530.41 | 60.53 | | |
| 1974 | 20.5 | 8.9 | 73.5 | 210.9 | 315.9 | 406.4 | 558.9 | 379.1 | 372.4 | 157.3 | 5.6 | 21.6 | 2530.8 | 24 | 2522.48 | 63.16 | | |
| 1975 | 36.7 | 58.2 | 34.0 | 87.7 | 279.3 | 402.0 | 548.4 | 227.3 | 503.0 | 236.2 | 3.0 | 14.6 | 2430.5 | 25 | 2520.70 | 65.79 | | |
| 1976 | 14.3 | 61.2 | 50.1 | 120.1 | 296.4 | 439.6 | 414.3 | 441.1 | 249.1 | 111.8 | 52.0 | 2.9 | 2252.8 | 26 | 2493.69 | 68.42 | | |
| 1977 | 21.5 | 15.8 | 119.5 | 312.8 | 297.1 | 340.4 | 455.4 | 611.1 | 341.4 | 234.4 | 91.8 | 53.5 | 2894.6 | 27 | 2489.87 | 71.05 | | |
| 1978 | 43.6 | 44.0 | 100.6 | 134.6 | 295.0 | 525.3 | 459.2 | 271.6 | 442.9 | 57.6 | 77.7 | 13.8 | 2466.0 | 28 | 2480.36 | 73.68 | | |
| 1979 | 7.4 | 39.0 | 37.1 | 107.0 | 136.6 | 336.0 | 665.8 | 429.4 | 477.8 | 225.5 | 41.6 | 17.5 | 2520.6 | 29 | 2475.44 | 76.32 | **2478** | 75 percent |
| 1980 | | | | | | | | | | | | | | 30 | 2471.17 | 78.95 | | |
| 1981 | | | | | | | | | | | | | | 31 | 2466.14 | 81.58 | | |
| 1982 | | | | | | | | | | | | | | 32 | 2445.86 | 84.21 | | |
| 1983 | | | | | | | | | | | | | | 33 | 2430.55 | 86.84 | | |
| 1984 | | | | | | | | | | | | | | 34 | 2387.46 | 89.47 | | |
| 1985 | | | | | | | | | | | | | | 35 | 2275.11 | 92.11 | | |
| 1986 | | | | | | | | | | | | | | 36 | 2264.03 | 94.74 | | |
| 1987 | | | | | | | | | | | | | | 37 | 2252.91 | 97.37 | | |
| 1988 | | | | | | | | | | | | | | | | | | |
| 1989 | | | | | | | | | | | | | | | | | | |
| 1990 | | | | | | | | | | | | | | | | | | |
| 1991 | | | | | | | | | | | | | | | | | | |
| 1992 | 20.9 | 86.4 | 75.3 | 131.6 | 662.3 | 281.3 | 646.9 | 521.7 | 327.0 | 156.6 | 5.9 | 13.7 | 2929.8 | | | | | |
| 1993 | 58.0 | 63.9 | 124.9 | 121.0 | 271.0 | 425.8 | 503.7 | 411.8 | 323.2 | 140.2 | 54.4 | 32.5 | 2530.4 | | | | | |
| 1994 | 70.6 | 81.9 | 396.6 | 194.4 | 251.5 | 314.7 | 317.1 | 435.3 | 293.9 | 91.3 | 20.9 | 7.2 | 2475.4 | | | | | |
| 1995 | 30.6 | 65.1 | 58.9 | 141.9 | 267.2 | 459.4 | 544.9 | 462.8 | 389.0 | 107.6 | 101.0 | 30.9 | 2659.4 | | | | | |
| 1996 | 46.0 | 73.8 | 140.4 | 377.0 | 368.3 | 355.2 | 540.8 | 464.5 | 307.4 | 250.1 | 6.5 | 3.6 | 2933.7 | | | | | |
| 1997 | 39.3 | 97.8 | 131.3 | 200.4 | 246.8 | 659.6 | 338.8 | 430.8 | 504.5 | 62.4 | 38.0 | 71.9 | 2821.6 | | | | | |
| 1998 | 10.3 | 64.8 | 203.1 | 146.4 | 244.5 | 512.8 | 653.2 | 515.6 | 310.5 | 188.6 | 11.8 | 7.1 | 2868.9 | | | | | |
| 1999 | 17.8 | 24.4 | 61.8 | 238.7 | 330.7 | 496.3 | 599.5 | 473.7 | 286.0 | 346.1 | 14.0 | 16.3 | 2905.1 | | | | | |

**Annexure- 4.1**

## METHODOLOGY OF DISCHARGE OBSERVATION

Floats are the simplest and undoubtedly, the earliest form of flow measurement device. Many flow measurements in India are undertaken using the float method since there is often no other viable alternative. However, their use is not recommended unless it is impossible to employ a current meter because of excessive velocities, or large depths, or presence of excessive amount of material in suspension, and for failure of current meter. Nevertheless, they still remain a simple and cheap, albeit less accurate method of estimating the discharge in a river section. Further for reconnaissance level planning, surface float method is *very* simple and convenient method for assessing the discharge of a stream.

Velocity as determined by surface float method is neither a local velocity nor an instantaneous one, since the mean value of the velocity (v) in the time (t) over a measured float path length (s) is determined as under :

$$V = s / t$$

The method involves the measurement of travel time of floats over a length of river reach as uniform as possible (preferably 3 to 5 times the width of the river). The minimum duration of measurement of 20 seconds is recommended. If possible, the floats should be released a sufficient distance upstream of the measuring reach to allow them to attain constant velocity. Also it is desirable to release the floats at different positions from the bank.

The surface velocities obtained by the float method have to be adjusted to obtain the mean velocity in the channel cross section. The factor to be applied on measured velocity is dependent on the depth of submergence and the shape of the float. The factors have been derived for different types of purpose built floats. Normally, for the surface floats i.e. floats which are not significantly submerged, the factor is in the range of 0.8 to 0.9.

In simple terms, the flow is basically obtained by estimating the mean surface water velocity (v) in the measuring reach and multiplying this by the float factor ($C_t$) and the mean cross sectional area of the reach (A)

$$Q = C_t VA$$

In high floods and in other difficult conditions, it is sometimes possible to undertake float measurement but not possible to measure the cross section as it usually changes drastically under the influence of high floods. In such circumstances, the water level in the river should be ascertained relative to a fixed datum e.g. bridge parapet and the cross-section can, then, be measured at a later date once it is possible to survey the channel.

**Types of Float**

There are three main types of purpose built floats as described below:

**Surface Floats**

These are the simplest type of floats. They are, however, most readily influenced by wind. These typically have float factor between 0.8

and 0.9 with a value of 0.85 being taken as a reasonable average. A float factor of 0.81 is currently being used by Central Water Commission for the measurement of discharge in Teesta Basin.

**Canister (Double / Sub-Surface) Floats**

These consist of a submerged canister or subsurface float, connected by a thin adjustable line. The canister dimension and its immersed depth are chosen in such a manner so that the float velocity is equal to the mean velocity at that section of river. Therefore, the float factor should be close to 1.0 for these types of floats.

**Rod Floats**

These are cylindrical rods weighted so that they float vertically in still water with only their tip protruding above the surface. They are used to measure the mean velocity in the vertical section of river and are designed so as to lower them in stream water to depth as deep as possible without the lower end touching the bed. The float factor will depend on the length of the rod relative to the depth of flow in the float flow path. Typically, the float factors are of the order of 0.9 to 1.0 for such type of floats. Floats must be easily recognizable. Therefore, the use of distinctive colours is recommended..

**Selection of Site**

The stream flow measurement technique by float method is also based on the velocity area method. The guide lines as per Indian Standard code 18:1192-1981 "Velocity - Area Methods for Measurement of Flow in Open Channels" for selection of site for measuring the discharge by Velocity Area Method are summarised below.

The more general criteria apply both to current meter gauging and float measurements. The accuracy of measurement is increased if the site is selected considering these aspects:

(i) the channel shall be straight and its cross section well defined;

(ii) the conditions of flow do not change within the period of measurement;

(iii) the observation verticals at all points are parallel to one another and at right angles to the measuring cross section; and

(iv) the measuring contours (Iso-vels) are regular in the vertical and horizontal planes on which they are measured.

**Selection of site**

The selected site should comply with the following requirements as closely as possible.

**General Requirement**

(a) The reach of the open channel at the gauging site shall be straight and of uniform cross section as far as possible, in order to avoid irregularities in velocity distribution. The length of the reach need not be more than 1,600 m and should not be less than 400 m. When the length of the straight channel is restricted, it is recommended that the straight length upstream of the measuring cross section should be twice that on the downstream for current meter measurements.

(b) The depth of water in the selected reach shall be sufficient to provide for the effective immersion of either the current meters or floats, whichever are to be used.

(c) When near a confluence, the site, if located on a tributary, it shall be sufficiently upstream preferably beyond the backwater effect and if located on the main stream, it shall be upstream or downstream of the confluence, i.e., it shall be beyond the disturbances due to the tributary.

(d) The site should be easily accessible at all times of the year.

In addition to the requirements specified above, the following points shall also be taken into consideration as desirable attributes in the selection of the gauging site.

(i) The flow should be confined in a single channel and there should be no overflow as far as possible. Where this is not possible, the site at which minimum number of channels exist and the flood plain has minimum width should be preferred.

(ii) Where these requirements cannot be met (for instance, when in all alluvial rivers, the river bed is changing its course during the period of measurement, or when, under flood conditions, the river is not confined to a single channel), a gauging site shall be chosen such that the bed change and/or overflow is minimum. Flood plain, if can not be avoided, shall be of minimum width and as smooth as possible with a distinct channel, and clear of bushes and trees. The flow in flood plain section (s) shall be measured separately and added, treating the whole as a composite section.

(iii) The site shall be away from any bend or natural or artificial obstruction, if disturbance to the flow is likely to be caused thereby.

(iv) The selected reach of the river should be such that the direction of flow is normal to the prevailing wind direction as closely as possible.

(v) Sites at which there are possibilities for the formation of a vortex or development of return flow shall be avoided.

(vi) The site should, as far as possible, be free from trees and obstructions which may interfere with flow and clear vision during observation.

(vii) The site shall be free from aquatic growth which is likely to interfere with the measurement of depth and the current meter reading.

(viii) The site shall be away from the backwater zone caused by any structure on the river.

(ix) The site should be sufficiently away from the disturbance caused by rapids and falls, etc.

**Specific Requirements for Sites for Float Method**

Most of the same general principles which apply to the selection of current meter gauging sites also apply to float measurement sites. However, the following are additional important consideration for the selection of site which are specific to float method.:

(a) Three cross sections shall be selected along the selected reach of the channel, one at the upstream, one in the middle and one at the end of the reach;

(b) The measuring length should be straight and uniform in cross--section, and if possible, be five times the average width of cross section;

(c) If possible the time taken by the float to travel the length of the measuring reach should be at least 20 seconds

(d) It is useful if there is a bridge upstream of the measuring reach in order to drop the floats in the river at the desired locations of the cross-section;

(e) It should be possible to install distance marker poles on both banks directly opposite each other in order to determine accurately when the float has passed the start and finishing section;

(f) Sites which are sheltered from high winds are to be preferred. However, if same is not possible, it is preferable to have prevailing wind at right angles to the direction of flow.

**DISCHARGE MEASUREMENT**

G&D sites are established at such a place that river course is straight upto a distance of about three times the length of the float run and without any other obstruction interfering with flow. The sites are accessible and are at right angles to the direction of flow.

Generally, a float run length of 20 m, 50 m, or 100 m with upstream, downstream and center stream gauges and target posts are adopted. The river width is divided into different segments of about 10m or smaller intervals depending on the width of stream at site. A float (a coloured balloon of dia 10 cm) filled with water and air is dropped at fixed point in the particular segment and the time taken by float in traveling the run distance i.e. 50m or 100 m is recorded and velocity 'of water is determined. Same process is repeated for all the segments with at least three reading for each segment to calculate average velocity in each segment. Mean velocity of the river water is then calculated by applying a float factor of 0.81 to the observed surface float velocity. The discharge in each segment is calculated by using the surveyed cross sectional area.

The other method of determination of discharge by float method, where the upstream and downstream cross sections of the stream have been estimated, is summarised below.

(i) The upstream and downstream cross sections are plotted and then divided into suitable number of segments of equal width. The cross sectional area of each of these segments is calculated.

(ii) Halfway between the two cross section lines, another line MN shall be drawn parallel to the cross section lines, the starting and end positions of each float may be plotted and joined by firm lines while the surface points separating the various panels of the two cross sections may be joined by dotted lines.

(iii) When the firm lines cross the line MN, the corresponding mean velocity (float velocity multiplied by the float factor) shall be plotted normal (at right angles) to MN and the end points of these velocity vectors joined to form a velocity distribution curve.

(iv) The mean area of corresponding segments of the upper and lower cross-sections, when multiplied by the mean velocity of this panel as shown by the velocity distribution represents the discharge through the segments.

(v) The summation of the discharges for all the segments is equal to the total discharge.

(vi) When it is impossible to obtain satisfactory movement of the floats across the whole width of the river, for example, it is only possible to place a few floats in the centre of flow or in a wide river where there is no means of distributing the floats across the cross section, the discharge should be estimated on the basis of the measurement of surface velocity or velocities. This discharge should then be multiplied by a surface coefficient determined on the basis of current meter gauging carried out simultaneously with float measurements. This gauging should be undertaken as close to the flow level as that to which the coefficient will subsequently be applied i.e. Estimate for the nearest current meter gauging and how the float velocity estimate compares with the mean current meter gauged velocity of the whole cross section and make the adjustments accordingly.

When it is only possible to measure flows in mid -stream where maximum velocity would be prevailing, there are some approximate float factors which are dependent on the depth of flow which can be applied to obtain a rough estimate of the mean velocity in the cross section. These have been extracted from an old standard in imperial units and converted to metric units and are summarised in Table 1 below.

**Table 1. Summary of float factors**

| Average Depth (m) | Float Factor |
|---|---|
| 0.3 | 0.66 |
| 0.6 | 0.68 |
| 0.9 | 0.70 |
| 1.2 | 0.72 |
| 1.5 | 0.74 |
| 1.8 | 0.76 |
| 2.7 | 0.77 |
| 3.7 | 0.78 |
| 4.6 | 0.79 |
| 6.0 | 0.80 |

## DIFFICULTIES ENCOUNTERED DURING DISCHARGE OBSERVATION IN TEESTA RIVER SYSTEM

(i) The floats have to be thrown in the water and it is not always possible to locate the exact starting point in respect of each float. The problem is compounded by the fact that both the banks of river are not approachable at the majority of the sites. The problem in respect of the proposed dam axis has been solved by providing suspension rope and cradle arrangement across the river.

(ii) There are considerable cross currents due to which the floats do not run along the axis of the river but travels in a zig-zag path along the river and hence the travel time observed may be too large. This problem is quite severe during low flow seasons and in the stretches upstream to Sirwani G&D station

(iii) The float run is affected by whirl, rapids and small pools of almost stagnant water due to which travel time of float at a particular RD are not uniform.

(iv) Due to highly turbulent flow, the velocity distribution along the depth of flow does not follow the standard assumptions derived from observing the rivers in alluvial planes. The velocity distribution may change considerably from peak flows to lean flows and the application of a uniform float factor does not appear correct. However, in the absence of any better alternatives, this practice has to be continued.

(v) The use of air filled balloons as floats has its own limitations. The velocity of the balloon when observed seems to be affected by the predominant wind direction at the water surface level. Hence, a consistent relation between the velocity and the gauge level is not established. Many times, the velocity increases with the increase in water level as well as with the decrease in water level. The problem needs some detailed study. It can be expected that the velocity of the balloon would be the function of the surface velocity of the water, velocity of wind and the volume of the balloon projecting over the water surface. Due to the very complex relationship between these factors, it is felt the need of laboratory model studies to throw more light on this phenomena. The studies can suggest application of correlation factors to the observed balloon velocities under different wind conditions.

**PROBLEMS OF GAUGE OBSERVATIONS**

(i) During the monsoon period (from May to Oct every year) high floods associated with high flow velocity are able to carry heavy boulders and wooden logs. The rolling boulders and floating logs cause extensive damage to the temporary / permanent gauge posts. At times, it becomes extremely difficult to install a new temporary gauge post due to the reasons enumerated above.

The high waves and vibrations created by turbulent flow of water, create a lot of problems in the accurate gauge observation. During such times the observation is taken according to the individual's judgment.

(ii) The river Teesta is still in its bouldery stage of evolution. Therefore, the cross section usually changes considerably during the heavy floods. Every year, three or more high floods passes through the river and thus results in change in cross section several times during the monsoon season. Practically, it is not always possible to take cross section as many times as the flood occur due to difficult terrain, non availability of bridges and some times bad weather also. This influences the accuracy of measurement. However, the same cannot be ascertained as the predominant average flow does not permit measurement of cross-section after the flood has passed.

**SUGGESTIONS FOR IMPROVING THE HYDROLOGICAL OBSERVATIONS**

(i) Cradle arrangements must be provided at every site.

(ii) The discharge values should be checked through other methods like tracer studies on a regular basis e.g. once a year at each site. It may also be necessary to develop such an expertise in-house.

(iii) To avoid the erratic effects due to the use of an air filled balloon, it is suggested that the floats may be of either wood or some other material. This would involve very high operational costs in view of the fact that the floats can not be recovered in any stages due to the nature of the river. To maintain the supply of such float in remote area would also be difficult. It would, therefore, be advisable to develop calibration charts for balloons by carrying out laboratory studies.

(iv) Keeping the variable nature of regime in view, the G&D observations must be continued till such time that a control structure actually comes in operation. This would be beneficial from hydrology point of view, as the Teesta Basin has not been gauged for a historically long duration.

(v) Since many such similar issues are required to be answered, it may be worthwhile to take up a research project through CBIP or any other research founding agencies.

Annexure-4.2

**MONTHLY AVERAGE RUNOFF ACROSS THE RIVER TEESTA AT CORONATION BRIDGE**

Unit: Mcm

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | Annual | m | m/N+1 | ZtoA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 403.8 | 335.4 | 384.2 | 553.6 | 1333.5 | 2765.7 | 3727.7 | 3829.4 | 2398.2 | 1499.3 | 589.1 | 478.3 | **18298** | 1 | 0.06 | 19930.5 |
| 1979 | 376.8 | 301.0 | 316.9 | 476.0 | 883.7 | 1338.6 | 3347.8 | 2524.3 | 2010.0 | 1555.9 | 817.6 | 658.4 | **14607** | 2 | 0.11 | 19197.4 |
| 1980 | 500.0 | 402.2 | 593.0 | 757.1 | 1427.0 | 2173.0 | 2942.4 | 2687.5 | 2257.2 | 1709.8 | 945.8 | 599.2 | **16994** | 3 | 0.17 | 18713.8 |
| 1981 | 427.4 | 401.3 | 490.0 | 754.3 | 1251.9 | 1853.9 | 3287.7 | 2913.3 | 2666.8 | 1415.7 | 887.9 | 454.8 | **16805** | 4 | 0.22 | 18298.2 |
| 1982 | 482.0 | 390.8 | 460.9 | 720.3 | 1177.9 | 2421.8 | 3464.3 | 2410.2 | 2203.8 | 1344.2 | 797.7 | 570.9 | **16445** | 5 | 0.28 | 18179.9 |
| 1983 | 472.0 | 418.5 | 486.3 | 612.9 | 1228.4 | 1889.0 | 3291.6 | 2457.7 | 3287.4 | 1675.7 | 1249.8 | 845.3 | **17915** | 6 | 0.33 | 17914.5 |
| 1984 | 740.8 | 623.9 | 617.4 | 740.0 | 1177.9 | 1900.6 | 3097.3 | 2783.2 | 2264.3 | 1474.6 | 696.8 | 675.5 | **16792** | 7 | 0.39 | 16994.2 |
| 1985 | 540.8 | 456.1 | 538.0 | 612.9 | 1063.4 | 2365.4 | 3334.7 | 2278.8 | 2308.0 | 1710.2 | 871.3 | 502.8 | **16582** | 8 | 0.44 | 16805.1 |
| 1986 | 369.3 | 271.6 | 319.4 | 464.3 | 761.2 | 1274.6 | 2337.1 | 1968.5 | 1903.1 | 1376.3 | 571.0 | 450.4 | **12067** | 9 | 0.50 | 16792.2 |
| 1987 | 359.7 | 383.8 | 380.9 | 589.6 | 905.8 | 1355.1 | 2304.2 | 1991.1 | 1909.0 | 1276.3 | 599.2 | 475.7 | **12530** | 10 | 0.56 | 16582.5 |
| 1988 | 382.2 | 307.7 | 354.7 | 545.1 | 1177.9 | 1605.3 | 3466.0 | 4198.0 | 2284.8 | 1502.5 | 1235.9 | 1119.9 | **18180** | 11 | 0.61 | 16444.9 |
| 1989 | 812.3 | 532.6 | 578.5 | 300.4 | 1680.6 | 2157.9 | 3715.2 | 3011.2 | 3363.3 | 2418.0 | 750.0 | 610.5 | **19930** | 12 | 0.67 | 14713.4 |
| 1990 | 372.6 | 348.8 | 381.4 | 759.3 | 1114.1 | 3053.8 | 4521.3 | 3055.0 | 2522.5 | 2055.1 | 368.3 | 645.1 | **19197** | 13 | 0.72 | 14607.0 |
| 1991 | 382.2 | 307.7 | 1276.0 | 1088.1 | 1098.3 | 2078.9 | 3550.5 | 4127.0 | 2475.3 | 1422.1 | 342.9 | 564.8 | **18714** | 14 | 0.78 | 13700.1 |
| 1992 | 369.3 | 296.5 | 295.4 | 571.0 | 985.6 | 1047.3 | 2394.9 | 2384.3 | 1738.5 | 1295.6 | 464.3 | 449.5 | **12292** | 15 | 0.83 | 12530.5 |
| 1993 | 381.4 | 348.8 | 372.6 | 368.3 | 1502.3 | 1552.5 | 2314.4 | 3078.8 | 1951.2 | 1438.7 | 759.3 | 645.1 | **14713** | 16 | 0.89 | 12292.2 |
| 1994 | 502.6 | 397.0 | 413.9 | 506.6 | 1301.7 | 2027.3 | 2150.0 | 2440.3 | 1629.4 | 970.0 | 746.7 | 614.5 | **13700** | 17 | 0.94 | 12066.8 |
| | | | | | | | | | | | **AVERAGE** | | **16221** | | | |

| | | |
|---|---|---|
| **75% Dependable Runoff** | 14154 | Mcm |
| **90% Dependable Runoff** | 12247 | Mcm |

<u>**Annexure-4.3 (a)**</u>

## Month wise sediment load and runoff at Chungthang on river Teesta during monsoon

(Unit: ham)

| Year | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Total | | % Sediment wrt runoff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | |
| 1983 | 0.794 | 37784 | 21.702 | 69323 | 35.219 | 97794 | 24.695 | 66542 | 29.968 | 68518 | 4.658 | 55891 | 117.036 | 395852 | 0.0296 |
| 1984 | 11.640 | 49019 | 20.435 | 58213 | 29.999 | 96518 | 9.899 | 75164 | 4.870 | 62595 | 1.623 | 45796 | 78.466 | 387305 | 0.0203 |
| 1985 | 5.401 | 40380 | 78.145 | 54074 | 42.211 | 86009 | 26.461 | 71851 | 7.793 | 62007 | 2.953 | 39131 | 162.964 | 353452 | 0.0461 |
| 1986 | 0.319 | 29052 | 13.955 | 90757 | 27.421 | 126264 | 17.431 | 89910 | 15.557 | 77088 | 3.179 | 49963 | 77.862 | 463034 | 0.0168 |
| 1987 | 2.948 | 39874 | 26.991 | 83101 | 32.562 | 101443 | 27.225 | 85844 | 19.560 | 75823 | 6.459 | 43670 | 115.745 | 429755 | 0.0269 |
| 1988 | 1.998 | 31212 | 2.794 | 43661 | 12.308 | 67498 | 13.627 | 63462 | 2.252 | 21391 | 1.205 | 22941 | 34.184 | 250165 | 0.0137 |
| 1989 | 1.491 | 40338 | 3.486 | 53636 | 7.311 | 68282 | 5.841 | 56663 | 3.814 | 44698 | 1.113 | 26064 | 23.056 | 289681 | 0.0080 |
| 1990 | 2.857 | 36369 | 9.129 | 54503 | 21.291 | 72919 | 15.884 | 62387 | 2.447 | 41908 | 1.258 | 24106 | 52.866 | 292192 | 0.0181 |
| 1991 | 2.384 | 25009 | 4.500 | 39890 | 5.181 | 46676 | 7.914 | 45494 | 5.144 | 37910 | 1.284 | 25340 | 26.407 | 220319 | 0.0120 |
| 1992 | 0.492 | 17316 | 4.161 | 27612 | 8.775 | 41038 | 8.191 | 45730 | 4.495 | 37695 | 0.927 | 25410 | 27.041 | 194801 | 0.0139 |
| 1993 | 1.932 | 23280 | 23.669 | 39396 | 45.882 | 96447 | 37.595 | 1E+05 | 11.552 | 76556 | 2.669 | 42809 | 123.299 | 380430 | 0.0324 |
| 1994 | 2.314 | 31361 | 23.734 | 65833 | 31.585 | 67794 | 12.555 | 58940 | 5.648 | 40668 | 0.756 | 20071 | 76.592 | 284667 | 0.0269 |
| 1995 | 20.542 | 57038 | 57.098 | 72979 | 23.000 | 50208 | 12.577 | 38406 | 9.614 | 35541 | 1.694 | 29319 | 124.525 | 283491 | 0.0439 |
| 1996 | 6.913 | 38606 | 30.837 | 56971 | 26.459 | 83263 | 18.912 | 71440 | 6.925 | 57115 | 3.112 | 37647 | 93.158 | 345042 | 0.0270 |
| 1997 | 1.184 | 22340 | 25.187 | 54402 | 29.439 | 75003 | 33.470 | 62447 | 9.044 | 54024 | 1.015 | 22600 | 99.339 | 290816 | 0.0342 |
| **Average** | **4.214** | **34599** | **23.055** | **57623** | **25.243** | **78477** | **18.152** | **66415** | **9.246** | **52902** | **2.260** | **34051** | **82.169** | **324067** | 0.0246 |
| **% Sediment wrt runoff** | **0.0122** | | **0.0400** | | **0.0322** | | **0.0273** | | **0.0175** | | **0.0066** | | **0.0254** | | |

**Annexure-4.3 (b)**

## Month wise sediment load and runoff at Sangklang on river Teesta during monsoon

(Unit: ham)

| Year | May | | Jun | | Jul | | Aug | | Sep | | Oct | | | Total | % Sediment wrt runoff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | |
| 1992 | 15.057 | 50194 | 39.101 | 88782 | 101.888 | 149223 | 64.023 | 136571 | 30.794 | 97535 | 3.686 | 57077 | 254.549 | 579382 | 0.0439 |
| 1993 | 9.464 | 63535 | 80.439 | 103092 | 358.403 | 149191 | 112.151 | 135440 | 20.167 | 85161 | 7.084 | 51952 | 587.708 | 588371 | 0.0999 |
| 1994 | 10.610 | 51326 | 88.012 | 88280 | 89.438 | 79772 | 73.663 | 85824 | 44.338 | 87408 | 5.847 | 47043 | 311.908 | 439653 | 0.0709 |
| 1995 | 224.429 | 100496 | 293.090 | 146174 | 261.116 | 170238 | 101.563 | 127395 | 31.108 | 99924 | 8.477 | 70322 | 919.783 | 714549 | 0.1287 |
| 1996 | 23.159 | 80259 | 71.636 | 117725 | 331.725 | 186748 | 59.343 | 122889 | 32.427 | 105712 | 4.448 | 64804 | 522.738 | 678137 | 0.0771 |
| 1997 | 5.120 | 40834 | 83.044 | 96506 | 78.106 | 114062 | 211.580 | 98829 | 129.661 | 102480 | 6.540 | 42653 | 514.051 | 495364 | 0.1038 |
| **Average** | **47.973** | **64441** | **109.220** | **106760** | **203.446** | **141539** | **103.721** | **117825** | **48.083** | **96370** | **6.014** | **55642** | **518.456** | **582576** | |
| **% Sediment wrt runoff** | **0.0744** | | **0.1023** | | **0.1437** | | **0.0880** | | **0.0499** | | **0.0108** | | **0.0890** | | |

**Annexure-4.3 (c)**

## Month wise sediment load and runoff at Dikchu on river Teesta during monsoon

(Unit: ham)

| Year | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Total | | % Sediment wrt runoff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | |
| 1986 | 6.479 | 51009 | 31.472 | 109834 | 59.071 | 159948 | 9.193 | 128758 | 5.303 | 124190 | 5.234 | 71440 | 116.752 | 645179 | 0.0181 |
| 1987 | 20.356 | 58405 | 103.260 | 130648 | 111.736 | 156183 | 90.598 | 140150 | 253.419 | 150203 | 11.245 | 69944 | 590.614 | 705533 | 0.0837 |
| 1988 | 45.557 | 78522 | 73.119 | 114126 | 156.795 | 180024 | 184.733 | 163539 | 43.673 | 95877 | 8.247 | 54487 | 512.124 | 686575 | 0.0746 |
| 1989 | 25.721 | 93761 | 61.026 | 124159 | 100.859 | 156824 | 62.522 | 150516 | 50.667 | 138749 | 5.577 | 71588 | 306.372 | 735597 | 0.0416 |
| 1990 | 94.174 | 74333 | 79.564 | 142886 | 111.671 | 152886 | 52.838 | 129981 | 42.567 | 118679 | 12.003 | 84140 | 392.817 | 702905 | 0.0559 |
| 1991 | 30.330 | 65917 | 116.666 | 155801 | 258.683 | 224515 | 220.934 | 244989 | 198.185 | 173951 | 17.195 | 80495 | 841.993 | 945668 | 0.0890 |
| 1992 | 86.769 | 61555 | 133.469 | 105083 | 244.872 | 192595 | 242.865 | 197856 | 197.085 | 141488 | 20.227 | 79684 | 925.287 | 778261 | 0.1189 |
| 1993 | 64.674 | 74363 | 252.020 | 122942 | 666.224 | 158334 | 660.070 | 194529 | 101.054 | 129704 | 12.385 | 85414 | 1756.427 | 765286 | 0.2295 |
| 1994 | 31.003 | 61291 | 155.944 | 130758 | 107.772 | 124209 | 79.634 | 123228 | 40.431 | 103305 | 14.229 | 56745 | 429.013 | 599536 | 0.0716 |
| 1995 | 146.577 | 111910 | 127.735 | 153218 | 135.440 | 192965 | 122.061 | 145747 | 42.037 | 113881 | 14.219 | 71754 | 588.069 | 789475 | 0.0745 |
| 1996 | 58.349 | 86151 | 130.023 | 127103 | 222.465 | 205521 | 145.131 | 147905 | 64.208 | 132244 | 48.366 | 87046 | 668.542 | 785970 | 0.0851 |
| 1997 | 32.343 | 59771 | 98.710 | 122024 | 114.758 | 147611 | 185.467 | 125538 | 156.007 | 131515 | 4.881 | 60189 | 592.166 | 646648 | 0.0916 |
| **Average** | **53.528** | **73082** | **113.584** | **128215** | **190.862** | **170968** | **171.337** | **157728** | **99.553** | **129482** | **14.484** | **72744** | **643.348** | **732219** | |
| **% Sediment wrt runoff** | **0.0732** | | **0.0886** | | **0.1116** | | **0.1086** | | **0.0769** | | **0.0199** | | **0.0879** | | |

## Annexure-4.3 (d)

### Month wise sediment load and runoff at Sirwani on river Teesta during monsoon

(Unit: ham)

| Year | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Total | | % Sediment wrt runoff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | |
| 1986 | 60.053 | 58954 | 71.608 | 134374 | 162.609 | 211850 | 46.256 | 154774 | 104.800 | 164959 | 4.193 | 90048 | 449.519 | 814959 | 0.0552 |
| 1987 | 76.609 | 71052 | 224.491 | 165610 | 207.913 | 214047 | 141.408 | 197425 | 443.660 | 197022 | 39.917 | 98040 | 1133.998 | 943196 | 0.1202 |
| 1988 | 123.208 | 100907 | 104.269 | 129555 | 251.725 | 245879 | 283.984 | 271370 | 154.129 | 166726 | 27.843 | 82170 | 945.158 | 996607 | 0.0948 |
| 1989 | 44.200 | 110720 | 179.369 | 182730 | 134.280 | 239992 | 97.969 | 214387 | 131.342 | 200167 | 14.914 | 89784 | 602.074 | 1037780 | 0.0580 |
| 1990 | 29.624 | 99582 | 114.066 | 200750 | 244.592 | 253317 | 80.184 | 197143 | 108.446 | 180384 | 6.993 | 107312 | 583.905 | 1038488 | 0.0562 |
| 1991 | 88.737 | 101673 | 67.730 | 174788 | 262.342 | 250933 | 178.175 | 270318 | 95.247 | 203504 | 19.013 | 95501 | 711.244 | 1096717 | 0.0649 |
| 1992 | 10.956 | 78324 | 48.895 | 116670 | 150.266 | 212970 | 56.959 | 192304 | 47.449 | 147897 | 13.920 | 85783 | 328.445 | 833948 | 0.0394 |
| 1993 | 41.239 | 90909 | 91.038 | 141267 | 111.287 | 204223 | 114.318 | 234484 | 14.423 | 151411 | 1.397 | 95233 | 373.702 | 917527 | 0.0407 |
| 1994 | 12.957 | 76760 | 61.583 | 156831 | 53.300 | 147599 | 69.997 | 149182 | 32.578 | 124541 | 12.940 | 72938 | 243.355 | 727851 | 0.0334 |
| 1995 | 119.485 | 145605 | 120.709 | 202433 | 170.528 | 248729 | 107.576 | 206736 | 43.892 | 165930 | 17.451 | 100444 | 579.641 | 1069877 | 0.0542 |
| 1996 | 138.636 | 111507 | 148.407 | 153847 | 310.036 | 246572 | 161.094 | 176444 | 88.637 | 157396 | 74.393 | 101962 | 921.203 | 947728 | 0.0972 |
| 1997 | 33.521 | 73824 | 196.383 | 162073 | 131.017 | 181068 | 253.859 | 160561 | 212.201 | 171851 | 7.768 | 73665 | 834.749 | 823042 | 0.1014 |
| **Average** | **64.935** | **93318** | **119.046** | **160077** | **182.491** | **221432** | **132.648** | **202094** | **123.067** | **169316** | **20.062** | **91073** | **642.249** | **937310** | |
| **% Sediment wrt runoff** | **0.0696** | | **0.0744** | | **0.0824** | | **0.0656** | | **0.0727** | | **0.0220** | | **0.0685** | | |

**Annexure-4.3 (e)**

## Month wise sediment load and runoff at Khanitar on river Teesta during monsoon

(Unit: ham)

| Year | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Total | | % Sediment wrt runoff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | Sediment load | Runoff | |
| 1995 | 150.143 | 142746 | 147.161 | 205991 | 203.204 | 225680 | 99.774 | 176442 | 45.126 | 144288 | 20.485 | 91624 | 665.893 | 986771 | 0.0675 |
| 1996 | 155.923 | 169740 | 292.575 | 255704 | 483.797 | 365012 | 143.875 | 239768 | 68.309 | 203810 | 27.751 | 139140 | 1172.230 | 1373174 | 0.0854 |
| 1997 | 18.928 | 66623 | 132.084 | 2E+06 | 52.688 | 226046 | 109.802 | 207497 | 88.126 | 217856 | 3.071 | 87222 | 404.699 | 2655730 | 0.0152 |
| **Average** | **108.331** | **126370** | **190.607** | **770727** | **246.563** | **272246** | **117.817** | **207902** | **67.187** | **188651** | **17.102** | **105995** | **747.607** | **1671892** | 0.056 |
| **% Sediment wrt runoff** | **0.0857** | | **0.0247** | | **0.0906** | | **0.0567** | | **0.0356** | | **0.0161** | | **0.0516** | | |

**Annexure-5.2**

## MINOR IRRIGATION CHANNELS
## LIST OF FUNCTIONING AND DEFUNCT SCHEMES
## EAST DISTRICT

| Sl.No | Name of Schemes | Block | Functioning | Defunct |
|---|---|---|---|---|
| 1 | Tamang Gumpa MIC | Assam Lingzey | Functioning | |
| 2 | Saj Botey MIC | Assam Lingzey | Functioning | |
| 3 | Jali Khola MIC | Assam Lingzey | Functioning | |
| 4 | Tamang Gaon MIC | Assam Lingzey | Functioning | |
| 5 | Kalijaley MIC | Assam Lingzey | | Defunct |
| 6 | Dara Khet MIC | Assam Lingzey | Functioning | |
| 7 | Raja Khet MIC | Assam Lingzey | Functioning | |
| 8 | Bhusuk Khola MIC | Assam Lingzey | | Defunct |
| 9 | Tamang Gain MIC | Assam Lingzey | Functioning | |
| 10 | Suntaley MIC | Assam Lingzey | | Defunct |
| 11 | Bhusuk Khola MIC | Assam Lingzey | Functioning | |
| 12 | Lukchy Khola MIC | Assam Lingzey | Functioning | |
| 13 | Ghirling Jhora MIC | Assam Lingzey | Functioning | |
| 14 | Sourani Pairini MIC | Assam Lingzey | Functioning | |
| 15 | Sourini sasbotey MIC | Assam Lingzey | Functioning | |
| 16 | Mangala Jhora MIC Tamla | Assam Lingzey | Functioning | |
| 17 | Borbotey MIC at Lingzey | Assam Lingzey | Functioning | |
| 18 | Subdar Jhora MIC at Assam Lingzey | Assam Lingzey | Functioning | |
| 19 | Chandrahang Jhora MIC | Assam Lingzey | Functioning | |
| 20 | Thaithaley MIC at U/Assam | Assam Lingzey | Functioning | |
| 21 | Bala Khola MIC at U/Assam | Assam Lingzey | | Defunct |
| 22 | Kami Dhara MIC at Lingzey | Assam Lingzey | Functioning | |
| 23 | Kali Khola MIC at Nandok | Assam Lingzey | Functioning | |
| 24 | Lepcha Jhora MIC at Nandok | Assam Lingzey | Functioning | |
| 25 | Poktp Jhora MIC Tamla | Assam Lingzey | Functioning | |
| 26 | L/sallaley MIC | Assam Lingzey | Functioning | |
| 27 | Settlement MIC | Assam Lingzey | Functioning | |
| 28 | Lungu MIC | Assam Lingzey | Functioning | |
| 29 | Rizeysunga Salaley MIC | Assam Lingzey | Functioning | |
| 30 | Payong Botey MIC | Assam Lingzey | Functioning | |
| 31 | Lepcha Gain MIC | Assam Lingzey | Functioning | |
| 32 | Upratey MIC at L/aho Yangtam | AhoYangtam | Functioning | |
| 33 | Chota Singtam Mic at AhoYangtam | AhoYangtam | | Defunct |
| 34 | ChungChongey MIC at L/aho | AhoYangtam | Functioning | |

| | | | | |
|---|---|---|---|---|
| 35 | Mandir Jhora MIC at aho Yangtam | AhoYangtam | Functioning | |
| 36 | Devithan Sajbotey MIC at L/aho | AhoYangtam | | Defunct |
| 37 | Devithan Sajbotey MIC Ahoyangtam | AhoYangtam | Functioning | |
| 38 | Bala Kulo ata Aho Yangtam | AhoYangtam | Functioning | |
| 39 | Mandir Khet MIC at above 8th Mile | AhoYangtam | Functioning | |
| 40 | Char hange MIC at U/Aho | AhoYangtam | Functioning | |
| 41 | Kutter botey MIC near Khada Factory at L/Aho | AhoYangtam | Functioning | |
| 42 | Bagala gaon Mic at Middle Aho | AhoYangtam | Functioning | |
| 43 | 8th Mile jhora MIC at Aho | AhoYangtam | Functioning | |
| 44 | Const. Of Paper Factory MIC | AhoYangtam | Functioning | |
| 45 | Const. Of Devithan MIC | AhoYangtam | Functioning | |
| 46 | Reegay Jhora MIC at Chagey Santi | ChageySanti | Functioning | |
| 47 | Gagcha Jhora MIC | ChageySanti | Functioning | |
| 48 | Jhakri Jhora MIC | ChageySanti | Functioning | |
| 49 | Jhakri Jhora MIC | ChageySanti | Functioning | |
| 50 | Changharay MIC | ChageySanti | Functioning | |
| 51 | SimalboteyMIc | Chujachen | Functioning | |
| 52 | Pam DharaMIC | Chujachen | Functioning | |
| 53 | Baggarey Khola MIC Rongli | Chujachen | Functioning | |
| 54 | Richu Khola MIC | Riwa Parakha | Functioning | |
| 55 | Ratey Khola MIC Linkey | Riwa Parakha | Functioning | |
| 56 | Ratey Khola MIC to Tunibotey | Riwa Parakha | Functioning | |
| 57 | Richu Khola MIC to Machong | Riwa Parakha | Functioning | |
| 58 | Changtheng Khola MIC to U/Parakha Bhutia Gaon | Riwa Parakha | Functioning | |
| 59 | Hamchang Jhora MIC to Phekuchen | Riwa Parakha | | Defunct |
| 60 | Sabda Khola to Lossing | Riwa Parakha | | Defunct |
| 61 | Gurung Khola to Riba | Riwa Parakha | Functioning | |
| 62 | Lungchen Jhora MIC at Bara Pathing | Latuk Chuchenpheri | Functioning | |
| 63 | Zilling MIC at Chuchenphen | Latuk Chuchenpheri | Functioning | |
| 64 | Salaley Khola MIC | Latuk Chuchenpheri | Functioning | |
| 65 | Tatopani MIC at Chuchen | Latuk Chuchenpheri | Functioning | |
| 67 | U/Ratey Khola MIC | Dalopchand | Functioning | |
| 68 | Chandani Jhora MIC | Dalopchand | Functioning | |
| 69 | Sawa Khola MIC | Dalopchand | Functioning | |
| 70 | Rata Khola MIC | Dalopchand | Functioning | |
| 71 | Uring ratey Hazong MIC | Dalopchand | Functioning | |
| 72 | Nava Khola MIC | Dalopchand | Functioning | |
| 73 | Bhok Bhaka MIC | Dalopchand | Functioning | |
| 74 | Subaney Dara MIC | Premlakha | Functioning | |

| | | | | |
|---|---|---|---|---|
| 75 | Devithan jhora MIC at Lamatean | Rolap Lamatam | Functioning | |
| 76 | Bulung Jhora MIC | Rolap Lamatam | Functioning | |
| 77 | Bhakutar MIC Lingtam | Lingtam Phademchen | Functioning | |
| 78 | Simana Khola MIC at Khamdong | Aritar | Functioning | |
| 79 | Kyonsna MIC at Khamdong | Aritar | Functioning | |
| 80 | Lapsi Khola MIC | Aritar | Functioning | |
| 81 | U/Lapsi Khola MIC | Aritar | Functioning | |
| 82 | Khimey Khola MIC | Aritar | Functioning | |
| 83 | Uring Khola MIC Sajhotey Jhora MIC | Aritar | Functioning | |
| 84 | Patpatey Jhora MIC | Aritar | Functioning | |
| 85 | Maney Jhora MIC | Aritar | Functioning | |
| 86 | Tuni Jhora MIC | Aritar | Functioning | |
| 87 | Kyongsa Khola MIC | Aritar | Functioning | |
| 88 | Hazabg Jhora MIC | Aritar | Functioning | |
| 89 | Mag Gaon MIC | Aritar | | Defunct |
| 90 | U/Simana Khola MIC | Aritar | | Defunct |
| 91 | Draupadhi MIC | Aritar | | Defunct |
| 92 | Mandhir Jhora MIC | Aritar | | Defunct |
| 93 | Simana Khola MIC at Khamdong | Aritar | | Defunct |
| 94 | Chowen Gaon MIC | Rehnock Tartpin | Functioning | |
| 95 | Chuba Khola MIC | Rehnock Tartpin | Functioning | |
| 96 | Bhattey Dhara MIC | Rehnock Tartpin | Functioning | |
| 97 | Reshi Khola MIC | Rehnock Tartpin | Functioning | |
| 98 | Guhay Khola MIC | Rehnock Tartpin | Functioning | |
| 99 | Kaijaley Khola MIC | Rehnock Tartpin | Functioning | |
| 100 | Bharlay Khola Mic | Pacheykhani | Functioning | |
| 101 | pachay Khola MIC | Pacheykhani | Functioning | |
| 102 | Dikling Jhora MIC | Pacheykhani | Functioning | |
| 103 | Shiva Mandir Jhora MIC | Pacheykhani | Functioning | |
| 104 | Ageetee Kholoa MIC | Pacheykhani | Functioning | |
| 105 | Pacho Khola MIC | Pacheykhani | Functioning | |
| 106 | Kali Khola MIC at Nandok | Pacheykhani | Functioning | |
| 107 | Lepcha Jhora MIC at Nandok | Pacheykhani | Functioning | |
| 108 | Danak Byassi MIC | Tareythang | | Defunct |
| 109 | Paudyal Jhora MIC | Tareythang | Functioning | |
| 110 | Manpur MIC | Tareythang | Functioning | |
| 111 | Patharey Byassi MIC | Tareythang | Functioning | |
| 112 | Linkey Source MIC | Tareythang | Functioning | |
| 113 | U/Biring MIC | Tareythang | Functioning | |
| 114 | Dhur Byassi MIC | Tareythang | Functioning | |

| | | | | |
|---|---|---|---|---|
| 115 | Gangatey Jhora MIC | Tareythang | Functioning | |
| 116 | Gautani Jhora MIC | Tareythang | Functioning | |
| 117 | L/Biring MIC | Tareythang | | Defunct |
| 118 | Sajbotey MIC | Tareythang | Functioning | |
| 119 | Rateay Khola MIC | Amba | Functioning | |
| 120 | Danak Khola MIC | Amba | Functioning | |
| 121 | Chuttang Byassi MIC | Amba | | Defunct |
| 123 | Takchang MIC | Amba | | Defunct |
| 124 | Bhagutey MIC | Amba | Functioning | |
| 125 | kathar Botey MIC | Amba | Functioning | |
| 126 | Ghimiray Khola MIC | Amba | Functioning | |
| 127 | Const. Of Chulthang Kalizy | Amba | Functioning | |
| 128 | Mulukay Khola MIC | Sudunglakha | Functioning | |
| 129 | gurung Khola MIC | Sudunglakha | Functioning | |
| 130 | L/Mulukey Khet MIC | Sudunglakha | Functioning | |
| 131 | Kali Khola MIC | Sudunglakha | Functioning | |
| 132 | Ruchal Jhora MIC | Taza | Functioning | |
| 134 | Aambotey Jhora | Taza | | Defunct |
| 135 | Rigmee Jhora MIC' | Taza | Functioning | |
| 136 | Danulla Jhora MIC | Taza | Functioning | |
| 137 | Durga Jhora MIC | Taza | Functioning | |
| 138 | Lepcha Jhora MIC at Nandok | Taza | Functioning | |
| 139 | Pradhan Jhora MIC | Taza | Functioning | |
| 140 | Thapa Jhora MIC | Taza | Functioning | |
| 141 | U/Basilakha MIC | Namchebong | | Defunct |
| 142 | L/Basilakha MIC | Namchebong | Functioning | |
| 143 | Namdu Jhora MIC | Namchebong | Functioning | |
| 144 | Thapa Jhora MIC | Namchebong | Functioning | |
| 145 | Bhoju Jhora MIC | Namchebong | Functioning | |
| 146 | Lepcha Jhora MIC | Namchebong | Functioning | |
| 147 | Basnett Jhora MIC | Namchebong | Functioning | |
| 148 | Sisney Khola MIC | Namchebong | Functioning | |
| 149 | Devithani Jhora MIC | Namchebong | Functioning | |
| 150 | Dorthek Jhora MIC | Namchebong | Functioning | |
| 151 | Lingeythang MIC | Pakyong | | Defunct |
| 152 | Sai Mandir MIC | Pakyong | Functioning | |
| 153 | Agi Khola MIC | Pakyong | Functioning | |
| 154 | Gairi Khet MIC | Pakyong | | Defunct |
| 155 | Sakhya Jhora MIC | Pakyong | Functioning | |
| 156 | Dikling Jhora MIC | Pakyong | Functioning | |

| | | | | |
|---|---|---|---|---|
| 157 | Mandir Jhora MIC at aho Yangtam | Pakyong | Functioning | |
| 158 | Lochu Khola MIC | Naitam | Functioning | |
| 159 | Rechey Khola MIC | Nandok | Functioning | |
| 160 | Zingla MIC | Phengyong | Functioning | |
| 161 | Rankey Khola MIC | Central Pandam | Functioning | |
| 162 | Sawney MIC | Central Pandam | Functioning | |
| 163 | Cheurey Botey MIC | Central Pandam | Functioning | |
| 164 | Mishratar MIC | Central Pandam | Functioning | |
| 165 | Gangatey MIC | Central Pandam | Functioning | |
| 166 | Kazigaon MIC | Central Pandam | Functioning | |
| 167 | Bhurung Khola MIC | Central Pandam | Functioning | |
| 168 | Samsing Suntaley MIC | Sajong | Functioning | |
| 169 | Birey Khola Gumpa dara MIC | East Pandam | Functioning | |
| 170 | Padamchey MIC | East Pandam | Functioning | |
| 171 | Supari Dara MIC | East Pandam | | Defunct |
| 172 | Kumrek MIC | East Pandam | Functioning | |
| 173 | Rajey Bungthang MIC | East Pandam | | Defunct |
| 174 | Kamarey MIC | East Pandam | Functioning | |
| 175 | Dikling Khola MIC | East Pandam | Functioning | |
| 176 | Kurley MIC | East Pandam | | Defunct |
| 176 | Samkey MIC | East Pandam | Functioning | |
| 177 | Simanal Khola MIC | West Pandam | Functioning | |
| 178 | Upper Patahaing MIC | West Pandam | Functioning | |
| 179 | Upper Baghey MIC | West Pandam | | Defunct |
| 180 | Toribari MIC | West Pandam | Functioning | |
| 181 | Middle Baghey MIC | West Pandam | Functioning | |
| 182 | Suntaley Baghey MIC | West Pandam | Functioning | |
| 183 | West Pandem MIC | West Pandam | Functioning | |
| 184 | Upper Mazitar MIC | West Pandam | Functioning | |
| 185 | Mazitar MIC | West Pandam | Functioning | |
| 186 | Koiraley MIC | West Pandam | Functioning | |
| 187 | Sakhu MIC | West Pandam | Functioning | |
| 188 | Gangatey MIC | West Pandam | Functioning | |
| 189 | Sawney MIC | West Pandam | Functioning | |
| 190 | Baghey Khola MIC | West Pandam | Functioning | |
| 191 | Arangthang MIC | Panchak | Functioning | |
| 192 | Sajbotey Dungdung MIC | Dungdung | Functioning | |
| 193 | Nampong MIC | Nampong | Functioning | |
| 194 | Sunderisan MIC | Nampong | Functioning | |
| 195 | Navey MIC | Navey | Functioning | |

| | | | | |
|---|---|---|---|---|
| 196 | Fengla to Genzing MIC | Navey | Functioning | |
| 197 | Shotak MIC | Navey | Functioning | |
| 198 | Mechu to Pakchu MIC | Navey | Functioning | |
| 199 | Sonam Wangchuk MIC | Navey | Functioning | |
| 200 | Parakyong Doring Khet MIC | Martam | Functioning | |
| 201 | Sajbotey MIC | Martam | Functioning | |
| 202 | Chumbokyong MIC | Martam | Functioning | |
| 203 | Malubhulkey MIC | Martam | Functioning | |
| 204 | Sourbotey Namphong MIC | Martam | Functioning | |
| 205 | Chamkan MIC atMartam | Martam | Functioning | |
| 206 | Dojey Khola MIC at Yangthang Martam | Martam | Functioning | |
| 207 | Hukey MIC at Yangthang Martam | Martam | | Defunct |
| 208 | Seti Khola MIC at Martam | Martam | Functioning | |
| 209 | Darim Khola MIC at Martam | Martam | Functioning | |
| 210 | Mal Khola; MIC at Martam | Martam | Functioning | |
| 211 | Bansari Gaon MIC at Martam | Martam | Functioning | |
| 212 | Takila MIC at Martam | Martam | Functioning | |
| 213 | Sankey Khola MIC at Yangthang Martam | Martam | Functioning | |
| 214 | Upper Nazitam MIC at Nazitam | Martam | Functioning | |
| 215 | Lower Nazitam MIC | Martam | Functioning | |
| 216 | Pharey KholaMIC Rabdong | Martam | Functioning | |
| 217 | Parkyong MIC at Martam | Martam | Functioning | |
| 218 | Chung Chung Pakha MIC at Martam | Martam | | Defunct |
| 219 | Lethang Khola MIC at Lingtam | Martam | Functioning | |
| 220 | ChuChu jhora MIC at Martam | Martam | Functioning | |
| 221 | Mamphong Dhara MIC | Martam | Functioning | |
| 222 | Damay Pani MIC at Martam | Martam | Functioning | |
| 223 | Sankey Khola MIC at Martam | Martam | Functioning | |
| 224 | Lingtam MIC at Martam | Martam | Functioning | |
| 225 | Kungi Khola MIC at Patim | Martam | Functioning | |
| 226 | ChotamgMIC atTirkutam | Martam | Functioning | |
| 227 | Lower Barmi Gaon MIC at Martam | Martam | Functioning | |
| 228 | LowerBhutey Jhora MIC at Rabdong | Martam | Functioning | |
| 229 | Hukey Olee kholaMIC at Yanthang Martam | Martam | Functioning | |
| 230 | Chomerey KholaMIC at Tirkutam | Martam | Functioning | |
| 231 | Dong Khola MICat lower Martam | Martam | Functioning | |
| 232 | Arithang MIC at Patim | Martam | | Defunct |
| 233 | Lashu Khola MIC at Tirkutam | Martam | Functioning | |
| 234 | Lower Chamerey Khola MIC at Tikrutam | Martam | Functioning | |
| 235 | Masha Khola MIC at Tirkutam | Martam | Functioning | |

| | | | | |
|---|---|---|---|---|
| 236 | Fekcha Khola MIC at Nazitam | Martam | Functioning | |
| 237 | kabrebotey MIC atPatim Nazitam | Martam | Functioning | |
| 238 | Tshalamthang MIC atTshalamthang | Martam | Functioning | |
| 239 | Reshi Khola MIC | Martam | Functioning | |
| 240 | Rajik Khola MIC | Martam | Functioning | |
| 241 | Namli MIC | Martam | Functioning | |
| 242 | Zingla MIC | Martam | Functioning | |
| 243 | Dubokorey Namli MIC | Martam | Functioning | |
| 244 | Kunzi Khola MIC | Tirkutam | Functioning | |
| 245 | Tirkutam MIC | Tirkutam | Functioning | |
| 246 | songchu MIC | Tshabumthang | Functioning | |
| 247 | Bashi Khola ;Mandir MIC | Pacheykhani | Functioning | |
| 248 | Pacha Khola MIC | Rorathang | Functioning | |
| 249 | Udawney MIC | Rakdong Tintek | Functioning | |
| 250 | Tularam MIC | Rakdong Tintek | Functioning | |
| 251 | Ninden MIC | Rakdong Tintek | Functioning | |
| 252 | Kuthurbing MIC | Barbing | Functioning | |
| 253 | Bhotey Kulo ;MIC | Luing | Functioning | |
| 254 | kali Khola MIC | Parbing | Functioning | |
| 255 | Bhotey Kulo ;MIC | Parbing | Functioning | |
| 256 | Dami Kholsa MIC | Ranka | Functioning | |
| 257 | Sorang Kulo MIC | Ranka | Functioning | |
| 258 | Kaijaley Kulo MIC | Ranka | Functioning | |
| 259 | Daley kansu MIC | Ranka | Functioning | |
| 260 | Sim Jhora MIC | Ranka | Functioning | |
| 261 | Pajong Khola MIC | Ranka | Functioning | |
| 262 | Ramitey Kulo MIC | Ranka | Functioning | |
| 263 | Changey Kulo MIC | Ranka | Functioning | |
| 264 | Latey Khola MIC | Ranka | Functioning | |
| 265 | Changey ( Changrang) Khola MIC | Ranka | Functioning | |
| 266 | gyashi Khola MIC | Ranka | Defunct | |
| 267 | Pachu Khola MIC | Ranka | Functioning | |
| 268 | Luing Bashi MIC | Ranka | Functioning | |
| 269 | Lain Jhora MIC | Ranka | Functioning | |
| 270 | Baarpipal Kulo MIC | Ranka | | Defunct |
| 271 | Devithaney MIC | Ranka | Functioning | |
| 272 | Paleythang gotamey MIC | Ranka | Functioning | |
| 273 | Bhatey Kulo MIC | Ranka | Functioning | |
| 274 | Kalabaong MIC | Ranka | Functioning | |
| 275 | Malam Khola MIC | Ranka | Functioning | |

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|---|---|---|---|---|
| 276 | Kholsa Luing MIC | Ranka | Functioning | |
| 277 | Lower Pachu Khola MIC | Ranka | Functioning | |
| 278 | Burshai Kulo Mic | Ranka | Functioning | |
| 279 | Kattal Gaon MI | Ranka | Functioning | |
| 280 | Kushidong MIC | Ranka | | Defunct |
| 281 | Lower Devithaney MIC | Ranka | Functioning | |
| 282 | Khashidong Bhaley Gaon | Ranka | Functioning | |
| 283 | Chobti Ratta MIC | Ranka | Functioning | |
| 284 | Dolishing Khola MIC | Ranka | Functioning | |
| 285 | Maley Tami Kami Dara | Ranka | Functioning | |
| 286 | Dami Kholsa MIC | Ranka | Functioning | |
| 287 | Malangthang MIC | Ranka | Functioning | |
| 288 | Chaindhara MIC | Ranka | Functioning | |
| 289 | Mansarey Kulo MIC | Ranka | Functioning | |
| 290 | School Jhora MIC | Ranka | Functioning | |
| 291 | Thamchey Kakha MIC | Ranka | Functioning | |
| 292 | Devi Kholsa Rai Gaon MIC | Ranka | Functioning | |
| 293 | MelJhora MIC | Sangtong | Functioning | |
| 294 | Dhaturey Ambakey MIC | Sangtong | Functioning | |
| 295 | Mel Botey MIC | Sangtong | Functioning | |
| 296 | Salangthang MIC | Sangtong | Functioning | |
| 297 | Virkuna MIC | Sangtong | Functioning | |
| 298 | Bhotey Dara MIC | Sangtong | Functioning | |
| 299 | Thalley dara MIC | Sangtong | Functioning | |
| 300 | chulumthang MIC | Sangtong | Functioning | |
| 301 | Bhotey Dhara MIC | Sangtong | Functioning | |
| 302 | Rankey Bhotey Dhara MIC | Sangtong | Functioning | |
| 303 | Thapa Jhora MIC | Rawtey Rumtek | Functioning | |
| 304 | Sajbptau MIC | Rawtey Rumtek | Functioning | |
| 305 | Dhendhengay MIC | Rawtey Rumtek | Functioning | |
| 306 | Kayathang MIC | Rawtey Rumtek | Functioning | |
| 307 | Rumtek School Jhora MIC | Rawtey Rumtek | Functioning | |
| 308 | Tatopani MIC | Rawtey Rumtek | Functioning | |
| 309 | Mandir Jhora MIC | Rawtey Rumtek | Functioning | |
| 310 | DhangDhangey MIC at Leprosey Hospital complex | Rawtey Rumtek | Functioning | |
| 311 | Maney dara MIC' | Rawtey Rumtek | Functioning | |
| 312 | Mandal Jhora MIC | Rawtey Rumtek | Functioning | |
| 313 | Rawtey Barbing MIC | Rawtey Rumtek | Functioning | |
| 314 | DhangDhangey MIC below Curior Shop | Rawtey Rumtek | Functioning | |

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|---|---|---|---|---|
| 315 | chengey Khola MIC | Rawtey Rumtek | Functioning | |
| 316 | Akchu Khola MIC | Rawtey Rumtek | Functioning | |
| 317 | DhangDhangey MIC below Neopaney Gaon | Rawtey Rumtek | | Defunct |
| 318 | Sajong Dara Gaon MIC | Rawtey Rumtek | Functioning | |
| 319 | Middle Chinzey MIC | Rawtey Rumtek | Functioning | |
| 320 | Reshi Khola MIC | Rawtey Rumtek | Functioning | |
| 321 | Akchu Khola MIC | Rawtey Rumtek | Functioning | |
| 322 | Chinzey Jhora MIC | Rawtey Rumtek | Functioning | |
| 323 | Sajong MIC below Neopani gaon | Rawtey Rumtek | Functioning | |
| 324 | Khayong Khola MIC above view point | Rawtey Rumtek | | Defunct |
| 325 | Bojani MIC | Rawtey Rumtek | Functioning | |
| 326 | Sirisay MIC | Rawtey Rumtek | Functioning | |
| 327 | Cheseni MIC | Rawtey Rumtek | Functioning | |
| 328 | Samdong MIC | Rawtey Rumtek | Defunct | |
| 329 | Sim Khola MIC | Rey Mindu | Functioning | |
| 330 | Phedong MIC | Rey Mindu | Functioning | |
| 331 | Beberchi MIC | Rey Mindu | Functioning | |
| 332 | rodong MIC | Rey Mindu | | Defunct |
| 333 | Lingdum Kholsa MIC | Rey Mindu | Functioning | |
| 334 | Rembek MIC | Rey Mindu | Functioning | |
| 335 | Reeksel MIC | Rey Mindu | | Defunct |
| 336 | Sekey Dara MIC | Rey Mindu | Functioning | |
| 337 | Kepur Kholsa MIC | Rey Mindu | Functioning | |
| 338 | Rey Kerchi MIC | Rey Mindu | Functioning | |
| 339 | Beling Khola MIC | Rey Mindu | Functioning | |
| 340 | Paleythang MIC | Rey Mindu | Functioning | |
| 341 | Segu Khola MIC | Rey Mindu | Functioning | |
| 342 | Shettri Khola MIC | Tathangchen | Functioning | |
| 343 | Bhelu Khola MIC | Tathangchen | Functioning | |
| 344 | Shurungchuk MIC | Tathangchen | Functioning | |
| 345 | Legamthang MIC | Tathangchen | Functioning | |
| 346 | Copi Bari MIC | Tathangchen | Functioning | |
| 347 | Aap Bhotey MIC | Tathangchen | Functioning | |
| 348 | Reng Reng Jhora MIC | Tathangchen | Functioning | |
| 349 | MES Jhora MIC | Tathangchen | | Defunct |
| 350 | Manger Gaon MIC | Tathangchen | Functioning | |
| 351 | Devithan MIC | Tathangchen | Functioning | |
| 352 | Gerethang MIC | Tathangchen | Functioning | |
| 353 | Tamang Gaon MIC | Tathangchen | Functioning | |
| 354 | Raigaon MIC | Tathangchen | Functioning | |

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|---|---|---|---|---|
| 355 | L/ Syari MIC | Tathangchen | Functioning | |
| 356 | Gangetay Khola MIC | Tathangchen | Functioning | |
| 357 | Khiku MIC | Tephyak Mendu | Functioning | |
| 358 | Sishay Shiva Mandir MIC | North Regu | Functioning | |
| 359 | Tikrak Khola MIC at Chuba | Samlik Marchak | Functioning | |
| 360 | Pendem Jhora MIC at tumblabong | Samlik Marchak | Functioning | |
| 361 | Chuba Khola MIC at Radong | Samlik Marchak | Functioning | |
| 362 | Parla Khola MIC at Samlik | Samlik Marchak | Functioning | |
| 363 | Chuba Khola MIC at Upper Namin | Samlik Marchak | | Defunct |
| 364 | Reshi Khola ;MIC at Marchak | Samlik Marchak | Functioning | |
| 365 | Reshi Khola MIC at Upper Samlik | Samlik Marchak | Functioning | |
| 366 | Sidi Jhora MIC ata Upper Marchak | Samlik Marchak | Functioning | |
| 367 | Kyongsing MIC at Middle Marchak | Samlik Marchak | | Defunct |
| 368 | Kharka Jhora MIC at Lower Marchak | Samlik Marchak | Functioning | |
| 369 | 9th MIC Namli | Samlik Marchak | Functioning | |
| 370 | chuba Khola MIC at Nepal Gaon | Samlik Marchak | Functioning | |
| 371 | Lasla Khola MIC at Tirkutam Samlik | Samlik Marchak | | Defunct |
| 372 | MIC at Namli Tumblabong | Samlik Marchak | Functioning | |
| 373 | Chuba Khola MIC at Namli | Samlik Marchak | Functioning | |
| 374 | DungDung to Ralap MIC | Khamdong | Functioning | |
| 375 | Singbel MIC at Khamdong | Khamdong | Defunct | |
| 376 | Sajbotey DungDung MIC | Khamdong | Functioning | |
| 378 | Bhuttey Khola MIC Ben | Ben Phegyong | Functioning | |
| 379 | Dharey Khola MIC at Phegyong | Ben Phegyong | Functioning | |
| 380 | Sang Khola MIC at Phegyong | Ben Phegyong | | Defunct |
| 381 | chisopani MIC at Sirwani | Ben Phegyong | Functioning | |
| 382 | Kazi Kulo MIC at Lower Sichey | Sichey Gaon | Functioning | |
| 383 | Kazi Jhora MIC at Lower Sichey | Sichey Gaon | Functioning | |
| 384 | Suntaley MIC at Lower Sichey | Sichey Gaon | Functioning | |
| 385 | Raja Khet Lower Sichey | Sichey Gaon | Functioning | |
| 386 | Tamging & Tamging MIC | Sichey Gaon | Functioning | |
| 387 | Tebuthang MIC | Sichey Gaon | Functioning | |
| 389 | Dhatway Khola MIC | Sichey Gaon | Functioning | |
| 388 | Karyi Khola MIC | Sichey Gaon | Functioning | |
| 390 | Tenzing & Tenzing Kholsa | Sichey Gaon | Functioning | |
| 391 | Sim Jhora MIC | Sichey Gaon | Functioning | |
| 392 | Kazey Khola MIC | Sichey Gaon | Functioning | |
| 393 | Goring Khola | Sichey Gaon | Functioning | |
| 394 | Old Diesel Power House MIC | Upper Sichey | | Defunct |
| 395 | Lama Rai gaon MIC | Upper Sichey | Functioning | |

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|---|---|---|---|---|
| 396 | Aansari Dara MIC | Upper Sichey | Functioning | |
| 397 | Sim Jhora MIC | Upper Sichey | Functioning | |
| 398 | TNHS School Jhora MIC | Upper Sichey | Functioning | |
| 399 | Dhajey MIC | Tumen Kambal | Functioning | |
| 400 | Agathang MIC | Kumen Kambal | Functioning | |
| 401 | Slay MIC | Kumen Kambal | Functioning | |
| 402 | Devithan Jhora MIC | Lingtam | Functioning | |
| 403 | Devithan MIC | Linkey | Functioning | |
| 404 | Reshithang MIC | Luing | Functioning | |
| 405 | Paleything MIC | L/Luing | Functioning | |
| 406 | Bhotey Kulo MIC | Luing | Functioning | |
| 407 | Linzey MIC | Sumin Lingzey | Functioning | |
| 408 | Gurung Gaon MIC | Sumin Lingzey | Functioning | |
| 409 | Bhotey Gaon MIC | Sumin Lingzey | Functioning | |
| 410 | Lower Sumin MIC | Sumin Lingzey | | Defunct |
| 411 | Pabong MIC | Simik Lingzey | Functioning | |
| 412 | Lassi Gaon MIC | Sumen Lingzey | Functioning | |
| 413 | Samdong MIC | Samdong | Functioning | |
| 414 | Barathang MIC | Samdong | Functioning | |
| 415 | Conat. Of Devithan MIC | Yangtam | Functioning | |
| 416 | Rodong MIC | Lingdum | Functioning | |
| 417 | Khiku MIC | Tephyak Mendu | Functioning | |
| 418 | Sishay Shiva Mandir MIC | North Regu | Functioning | |
| 419 | Const, Of MIC at 6th mile | Samdur | Functioning | |
| 420 | Bagey Khola MIC | Regu | Functioning | |
| 421 | samdong MIC | Sajong | Functioning | |

**Annexure-5.3**

## MINOR IRRIGATION CHANNELS
## LIST OF FUNCTIONING AND DEFUNCT SCHEMES
## SOUTH DISTRICT

| S NO. | Name of channels | Block | Functional | Defunct |
|---|---|---|---|---|
| 1 | Ben MIC | Ben Namphrik | Functional | |
| 2 | Ben rolok MIC | Ben Namphrik | Functional | |
| 3 | Burfung Lingtam MIC | Burfung Zarong | | Defunct |
| 4 | Bojey khola MIC I | Burfung Zarong | | Defunct |
| 5 | Bojey khola MICII | Burfung Zarong | | Defunct |
| 6 | Anethang pvt. Channel | Burfung Zarong | | Defunct |

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|---|---|---|---|---|
| 7 | Zorrong kutcha channel | Burfung Zarong | Functional | |
| 8 | Zorong MIC | Burfung Zarong | Functional | |
| 9 | Bermiok MIC | Bermiok Tokal | Functional | |
| 10 | Doring MIC | Bermiok Tokal | Functional | |
| 11 | Tokal kutch kulo | Bermiok Tokal | | Defunct |
| 12 | Bermiok Rabini kulo | Bermiok Tokal | | Defunct |
| 13 | Mangley Ramphutar kutcha | Ben Namphrik | Functiuonal | |
| 14 | Ben Namprik MIC | Ben Namphrik | | Defunct |
| 15 | Ben Gabghha kulo | Ben Namphrik | | Defunct |
| 16 | Namprik kutcha kulo | Ben Namphrik | Functional | |
| 17 | Gayree khet kutcha channel | Borong Phamtam | | Defunct |
| 18 | Polok MIC | Borong Phamtam | | Defunct |
| 19 | Borobng kutcha kulo | Borong Phamtam | Functional | |
| 20 | Sada kutcha kulo | Borong Phamtam | Functional | |
| 21 | Chil khota kutcha | Borong Phamtam | | Defunct |
| 22 | Borong kutcha kulo | Borong Phamtam | | Defunct |
| 23 | lower borong MIC | Borong Phamtam | Functional | |
| 24 | Alachi bari kulo ar dalep | Kewzing Bhakhim | | Defunct |
| 25 | Kewzing MIC | Kewzing Bhakhim | Functional | |
| 26 | Lowe samsingMIC | Kewzing Bhakhim | Functional | |
| 27 | Samsing kutcha kulo | Kewzing Bhakhim | Functional | |
| 28 | Kewzing kutcha kulo | Kewzing Bhakhim | | Defunct |
| 29 | Lingzo kutcha channel | Kewzing Bhakhim | Functional | |
| 30 | Dalop MIC | Kewzing Bhakhim | Functional | |
| 31 | Lizzo MIC | Kewzing Bhakhim | Functional | |
| 32 | Hingdan kutcha kulo | Lamating Tingzo | | Defunct |
| 33 | Lower Hingdan kutcha kulo | Lamating Tingzo | | Defunct |
| 34 | Tingmo kutcha kulo | Lamating Tingzo | Functional | |
| 35 | Upper tingmo kutcha kulo | Lamating Tingzo | Functional | |
| 36 | Kazi kulo Tingmo | Lamating Tingzo | Functional | |
| 37 | Middle Tingmo kutcha kulo | Lamating Tingzo | Functional | |
| 38 | Gairi khet kutcha kulo | Lamating Tingzo | | Defunct |
| 39 | Lower Tingmo Kutcha kulo | Lamating Tingzo | | Defunct |
| 40 | Sajbotey kutcha kulo | Lamating Tingzo | | Defunct |
| 41 | Tingmo MIC | Lamating Tingzo | Functional | |
| 42 | Kawkhola MIC | Lingi Payong | Functional | |

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|---|---|---|---|---|
| 43 | Lingi MIC | Lingi Payong | Functional | |
| 44 | Middle Payong MIC | Lingi Payong | | Defunct |
| 45 | Kawkhola kutcha kulo | Lingi Payong | | Defunct |
| 46 | Middle law kuylo | Lingi Payong | | Defunct |
| 47 | Lower kaw kulo | Lingi Payong | Functional | |
| 48 | Ranglap Kulo | Lingi Payong | Functional | |
| 49 | Thapa kulo | Lingi Payong | Functional | |
| 50 | Karzi kulo | Lingi Payong | Functional | |
| 51 | Dakal kulo | Lingi Payong | Functional | |
| 52 | Lower karzi kulo | Lingi Payong | Functional | |
| 53 | Upper Karzi kulo | Lingi Payong | Functional | |
| 54 | Tamyang kulo | Lingi Payong | Functional | |
| 55 | Kawkhola kutcha kulo | Lingi Payong | Functional | |
| 56 | Lower payong kutcha kulo | Lingi Payong | Functional | |
| 57 | Lower samsari | Lingi Payong | | Defunct |
| 58 | Lowersamsari kutcdha kulo | Lingi Payong | | Defunct |
| 60 | Upper payong kutcha kulo | Lingi Payong | | Defunct |
| 61 | Upper payong kutcha kulo ii | Lingi Payong | Functional | |
| 62 | Upper Lingi payong | Lingi Payong | Functional | |
| 63 | Kolthang papthang MIC | Lingmo Kolthang | Functional | |
| 64 | Adhikari kutcha kulo | Lingmo Kolthang | Functional | |
| 65 | Kolthang kutcha kulo I | Lingmo Kolthang | | Defunct |
| 66 | Kolthang kutcha kulo II | Lingmo Kolthang | | Defunct |
| 67 | Kolthangkutha kulo III | Lingmo Kolthang | Functional | |
| 68 | Kolthang kuthca kulo IV | Lingmo Kolthang | Functional | |
| 69 | Kolthang kuthca kulo V | Lingmo Kolthang | | Defunct |
| 70 | Kolthang kuthca kulo VI | Lingmo Kolthang | | Defunct |
| 71 | Kolthang kutha kulo VII | Lingmo Kolthang | Functional | |
| 72 | Kolthang kutha kulo VIII | Lingmo Kolthang | | Defunct |
| 73 | Lingmo Kutha kulo I | Lingmo Kolthang | | Defunct |
| 74 | Lingmo Kutha kulo II | Lingmo Kolthang | Functional | |
| 75 | Mangzing Kutcha kulo I | Lingmo Kolthang | Functional | |
| 76 | Mangzing Kutcha kulo I | Lingmo Kolthang | Functional | |
| 77 | Mangzing kutcha kulo III | Lingmo Kolthang | Functional | |
| 78 | Kaw kutcha kulo I | Lingmo Kolthang | | Defunct |
| 79 | Kaw kutcha kulo II | Lingmo Kolthang | Functional | |

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|---|---|---|---|---|
| 80 | Kaw kutcha kulo III | Lingmo Kolthang | Functional | |
| 81 | Kaw kutcha kulo IV | Lingmo Kolthang | | Defunct |
| 82 | Kaw kutcha kulo V | Lingmo Kolthang | Functional | |
| 83 | Kaw kutcha kulo VI | Lingmo Kolthang | Functional | |
| 84 | Kaw kutcha kulo VII | Lingmo Kolthang | Functional | |
| 85 | Kaw Kutcha kulo | Lingmo Kolthang | Functional | |
| 86 | Kaw Khola kutcha kulo | Lingmo Kolthang | | Defunct |
| 87 | Tokday Kutcha Kulo | Lingmo Kolthang | | Defunct |
| 88 | Lower Lingmo MIC | Lingmo Kolthang | Functional | |
| 89 | Lingmo Kutcha kulo I | Lingmo Kolthang | | Defunct |
| 90 | Lingmo Kutcha Kulo II | Lingmo Kolthang | Functional | |
| 91 | Khumbrangey kutcha kulo | Lagchok Kamarey | | Defunct |
| 92 | Tirikhola MIC | Mamley Kamrang | Functional | |
| 93 | Kitchu Dumra MIC | Mamley Kamrang | Functional | |
| 94 | Kamrang MIC | Mamley Kamrang | Functional | |
| 95 | Upper Mainabotay kutcha channel | Mamley Kamrang | | Defunct |
| 96 | Rangap MIC | Mamley Kamrang | Functional | |
| 97 | Mamley MIC | Mamley Kamrang | Functional | |
| 98 | Pakzer MIC | Mamley Kamrang | | Defunct |
| 99 | Nangdang kutcha kulo | Mamley Kamrang | Functional | |
| 100 | Lower Bakhim pvt.kulo | Mamley Kamrang | Functional | |
| 101 | Mainabotey MIC | Mamley Kamrang | Functional | |
| 102 | Mamley Nangdong MIC | Mamley Kamrang | Functional | |
| 103 | Kerabari MIC | Mellidara Payong | Functional | |
| 104 | Mellidara MIC | Mellidara Payong | Functional | |
| 105 | Kubinday MIC | Mellidara Payong | Functional | |
| 106 | Pradhan gaonb kutcha kulo | Mellidara Payong | Functional | |
| 107 | Payong Kutcha kulo | Mellidara Payong | | Defunct |
| 108 | Khani khola to payong | Mellidara Payong | Functional | |
| 109 | Rabi khola to lower payong | Mellidara Payong | Functional | |
| 110 | Tanam Khola kutcha kulo | Mellidara Payong | | Defunct |
| 111 | Salleybong MIC | Maniram Phalidara | Functional | |
| 112 | Manpur kitam MIC | Mikhol;a Kitam | Functional | |
| 113 | Mikhola MIC | Mikhol;a Kitam | Functional | |
| 114 | Salbotey kutcha kulo | Mikhola Kitam | | Defunct |
| 115 | Lowe kitam kutcha kulo | Mikhola Kitam | | Defunct |

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|---|---|---|---|---|
| 116 | Karek Kabrey Kutcha kulo | Nagi Maney Dara | Functional | |
| 117 | Karek kutcha kulo | Nagi Maney Dara | Functional | |
| 118 | Kabrey kutcha kulo | Nagi Maney Dara | | Defunct |
| 119 | Kateng kutcha kulo | Nagi Maney Dara | Functional | |
| 120 | Bokrang kutcha channel | Nagi Maney Dara | Functional | |
| 121 | Maneydara kutcha channel | Nagi Maney Dara | Functional | |
| 122 | Nagi kutcha channel | Nagi Maney Dara | | Defunct |
| 123 | Nalam kolbong kutcha channel | Nagi Maney Dara | Functional | |
| 124 | Palitam kutcha kulo | Nagi Maney Dara | | Defunct |
| 125 | Sali khola kateng MIC | Nagi Maney Dara | Functional | |
| 126 | Botey kulo at chalmthang | Namphing | Functional | |
| 127 | Zilkey Dara MIC | Namphing | Functional | |
| 128 | Namphing kutcha kulo I | Namphing | Functional | |
| 129 | Namphing kutcha kulo II | Namphing | Functional | |
| 130 | Reyship kutcha kulo | Namphing | | Dfefunct |
| 131 | Chalamthang kuthca kulo I | Namphing | Functional | |
| 132 | Chalamthang kuthca kulo II | Namphing | Functional | |
| 133 | Lower chalamthang kutcha kulo | Namphing | Functional | |
| 134 | Pabong Namphing MIC | Namphing | Functional | |
| 135 | Reyship Namphing MIC | Namphing | Functional | |
| 136 | Kharel kulo | Namphing | Functional | |
| 137 | Burul Badamtam MIC | Perbing chuba | Functional | |
| 138 | Samardung MIC | Perbing chuba | Functional | |
| 139 | Pagla kutcha kulo | Perbing chuba | Functional | |
| 140 | Ramang kutcha kulo | Perbing chuba | Functional | |
| 141 | Lower samardung kutcha kulo | Perbing chuba | | Defunct |
| 142 | Nandugaier khola ghari Samdor | Perbing chuba | Functional | |
| 143 | Denchung MIC | Polok Denchung | Functional | |
| 144 | Dongkhola MIC | Polok Denchung | Functional | |
| 145 | Tokal MIC | Polok Denchung | Functional | |
| 146 | Poklok MIC | Polok Denchung | Functional | |
| 147 | Lambetar pvt.channel | Polok Denchung | | Defunct |
| 148 | Samatar kutcha kulo | Polok Denchung | Functional | |
| 149 | Tinik Pvt.channel | Polok Denchung | Functional | |
| 150 | Dozok Sangmo MIC | Rabong Sangmo | | Defunct |
| 151 | Gangla MIC | Rabong Sangmo | | Defunct |

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|---|---|---|---|---|
| 152 | Middle Lingding MIC | Ralong Namlung | Functional | |
| 153 | Lingding kutcha channel | Ralong Namlung | Functional | |
| 154 | Namlung MIC | Ralong Namlung | Functional | |
| 155 | Lingding kutcha kulo | Ralong Namlung | Functional | |
| 156 | Namlung kutcha kulo | Ralong Namlung | Functional | Defunct |
| 157 | Lower Lingding MIC | Ralong Namlung | Functional | |
| 158 | Namling MIC | Ralong Namlung | Functional | |
| 159 | Bikmat Ratey pani MIC | Ratey Pani | Functional | |
| 160 | Bikmat old channel | Ratey Pani | Functional | |
| 161 | Bikmat kharebotey MIC | Ratey Pani | Functional | |
| 162 | Passi MIC | Ratey Pani | Functional | |
| 163 | Upper Passi MIC | Ratey Pani | Functional | |
| 164 | Ratey pani gari khet MIC | Ratey Pani | | Defunct |
| 165 | Ratey khola to l/passi kutcha kulo | Ratey Pani | | Defunct |
| 166 | Alaichibari kutcha kulo | Ratey Pani | | Defunct |
| 167 | Ratey kutcha channel | Ratey Pani | | Defunct |
| 168 | Bul kutcha kulo | Rong Bul | | Defunct |
| 169 | Palum kutcha channel | Rong Bul | Functional | |
| 170 | Toe khola kutcha channel | Rong Bul | Functional | |
| 171 | Singtam kutcha kulo | Rong Bul | Functional | |
| 172 | Raleypon passi MIC | Rong Bul | Functional | |
| 173 | Paney khola MIC | Rong Bul | Functional | |
| 174 | Rabitar MIC | Sadam Sukrabarey | Functional | |
| 175 | Lower rabitar MIC | Sadam Sukrabarey | Functional | |
| 176 | Limbo dara kutcha channel | Sadam Sukrabarey | Functional | |
| 177 | Middle rabitar pvt. Channel | Sadam Sukrabarey | | Defunct |
| 178 | Sadam Pvt. Channel | Sadam Sukrabarey | | Defunct |
| 179 | Upiya khola MIC | Sadam Sukrabarey | Functional | |
| 180 | Sukrabaqrey Kutcha kulo | Sadam Sukrabarey | Functional | |
| 181 | Phaladay khola kutcha kulo | Sadam Sukrabarey | Functional | |
| 182 | Sumtaley kutcha kulo | Sadam Sukrabarey | Functional | |
| 183 | Timburey pvt. Channel | Salghari | Functional | |
| 184 | Dorop to salghari | Salghari | Functional | |
| 185 | Dorop kutcha kulo I | Salghari | Functional | |
| 186 | Dorop kutcha kulo II | Salghari | | Defunct |
| 187 | Dorop kutcha kulo III | Salghari | | Defunct |

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|---|---|---|---|---|
| 188 | Dorop kutcha kulo IV | Salghari | | Defunct |
| 189 | Dong pherasay MIC | Salghari | Functional | |
| 190 | Salghari MIC | Salghari | Functional | |
| 191 | Sanganth kutcha kulo I | Sanganath | Functional | |
| 192 | Sanganath kutcha kulo II | Sanganath | Functional | |
| 193 | Upper boomtar MIC | Singithang | | Defunct |
| 194 | Lower boomter MIC | Singithang | Functional | |
| 195 | Tasngsang MIC | Singithang | Functional | |
| 196 | L/Boomtar MIC | Singithang | Functional | |
| 197 | Gom MIC | Sork-Syampani | | Defunct |
| 198 | Tinkitam sanganath MIC | Tingkitam Rayong | Functional | |
| !99 | Royong Pvt, channel | Tingkitam Rayong | | Defunct |
| 200 | Pancharey kutcha kulo I | Turuk | Functional | |
| 201 | Panchgharey kutcha kulo II | Turuk | Functional | |
| 202 | Ramabong kutcha kulo | Turuk | | Defunct |
| 203 | Turuk Kutcha kulo channel | Turuk | | Defunct |
| 204 | Hee kwlan MIC | Turuk | Functional | |
| 205 | Turuk Tingbong MIC | Turuk | Functional | |
| 206 | Mamring MIC | Turung Pamphok | Functional | |
| 207 | Kharpani MIC lower Mamring | Turung Pamphok | Functional | |
| 208 | Julongey kutcha channel | Turung Pamphok | | Defunct |
| 209 | Kamlet kutcha channel | Turung Pamphok | Functional | |
| 210 | Karamtak kutcha kulo | Turung Pamphok | | Defunct |
| 211 | Phampok kutcha kulo I | Turung Pamphok | Functional | |
| 212 | Pamphok kutcha kulo II | Turung Pamphok | | Defunct |
| 213 | Turung kutcha Kulo | Turung Pamphok | | Defunct |
| 214 | Donuk MIC | Turung Pamphok | Functional | |
| 215 | Subingkhor MIC | Turung Pamphok | Functional | |
| 216 | Chumlok MIC | Wok Omchu | Functional | |
| 217 | Omchu MIC | Wok Omchu | | Defunct |
| 218 | Omchu kutcha kulo | Wok Omchu | | Defunct |
| 219 | Sumdong MIC | Wok Omchu | Functional | |
| 220 | Sripatam kutcha kulo I | Sripatam Niy Brum | Functional | |
| 221 | Sripatam kutcha kulo II | Sripatam Niy Brum | | Defunct |
| 222 | Sripatam kutcha kulo III | Sripatam Niy Brum | | Defunct |
| 223 | Sawaney kutcha kulo | Sripatam Niy Brum | | Defunct |

| | | | | |
|---|---|---|---|---|
| 224 | Kuwapani Kulo at Nampok | Sripatam Niy Brum | | Defunct |
| 225 | Sripatam MIC | Sripatam Niy Brum | Functional | |
| 226 | Namphrick kutcha kulo I | Sripatam Niy Brum | Functional | |
| 227 | Namphrick kutcha kulo II | Sripatam Niy Brum | Functional | |
| 228 | Namphrick kutcha kulo III | Sripatam Niy Brum | Functional | |
| 229 | Namphrick kutcha kulo IV | Sripatam Niy Brum | Functional | |
| 230 | Namphrick kutcha kuloI V | Sripatam Niy Brum | Functional | |
| 231 | Namphrick kutcha kulo VI | Sripatam Niy Brum | Functional | |
| 232 | Namphrick kutcha kulo VII | Sripatam Niy Brum | Functional | |
| 233 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | | Defunct |
| 234 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | | Defunct |
| 235 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | | Defunct |
| 236 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | | Defunct |
| 237 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | Functional | |
| 238 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | Functional | |
| 239 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | Functional | |
| 240 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | Functional | |
| 241 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | | Defunct |
| 242 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | Functional | |
| 243 | Niya Brum pvt. Kulo. | Sripatam Niy Brum | Functional | |
| 244 | Namphok MIC Sripatam | Sripatam Niy Brum | Functional | |
| 245 | Niya Brum MIC | Sripatam Niy Brum | Functional | |
| 246 | L/Sripatam MIC | Sripatam Niy Brum | Functional | |
| 247 | Bhaley khola MIC | Sripatam Niy Brum | Functional | |
| 248 | Belboty kutcha channel | Sumbuk Kartikey | Functional | |
| 249 | Sumbuk Kartikey MIC II | Sumbuk Kartikey | Functional | |
| 250 | Urbura MIC | Sumbuk Kartikey | Functional | |
| 251 | Sumbuk Kutcha channel I | Sumbuk Kartikey | Functional | |
| 252 | Sumbuk Kutcha channel II | Sumbuk Kartikey | | Defunct |
| 253 | Sumbuk Suntaley kutcha channel | Sumbuk Kartikey | | Defunct |
| 254 | Baramaney khola MIC | Sumbuk Kartikey | Functional | |
| 255 | Sumbuk Kartikey MIC | Sumbuk Kartikey | Functional | |
| 256 | Temi Aifaltar MIC | Temi Tarku | Functiuonal | |
| 257 | Gangatey dara MIC | Temi Tarku | | Defunct |
| 258 | Pabong MIC | Temi Tarku | Functional | |
| 259 | Temi Devithaney MIC | Temi Tarku | Functional | |

| | | | | |
|---|---|---|---|---|
| 260 | Tanak kutcha kulo | Temi Tarku | | Defunct |
| 261 | Dara khet kutcha kulo | Temi Tarku | Functional | |
| 262 | Sajbotey kutcha kulo | Temi Tarku | Functional | |
| 263 | Tarku kutcha kulo I | Temi Tarku | Functional | |
| 264 | Tarku Kutcha kulo II | Temi Tarku | | Defunct |
| 265 | Tanak MIC Tarku | Temi Tarku | Functional | |
| 266 | Tarku Melet gram MIC | Temi Tarku | Functional | |
| 267 | Ganyang MIC | Yangang Rangang | | Defunct |
| 268 | Satam MIC | Yangang Rangang | Functional | |
| 269 | Satam Samruk MIC | Yangang Rangang | Functional | |
| 270 | Rangang Kutcha kulo I | Yangang Rangang | Functional | |
| 271 | Rangang kutcha kulo II | Yangang Rangang | Functional | |
| 272 | Rangang kutcha kulo III | Yangang Rangang | Functional | |
| 273 | Rangang kutcha kulo IV | Yangang Rangang | | Defunct |
| 274 | Rangang kutcha kulo V | Yangang Rangang | 0 | Defunct |
| 275 | Satam Kutcha kulo | Yangang Rangang | | Defunct |
| 276 | Yangang kutcha kulo I | Yangang Rangang | Functional | |
| 277 | Yangang kutcha kulo II | Yangang Rangang | | Defunct |

**Annexure 5.4**

## MINOR IRRIGATION CHANNELS
## LIST OF FUNCTIONING AND DEFUNCT SCHEMES
## SORENG & GAYLSING SUB DIVISION

| Sl.No. | NAME OF SCHEME | BLOCK | FUNCTIONING | Defunct |
|---|---|---|---|---|
| 1 | Luxcer MIC | L/Thambong | Functioning | |
| 2 | Indraman MIC | L/Thambong | Functioning | |
| 3 | Rajaya MIC | L/Thambong | Functioning | |
| 4 | Kazini MIC | L/Thambong | Functioning | |
| 5 | Naya Kulo MIC | L/Thambong | Functioning | |
| 6 | Sarankey MIC | L/Thambong | | Defunct |
| 7 | Bhir Kulo MIC | L/Thambong | Functioning | |
| 8 | Kipatey katcha MIC | L/Thambong | Functioning | |
| 9 | Ghambirey MIC | L/Thambong | Functioning | |
| 10 | Ringyang MIC | L/Fambong | Functioning | |

| | | | | |
|---|---|---|---|---|
| 11 | Diwani kulo *MIC* | L/Fambong | Functioning | |
| 12 | L/Fambong MIC | L/Fambong | Functioning | |
| 13 | Devithaney jhora MIC | L/Fambong | Functioning | |
| 14 | Chagey kulo MIC | L/Fambong | Functioning | |
| 15 | Leenthing Kulo | L/Fambong | | Defunct |
| 16 | Tindharey MIC | L/Fambong | Functioning | |
| 17 | Ringyang Thambong MIC | L/Fambong | Functioning | |
| 18 | Ringzing Thambong MIC | L/Fambong | Functioning | |
| 19 | Bhakta kulo MIC-I | L/Fambong | Functioning | |
| 20 | Bhakta Kulo MIC - II | L/Fambong | Functioning | |
| 21 | Ambotey MIC - I | L/Fambong | Functioning | |
| 22 | Ambotey MIC -II | L/Fambong | Functioning | |
| 23 | Thari khloa MIC | L/Fambong | Functioning | |
| 24 | Bal Bdr. Kulo MIC | L/Fambong | Functioning | |
| 25 | Ringyang Sumphu MIC | L/Thambong | Functioning | |
| 26 | Rajayakulo MIC | L/Salangdang | Functioning | |
| 27 | Dalbir kulo MIC | L/Salangdang | | Defunct |
| 28 | Lunchok Salangdang MIC | L/Salangdang | | Defunct |
| 29 | Pairaney kulo MIC | L/Salangdang | Functioning | |
| 30 | Devithan MIC | L/Salangdang | | Defunct |
| 31 | Tindovaney MIC | L/Salangdang | Functioning | |
| 32 | Tindovaney MIC | U/Rumbuk | Functioning | |
| 33 | Virkuna MIC | U/Rumbuk | | Defunct |
| 34 | Melbotey MIC | U/Rumbuk | Functioning | |
| 35 | Singlep MIC | U/Rumbuk | | Defunct |
| 36 | Sumbuk MIC | U/Rumbuk | Functioning | |
| 37 | Bahadur MIC | U/Rumbuk | Functioning | |
| 38 | Dalechen MIC | L/Rumbuk | | Defunct |
| 39 | Bash Ghari MIC | L/Rumbuk | Functioning | |
| 40 | L/Rumbuk MIC - I | L/Rumbuk | Functioning | |
| 41 | L/Rumbuk -II | L/Rumbuk | Functioning | |
| 42 | Tam khola MIC | Tikpur Siktam | | Defunct |
| 43 | Singking MIC | L/Tikpur | | Defunct |
| 44 | Singling Tank MIC | Singling | | Defunct |
| 45 | U/Singling MIC | Singling | | Defunct |
| 46 | Barakhaley Tank MIC | Singling | | Defunct |

| | | | | |
|---|---|---|---|---|
| 47 | Dodak Tharpu MIC | Dodak-Burikhop | | Defunct |
| 48 | Devi khola MIC | Dodak-Burikhop | | Defunct |
| 49 | Dodak Burikhop MIC | Dodak-Burikhop | | Defunct |
| 50 | Anbetar Shiran kulo MIC Tharpu | Timburbong | Functioning | |
| 51 | Ridang khola Bdr.Kulo MIC | Timburbong | Functioning | |
| 52 | Lapsey Botey MIC | Timburbong | Functioning | |
| 53 | Ridang khola Giri goan MIC | Timburbong | Functioning | |
| 54 | Timburbong Shiran MIC | Timburbong | Functioning | |
| 55 | Ridang khola Arubotey | Timburbong | | Defunct |
| 56 | Ridang khola Sarankey MIC | Timburbong | Functioning | |
| 57 | Ambetar Putcher kulo | Timburbong | Functioning | |
| 58 | Bojek MIC | Timburbong | Functioning | |
| 59 | Ridang khola sorety MIC | Timburbong | Functioning | |
| 60 | Ringyong MIC | Timburbong | Functioning | |
| 61 | Ghising khola MIC | Soreng | | Defunct |
| 62 | Churibotey MIC | Soreng | | Defunct |
| 63 | Suntaley Laley MIC | Soreng | Functioning | |
| 64 | Rani khola at Mangshari | Soreng | Functioning | |
| 65 | U/Bararey MIC | Soreng | Functioning | |
| 66 | Nandey MIC | Soreng | Functioning | |
| 67 | Voo khola MIC Budhang | Soreng | Functioning | |
| 68 | Mangshari Dara kulo MIC | Soreng | Functioning | |
| 69 | Birkuna Mangshari MIC | Soreng | Functioning | |
| 70 | Harrabotey MIC | Malbasey | | Defunct |
| 71 | Chagey jhora MIC | Malbasey | Functioning | |
| 72 | Hukpa gaon MIC | Malbasey | | Defunct |
| 73 | Mangalbarey MIC | Malbasey | Functioning | |
| 74 | Pangarey Dhar MIC | Malbasey | Functioning | |
| 75 | Voo khola MIC at Budhang | Malbasey | | Defunct |
| 76 | Malidang Budhang MIC | Malbasey | Functioning | |
| 77 | Mem khola MIC Budhang | Malbasey | Functioning | |
| 78 | Mem khola Gangetey MIC | Malbasey | | Defunct |
| 79 | Mem khola Rawat gaon MIC | Malbasey | Functioning | |
| 80 | Mem khola Pradhan gaon MIC | Malbasey | Functioning | |
| 81 | Mem khola Dhakal MIC | Malbasey | | Defunct |

| | | | | |
|---|---|---|---|---|
| 82 | Mem khola Dara kulo MIC | Malbasey | Functioning | |
| 83 | Sunil gaon MIC | Malbasey | Functioning | |
| 84 | Harrabotey MIC lower | Malbasey | Functioning | |
| 85 | U/Timburey MIC | Malbasey | Functioning | |
| 86 | L/Timburey MIC | Malbasey | | Defunct |
| 87 | Kazi kulo MIC | Malbasey | | Defunct |
| 88 | Voo khola MIC at Mangalbaria | Malbasey | | Defunct |
| 89 | Seti khola MIC | Malbasey | Functioning | |
| 90 | L/Budhang Malidang MIC | Malbasey | Functioning | |
| 91 | Mem khola MIC Budhang | Malbasey | Functioning | |
| 92 | Lama khola MIC | Malbasey | Functioning | |
| 93 | Nirola khola MIC | Malbasey | Functioning | |
| 94 | Malidang Siran kulo MIC | Malbasey | Functioning | |
| 95 | Voo khola MIC | Malbasey | Functioning | |
| 96 | Const. of L/Chudharey MIC | Chakung | | Defunct |
| 97 | Const. of Kaprey MIC | Chakung | | Defunct |
| 98 | Const. of Pandherea khola MIC | Chakung | | Defunct |
| 99 | Const of Jugdung khola MIC | Chakung | | Defunct |
| 100 | Const of Rothak khola MIC | Chakung | | Defunct |
| 101 | Const. of U/Chundharey MIC | Chakung | | Defunct |
| 102 | Const. of Rungdung Baiguney MIC | Chakung | | Defunct |
| 103 | Const. of Titirey MIC | Chakung | Functioning | |
| 104 | Gangatey MIC at Chakung | Chakung | Functioning | |
| 105 | Ingidena kulo MIC | Chakung | Functioning | |
| 106 | Jogi Dara MIC | Chakung | Functioning | |
| 107 | Reshi khola MIC | Deythang | | Defunct |
| 108 | Meribotey MIC | Deythang | Functioning | Defunct |
| 109 | Ramthang kulo MIC Parranggaon | Deythang | Functioning | |
| 110 | Simkuna MIC | Deythang | Functioning | |
| 111 | Devithaney MIC | Samdong | | Defunct |
| 112 | Reshi to Namedang MIC | Samdong | | Defunct |
| 113 | Reshi to U/Samdong MIC | Samdong | | Defunct |
| 114 | Shor khola MIC | Sangdorjee | | Defunct |
| 115 | Rangsang khola MIC | Sangdorjee | | Defunct |
| 116 | Dakbanglo MIC | Sangdorjee | | Defunct |

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|---|---|---|---|---|
| 117 | Zim khola MIC | Sangdorjee | | Defunct |
| 118 | Tadong khola MIC | Sangdorjee | | Defunct |
| 119 | L/Zim khola MIC | Sangdorjee | | Defunct |
| 120 | Sungtung Mic | Sangdorjee | Functioning | |
| 121 | Rani khola MIC | Sangdorjee | | Defunct |
| 122 | Putch khola MIcRhenock khola Mic | Sangdorjee | | Defunct |
| 123 | Rafang to Reshi khola MIC | Sangdorjee | Functioning | |
| 124 | Zim khola MIC at Karthok | Sangdorjee | Functioning | |
| 125 | Tadong MIC | Sangdorjee | Functioning | |
| 126 | Katchu khola MIC | Chigthang | Functioning | |
| 127 | Chihandara MIC | Chigthang | Functioning | |
| 128 | Feng khola MIC | Chigthang | Functioning | |
| 129 | Kepsen khola MIC | Chigthang | Functioning | |
| 130 | Chingtang MIC | Chigthang | Functioning | |
| 131 | Hee khola MIC | Hee-gaon | | Defunct |
| 132 | Thulo khola MIC | Hee-gaon | Functioning | |
| 133 | Ramitey khola MIC | Hee-gaon | Functioning | |
| 134 | Keng khola MIC | Hee-gaon | | Defunct |
| 135 | Keng khola MIC | Hee-gaon | | Defunct |
| 136 | Borthang Rongdu MIC | Hee-gaon | | Defunct |
| 137 | Bhutter khola MIC | Hee-gaon | Functioning | |
| 138 | Ram-sang to Dhami dara | Hee-gaon | Functioning | |
| 139 | Ramthang Dara MIC | Hee-gaon | Functioning | |
| 140 | Mazgaon MIC | Hee-gaon | Functioning | |
| 141 | Chodrey MIC | Chumbong | Functioning | |
| 142 | Shichulu MIC at Zoom | Zoom | | Defunct |
| 143 | Dentam khola Mic | Sanku Radhu Khandu | Functioning | |
| 144 | Satdulay MIC | Sanku Radhu Khandu | | Defunct |
| 145 | Ronak MIC | Sanku Radhu Khandu | Functioning | |
| 146 | Holder kulo MIC | Sanku Radhu Khandu | Functioning | |
| 147 | Khandu MIC | Sanku Radhu Khandu | | Defunct |
| 148 | Onsal jhora MIC | Sanku Radhu Khandu | Functioning | |
| 149 | Dentam khola MIC | Sanku Radhu Khandu | Functioning | |
| 150 | Rithak MIC | Khanishurbong | | Defunct |
| 151 | Khorong MIC | Linzchom Tikjyak | Functioning | |

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|---|---|---|---|---|
| 152 | Matung khola MIC | Linzchom Tikjyak | Functioning | |
| 153 | Rahit khola MIC | Linzchom Tikjyak | | Defunct |
| 154 | U/Linchom MIC | Linzchom Tikjyak | Functioning | |
| 155 | Birkuna Mangshari MIC | Linzchom Tikjyak | Functioning | |
| 156 | Laso MIC | Tashiding | | Defunct |
| 157 | Limbong MIC | Tashiding | Functioning | |
| 158 | Darap MIC | Darap | Functioning | |
| 159 | L/Chumbong MIC | Dentam | Functioning | |
| 160 | Lepcha goan MIC | Dentam | Functioning | |
| 161 | Bagha MIC | Dentam | | Defunct |
| 162 | Sankhu Khandi | Dentam | | Defunct |
| 163 | Ledung MIC | Dentam | | Defunct |
| 164 | Lepcha gaon MIC | Dentam | | Defunct |
| 165 | Dentam khola MIC | Dentam | | Defunct |
| 166 | Begha khola MIC | Dentam | | Defunct |
| 167 | Porombhik khola MIC | Dentam | Functioning | |
| 168 | Litay pani MIC | Dentam | Functioning | |
| 169 | Jugay pani MIC | Dentam | Functioning | |
| 170 | Maney khola MIC | Dentam | Functioning | |
| 171 | Mandirey khola MIC | Dentam | | Defunct |
| 172 | Begha kutcha Kulo | Dentam | Functioning | |
| 173 | Dentam MIC | Dentam | Functioning | |
| 174 | L/Onsal khola | Dentam | Functioning | |
| 175 | Sanodhab kutcha kulo | Dentam | | Defunct |
| 176 | Simbring kutcha kulo | Dentam | Functioning | |
| 177 | Rani khola to Gumpa dara khet | Gyalsing | | Defunct |
| 178 | Bandaray khola to Rethang khet | Gyalsing | Functioning | |
| 179 | Simana khola kulo MIC | Gyalsing | Functioning | |
| 180 | Dharapani kholsa MIC | Gyalsing | | Defunct |
| 181 | Rani khola to Gumpa khet | Gyalsing | Functioning | |
| 182 | Dharapani khola kutcha kulo | Gyalsing | Functioning | |
| 183 | Devi khola to dhangrey | Gyalsing | | Defunct |
| 184 | Devi khola to Onchung | Gyalsing | Functioning | |
| 185 | Kyongsa MIC | Gyalsing | | Defunct |
| 186 | Onchuling MIC | Yangtem | Functioning | |
| 187 | Limband MIC | Yangtem | Functioning | |

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|---|---|---|---|---|
| 188 | Munchi kulo MIC | Yangtem | Functioning | |
| 189 | Guruthang Mistri MIC | Yangtem | Functioning | |
| 190 | Bhuttey khola MIC | Yangtem | Functioning | |
| 191 | Toyong MIC | Yangtem | Functioning | |
| 192 | Butar kulo MIC | Yangtay | Functioning | |
| 193 | Dhupi dara MIC | Yangtay | Functioning | |
| 194 | Kabirthang MIC | Yangtay | Functioning | |
| 195 | Kagethang DCC MIC | Yangtay | Functioning | |
| 196 | Andheri khola to Manayadara | Yangtay | Functioning | |
| 197 | Maney khola to Chundara | Yangtay | Functioning | |
| 198 | Yangtey khola kutcha MIC | Yangtay | Functioning | |
| 199 | Manay kholsa kabirthang | Yangtay | Functioning | |
| 200 | Rabdenste kholsa MIC | Yangtay | Functioning | |
| 201 | Andheri khola MIC | Yangtay | Functioning | |
| 202 | Dantay kholsa Dhupi daras | Yangtay | Functioning | |
| 203 | Many khola to Andheri khola | Yangtay | Functioning | |
| 204 | Kabirthang kutcha MIC | Yangtay | Functioning | |
| 205 | Manay khola to Chandara | Yangtay | Functioning | |
| 206 | Langang khola to Charkzong | Yangthang kyong | Functioning | |
| 206 | Langang kholsa to Charkholay | Yangthang kyong | Functioning | |
| 207 | Devithaney khola MIC | Yangthang kyong | Functioning | |
| 208 | Thari biribung DCC MIC | Yangthang kyong | Functioning | |
| 209 | Kyakchu kholsa Arigoan | Yangthang kyong | Functioning | |
| 210 | Mistri kulo | Yangthay kyongsa | Functioning | |
| 211 | Munshi kulo | Yangthay kyongsa | Functioning | |
| 212 | Chyandara to Gaycharan MIC | Yangthay kyongsa | Functioning | |
| 213 | Devithaney to Dovaney MIC | Yangthay kyongsa | Functioning | |
| 214 | Kyakchu to Shiva Mandir MIC | Yangthay kyongsa | Functioning | |
| 215 | Kyakchu to Shiva Mandir MIC | Yangthay kyongsa | Functioning | |
| 216 | Taherikholasa to Hitti Dhara MIC | Yangthay kyongsa | Functioning | |
| 217 | Sidaba khola Mic | Yuksom | Functioning | |
| 218 | Labing MIC | Yuksom | Functioning | |
| 219 | Gerethang MIC | Gerethang | | Defunct |
| 220 | Gerethang MIC - II | Gerethang | | Defunct |
| 221 | Tamatam MIC | Gerethang | | Defunct |
| 222 | Gerethang to Lunzik MIC | Gerethang | Functioning | |

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|---|---|---|---|---|
| 223 | Labing MIC | Gerethang | Functioning | |
| 224 | Upper Karchi Mic | Gerethang | | Defunct |
| 225 | Dhupi khola MIC | Gerethang | | Defunct |
| 226 | Nar khola Mic | Gerethang | | Defunct |
| 227 | Rani khola MIc | Kngri Labdang | Functioning | |
| 228 | Lower Kongri Mic | Kngri Labdang | Functioning | |
| 229 | Mahong khola MIC | Lingchom Tikjya | Functioning | |
| 230 | Rahu khola MIC | Lingchom Tikjya | Functioning | |
| 231 | Japchu khola MIC | Lingchom Tikjya | | Defunct |
| 232 | Lapcha khola to Chokti | Lingchom Tikjya | | Defunct |
| 233 | Lepcha kholsa to Kongsu | Lingchom Tikjya | | Defunct |
| 234 | Kangshu to Tablong | Lingchom Tikjya | | Defunct |
| 235 | Linchom japchu MIC | Lingchom Tikjya | | Defunct |
| 236 | Jungali kholsa to Devithaney | Lingchom Tikjya | Functioning | |
| 237 | Simphok khola MIC | Maneybong Sopokha | Functioning | |
| 238 | Andheri kholsa to Lofobong | Maneybong Sopokha | Functioning | |
| 239 | Andheri kholsa to Ambotey | Maneybong Sopokha | Functioning | |
| 240 | Andheri kholsa to Sarelong Salley Mic | Maneybong Sopokha | Functioning | |
| 241 | Ritlhabotey Sardong MIC | Maneybong Sopokha | | Defunct |
| 242 | Simana khola MIC | Arithang Chon | | Defunct |
| 243 | Lan gkhola kutcha | Arithang Chon | | Defunct |
| 244 | Tinzering khola MIC | Arithang Chon | | Defunct |
| 245 | Nesha khola to Chon | Arithang Chon | | Defunct |
| 246 | Chagey kutcha kulo | Bangten Karmatar | | Defunct |
| 247 | Bore khola MIC | Bangten Karmatar | | Defunct |
| 248 | Zoom khola Mic | Bangten Karmatar | Functioning | |
| 249 | Gitang khola Mic | Bangten Karmatar | Functioning | |
| 250 | Tyong khola MIC | Bangten Karmatar | Functioning | |
| 251 | Changey khola MIC | Bangten Karmatar | Functioning | |
| 252 | Chagey khola MIC-II | Bangten Karmatar | Functioning | |
| 253 | Kongsa MIC | Chumbong | Functioning | |
| 254 | Omchung MIC | Chumbong | Functioning | |
| 255 | Limbini khola MIC | Darap | Functioning | |
| 256 | Andheri khola MIC | Darap | Functioning | |
| 257 | Devithaney khola MIC | Darap | Functioning | |
| 258 | Lumbini khola MIC-I | Darap | Functioning | |

| | | | | |
|---|---|---|---|---|
| 259 | Lumbini khola MIC-II | Darap | Functioning | |
| 260 | Singyang MIC | Singyang Chongraong | | Defunct |
| 261 | L/Singyang MIC | Singyang Chongraong | | Defunct |
| 262 | Chograng MIC | Singyang Chongraong | Functioning | |
| 263 | Gairi khet MIC | Singyang Chongraong | | Defunct |

**Annexure-5.5**

## Schemes proposed under AIBP funding during the year 2003-04
## North - East Division

| SlNo. | Name of Work | Amount (Rs. Lakh) | Potential to be created (ha) |
|---|---|---|---|
| 1 | Gairey Bari MIC at Neopani Gaon | 1.45 | 6.15 |
| 2 | Tuni Bhotey MIC | 2.00 | 8.00 |
| 3 | School Dara MIC at Devithan Source ( Biring) | 2.00 | 8.00 |
| 4 | Gautheley MIC at Samdong | 1.00 | 1.90 |
| 5 | Maharaja Tar MIC | 2.50 | 8.75 |
| 6 | Navey MIC Phase - I | 1.50 | 2.90 |
| 7 | Gagangtey MIC | 3.00 | 12.00 |
| 8 | Sajong MIC near laprosy Hospital | 0.90 | 3.75 |
| 9 | Dara Khet MIC at Middle Namchepong | 2.00 | 8.75 |
| 10 | Mangzing MIC | 1.00 | 1.74 |
| 11 | Restoration/Reno. Of P.P.Damala MIC | 2.00 | 8.25 |
| 12 | Tingchim MIC | 1.50 | 3.88 |
| 13 | Sath Garey MIC at Kabuthang under Taja Block | 1.00 | 5.00 |
| 14 | Gaguney MIC | 1.50 | 2.60 |
| 15 | Middle Amba Gimerey MIC | 2.00 | 8.00 |
| 16 | Tingling Bong MIC at Ray | 1.45 | 6.50 |
| 17 | Manghim MIC at Mangshila | 1.50 | 5.15 |
| 18 | Lower Rejey Gaon MIC ( Nandok ) | 1.50 | 5.50 |
| 19 | Sokeythang MIC at L/Lingding | 2.50 | 6.00 |
| 20 | Siram Khola MIC | 1.50 | 5.75 |
| 21 | Babu Khola MIC | 1.60 | 5.22 |
| 22 | Zingla MIC | 2.90 | 13.00 |
| 23 | Tutukey Khola MIC | 1.50 | 6.50 |
| 24 | Lasa Khla MIC | 1.80 | 6.00 |

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|---|---|---|---|
| 25 | Lepcha Kulo MIC at Mamring | 1.50 | 6.50 |
| 26 | Sikkim Dara MIC at Pathang Busty | 2.00 | 8.00 |
| 27 | Bagey Khola MIC near Hume pipe Factory | 1.50 | 6.50 |
| 28 | Therim Khola MIC at Marchak | 1.50 | 6.50 |
| 29 | Goar MIC | 2.00 | 6.10 |
| 30 | Lower Basilakha MIC | 2.80 | 8.00 |
| 31 | Dalapchen MIC | 2.00 | 8.00 |
| 32 | Thalthaley MIC at Assam Lingzey | 1.00 | 5.57 |
| 33 | Navey MIC phase - II | 2.00 | 6.25 |
| 34 | Lingmo Khola to Kyongmat MIC at Phensong | 1.50 | 2.80 |
| 35 | Chulumthang MIC at Sangtum | 1.00 | 3.75 |
| 36 | Laseythang Mamring MIC | 1.50 | 6.50 |
| 37 | Simik Lingzey MIC | 1.50 | 6.50 |
| 38 | Chothang MIC below Pema Sir House | 1.50 | 6.50 |
| 39 | Lepcha kulo MIC at chota Singtam | 1.50 | 5.75 |
| 40 | Simna Khola MIC | 1.00 | 5.00 |
| 41 | Raju Khet, Raigaon, Shivadham MiC L/Syari | 1.50 | 7.50 |
| 42 | Duga Sawaney MIC | 2.00 | 8.00 |
| 43 | Ralak MIC at mangshila | 1.50 | 3.60 |
| 44 | Lower Tumin MIC | 1.00 | 2.10 |
| 45 | Ramthang MIC | 1.00 | 3.03 |
| 46 | Passithang MIC | 2.00 | 5.09 |
| 47 | Damala Gaon MIC | 1.00 | 3.75 |
| 48 | DungDung MIC | 1.50 | 6.50 |
| 49 | Lepcha Jhora MIC | 1.00 | 6.50 |
| 50 | Chisopani MIC | 2.00 | 8.00 |
| 51 | Tarathang MIC | 1.60 | 6.50 |
| 52 | Karki Dara MIC at Kayathang | 1.45 | 6.15 |
| 53 | karchi Kholsa MIC at Lingdum | 0.65 | 3.28 |
| | **TOTAL** | **85.60** | **317.51** |

Annexure-5.6

## Schemes proposed under AIBP funding during the year 2003-04
## South-West Division

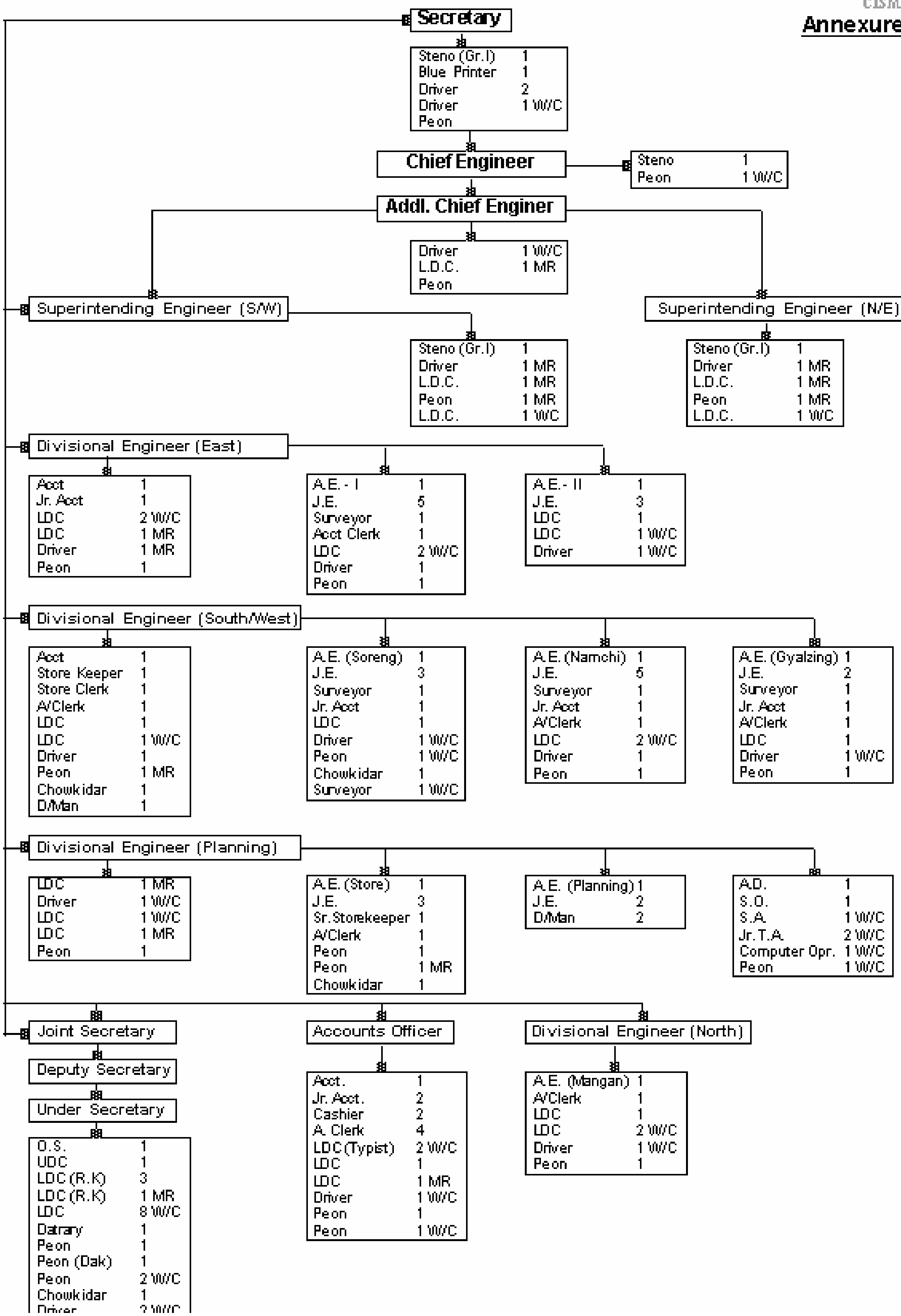
| SlNo. | Name of Work | Amount (Rs. Lakh) | Potential to be created (ha) |
|---|---|---|---|
| 1 | const. of Zeel Hatidunga MIC ( puth khola soruce ph - II ) | 2.00 | 7.50 |
| 2 | Const. of Ambeytar-Puchar Kulo, Tharpu MIC | 2.00 | 16.00 |
| 3 | Const. of MIC Gaulay Khola Gairi Gaon L/Tanak | 2.60 | 10.00 |
| 4 | kazini Kulo MIC | 3.00 | 20.00 |
| 5 | Const of Chokam Khola MIC | 1.00 | 2.50 |
| 6 | Const of MIC at Tokal | 3.00 | 11.00 |
| 7 | Const.of Gagyong MIC | 3.00 | 12.00 |
| 8 | Const of Nagi MIC at Ruchung | 2.50 | 9.50 |
| 9 | Const of Langang Kholsa to Toyang MIC | 3.00 | 18.00 |
| 10 | Const/Extesion of Dong Khola MIC | 3.00 | 11.00 |
| 11 | Const. of Chalamthang MIC at Chalamthang | 5.00 | 18.00 |
| 12 | Const of L/lasso MIC | 2.00 | 16.00 |
| 13 | Const. of Chilkhola MIC | 3.00 | 11.00 |
| 14 | Const, ofMangshari Dara Kulo MIC | 2.00 | 17.60 |
| 15 | Const./Extension of Mainabotey MIC | 3.00 | 12.00 |
| 16 | Const, of Chundharey Khola MIC at Budag | 2.00 | 15.00 |
| 17 | Extension of L/passi MIC | 2.50 | 9.50 |
| 18 | Cosnt. Of Doksing Khola MIC | 2.00 | 13.00 |
| 19 | Cosnt of Menchu Khola MIC of Sisney kulo Ph-I | 3.00 | 16.00 |
| 20 | Const. of Rajaya Kulo MIC at U/Thambong | 1.00 | 7.00 |
| 21 | Const./Extension of Hee Khola MIC | 3.00 | 10.50 |
| 22 | Const./Extension of Omchu MIC | 2.00 | 7.00 |
| 23 | Const of MIC at Sadam Suntaley ( Phaldey Khola ) | 2.05 | 7.50 |

| | | | |
|---|---|---|---|
| 24 | Const. /Extension of Khalbaley MIC ( D.P.Rai) | 2.00 | 8.00 |
| 25 | Const. of Lower Namlung MIA | 3.00 | 12.00 |
| 26 | Const.of Nangdang TIRI KHOLA | 3.00 | 11.00 |
| 27 | Const of Devithaney Tanak MIC | 4.00 | 18.00 |
| 28 | Const of Jugdum Khola MIC at Aroobotey | 2.00 | 12.00 |
| 29 | Const of MIC Devithaney to Tholo Khet Tanak | 1.75 | 7.00 |
| 30 | Const of Upper Mangmoo MIC Dentam | 3.00 | 15.00 |
| 31 | const ofTathang MIC | 1.75 | 12.00 |
| 32 | Const. of MIC Pagla to Tinley | 4.00 | 15.00 |
| 33 | Const of Biriling MIC | 3.00 | 11.00 |
| 34 | Const of Zim Khola MIC at Karthok | 2.00 | 7.50 |
| 35 | Reshi Khola to Hokengdang MIC | 3.00 | 6.50 |
| 36 | Const of L/Arithang MIC under Tashiding | 3.00 | 19.00 |
| 37 | Niya Khola MIC Phase - I | 2.00 | 7.00 |
| 38 | Cosnt.of U/Timburey MIC upper Budang | 2.00 | 10.00 |
| 39 | Const of Temi Aifal Tar | 1.00 | 3.75 |
| 40 | Const of Salley MIC Lingchom | 2.00 | 16.00 |
| 41 | Const. of L/Chumbung MIC | 1.75 | 13.00 |
| 42 | Middle Barfok MIC | 3.00 | 8.00 |
| 43 | Const. of Ekley Khola MIC | 1.00 | 2.00 |
| 44 | Doubly Kulo MIC below Hee Bazar | 2.75 | 10.10 |
| 45 | Cosnt of Geytan MIC Dentam | 3.00 | 13.00 |
| 46 | Const of L/Labing MIC | 1.75 | 11.00 |
| 47 | Cosnt of Leedung MIC | 1.00 | 10.00 |
| | **TOTAL** | **114.40** | **535.45** |

**Superintending Engineer (Plg.)**
**Irrigation & Flood Control Department,**
**Government of Sikkim,**
**Gangtok, SIKKIM>**

# ORGANISATION SET-UP DIAGRAM OF IRRIGATION DEPARTMENT

**Annexure-5.7**



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## LAND ENVIRONMENT - SOIL

## VOLUME – IV

## WATER ENVIRONMENT

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**CHAPTER**

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