

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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&

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

CARRYING CAPACITY STUDY OF TEESTA BASIN IN SIKKIM



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FACTS AT A GLANCE

FACTS AT A GLANCE

PART A – EXISTING SCENARIO

1	Geographical Area		Sikkim
2	Landuse (1956-96)		
	Reporting area	th ha	172.09
	Forest	th ha	50.71
	Not available for cultivation	th ha	12.49
	Total cultivable area	th ha	108.89
	(a) Net sown area	th ha	62.04
	(b) Follow land	th ha	34.65
	(c) Other uncultivable land	th ha	2.20
3	Land Holdings	No.	51127
	Operated area	th ha	107.00
	Average size per holding	ha	2.01
4	Hydrology		
	(a) Average annual normal rainfall		
	North District	mm	2306.01
	South District	mm	2224.50
	East District	mm	3259.90
	West District	mm	2518.70
	Average for state	mm	2544.40
	(b) Average runoff		
	(i) Chungthang	Mcum	4332
	(ii) Khanitar	Mcum	11569
	(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	
Dikchu	mm/year	0.95	
Sirwani	mm/year	0.51	
Khanitar	mm/year	0.42	
5. Agriculture (1990-91)			
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	

PART B – DEVELOPMENT PERSPECTIVE

1	Water Resources					
	Rainfall	mm			2544.4	
	Potential	mm			1531	
	evapotranspiration					
	100 years return year flood					
2	(a) Khanitar	cumec			5779	
	(b) Coronation Bridge	cumec			5919	
	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	%	179.00	180.0		
	(GCA/NSA)			0		
	Extent of irrigation	%	20.00	50.60		
	(GIA/GCA)					
	Cropped area under					
	(i) Kharif	th ha		73		
	(ii) Rabi	th ha		25		
	(iii) Perennial & others	th ha		40.3		
	Cropping pattern (as % of th ha GCA)					
		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 projected demands 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

SALIENT CHARACTERISTICS OF SIKKIM

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 Tibetan 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 Jeleppla 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 snow 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 as 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 :

(i) In Sikkim	:	151
(in km) (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 as 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 Melli 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 part 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 changes 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 carry out 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 up to 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° 24'	88° 31'	1957 to 63, 1971-80 & 1992-99
2.	Singhik	27° 31'	88° 30'	1957 to 63, 1971-80 & 1992-99
3.	Chhungthang	27° 36'	88° 30'	1957-84
4.	LaChhung	27° 42'	88° 45'	1957-63, 1971-79 and 1990-99
5.	Yumthang	27° 48'	88° 42'	1957-63, 1971-80 and 1985, 1987
6.	Lachen	27° 43'	88° 32'	1951-67, 1971,1972 7 1992-99
7.	Thangu	27° 53'	88° 31'	1951-69 & 1980
8.	Damthang	27° 14'	88° 23'	1957-63
9.	Yoksum	27° 27'	88° 12'	1958-63,1971-80, 1991-99
10.	Dentam	27° 15'	88° 09'	1958-63,1971-80, 1992-99
11.	Chhangu	27° 22'	88° 40'	1958-63,1971-72 1978,1992
12.	Rongli	27° 12'	88° 41'	1957-63, 1971-79, 1991-99
13.	Geyzing	27° 17'	88° 16'	1957-78
14.	Gangtok	27° 30'	88° 37'	1957-78, 1990-99
15.	Mangan	27° 30'	88° 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:

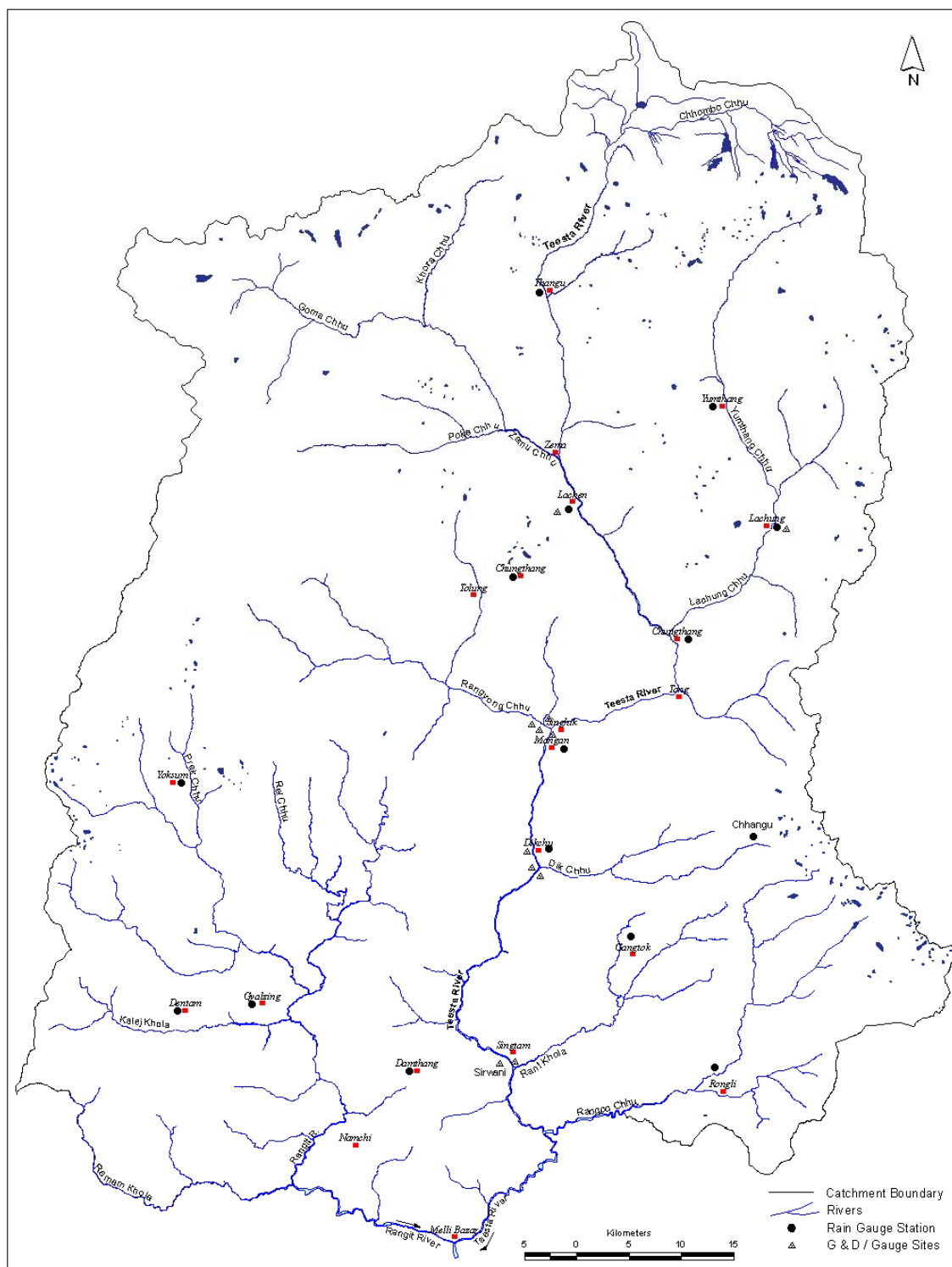


Fig.3.1 Index map showing rain gauge and G&D sites in Teesta basin in Sikkim

- (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 per the above guidelines, a network of one ordinary rain gauge for every 300 km² 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.

The 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 P_x at the station is given by the equation:

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

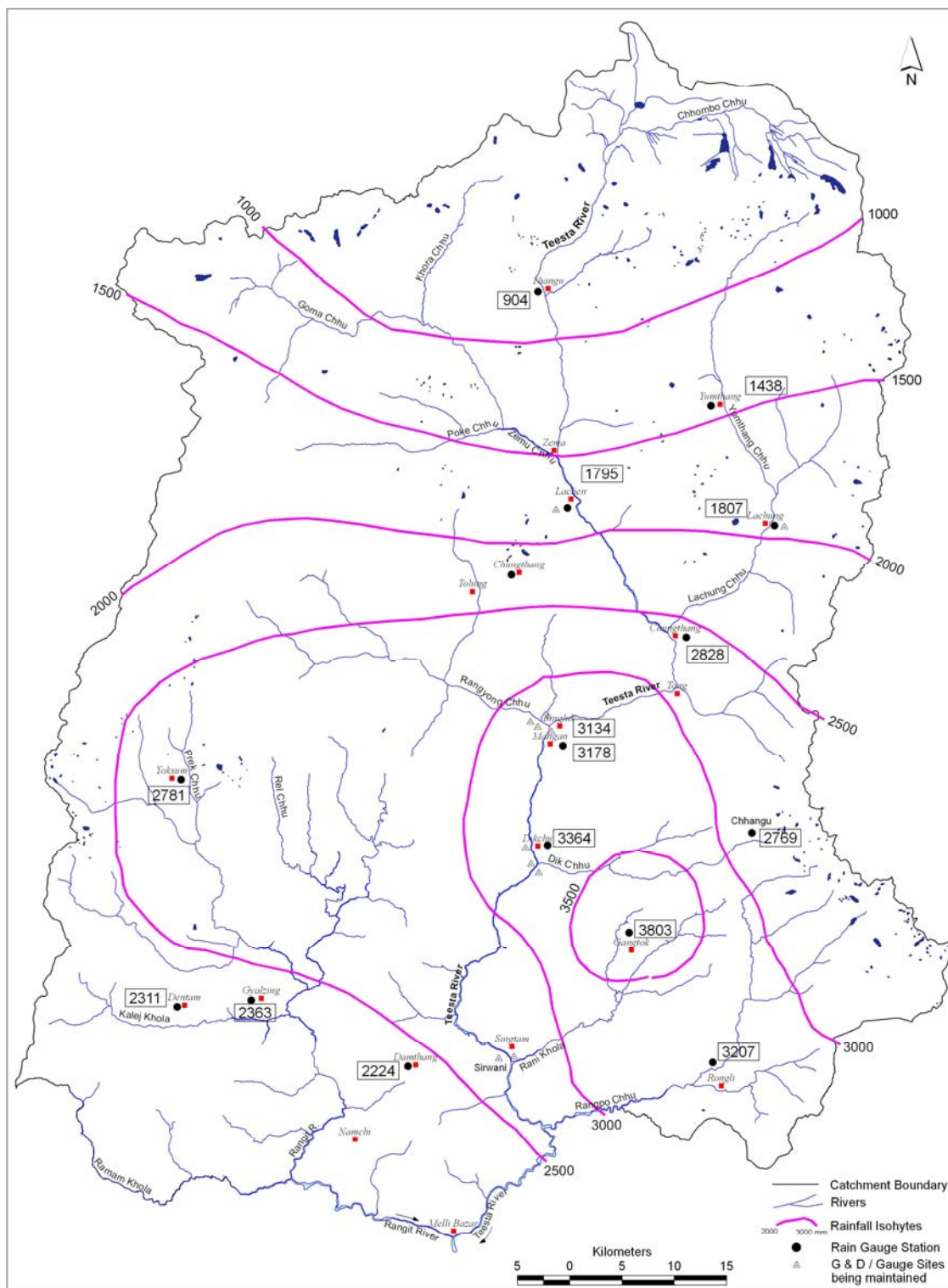


Fig.3.2(a) Annual Normal Rainfall in Teesta basin in Sikkim

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

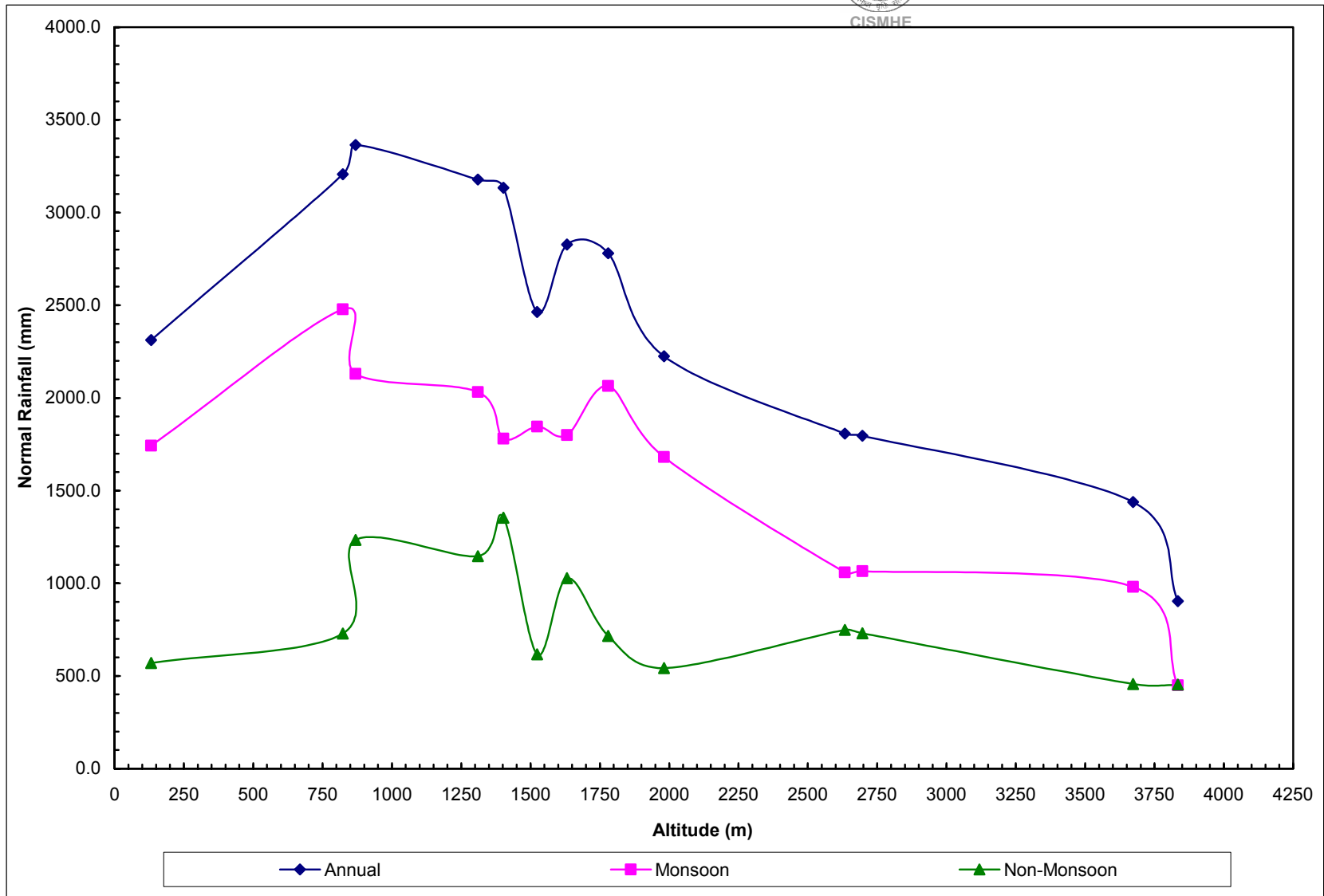


Fig. 3.3 Altitude vs. normal rainfall

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 Thiessen polygon method. The Thiessen polygon are plotted at Fig.3.5(a) to Fig.3.5(e). The computed Thiessen 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° C in September to 20.7° C in the month of January. Mean daily minimum temperatures are around 7.5° C in January, 10.7° C in April, 14.5° C in July and 13.3° 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.

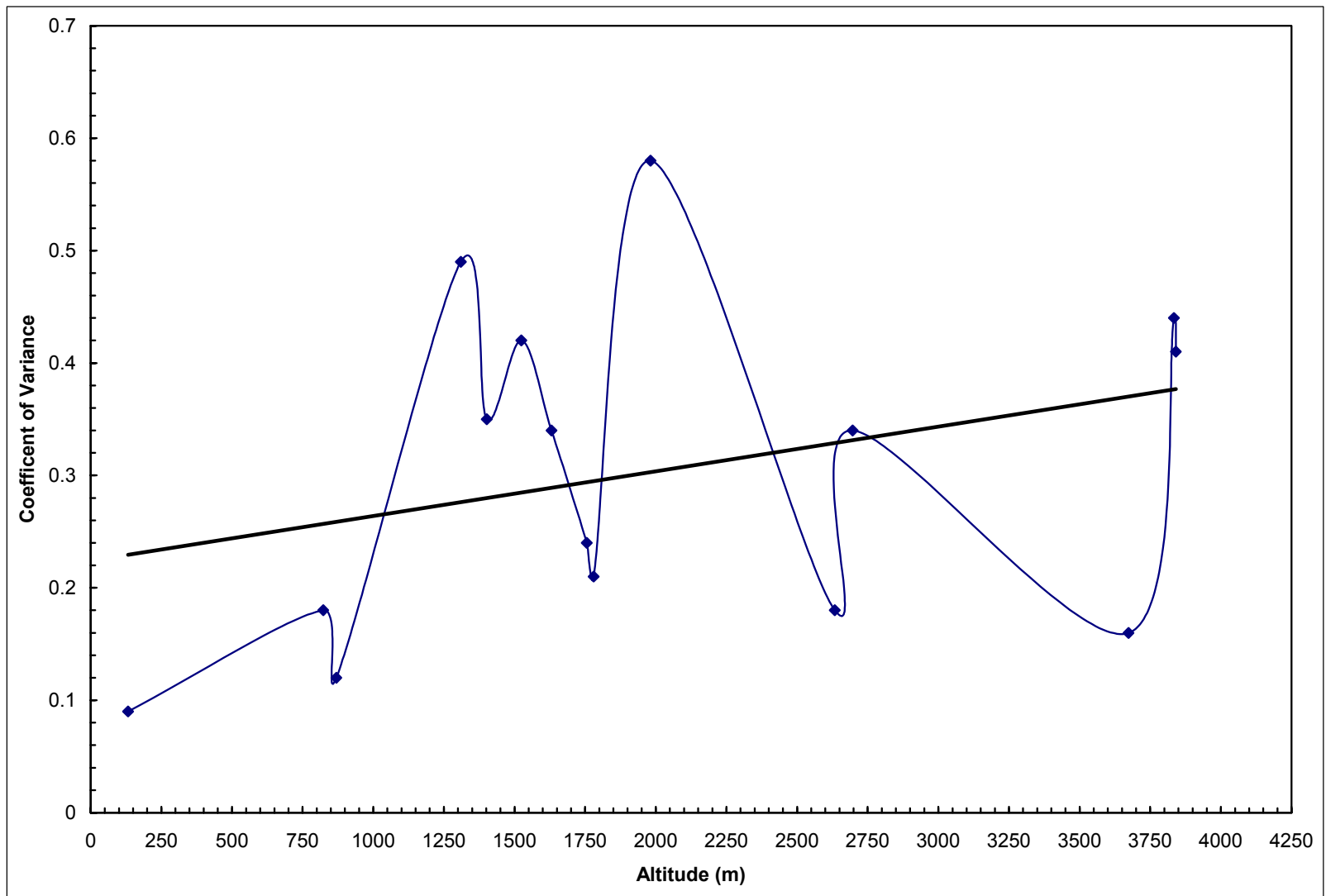


Fig. 3.4 Altitude vs. coefficient of variance

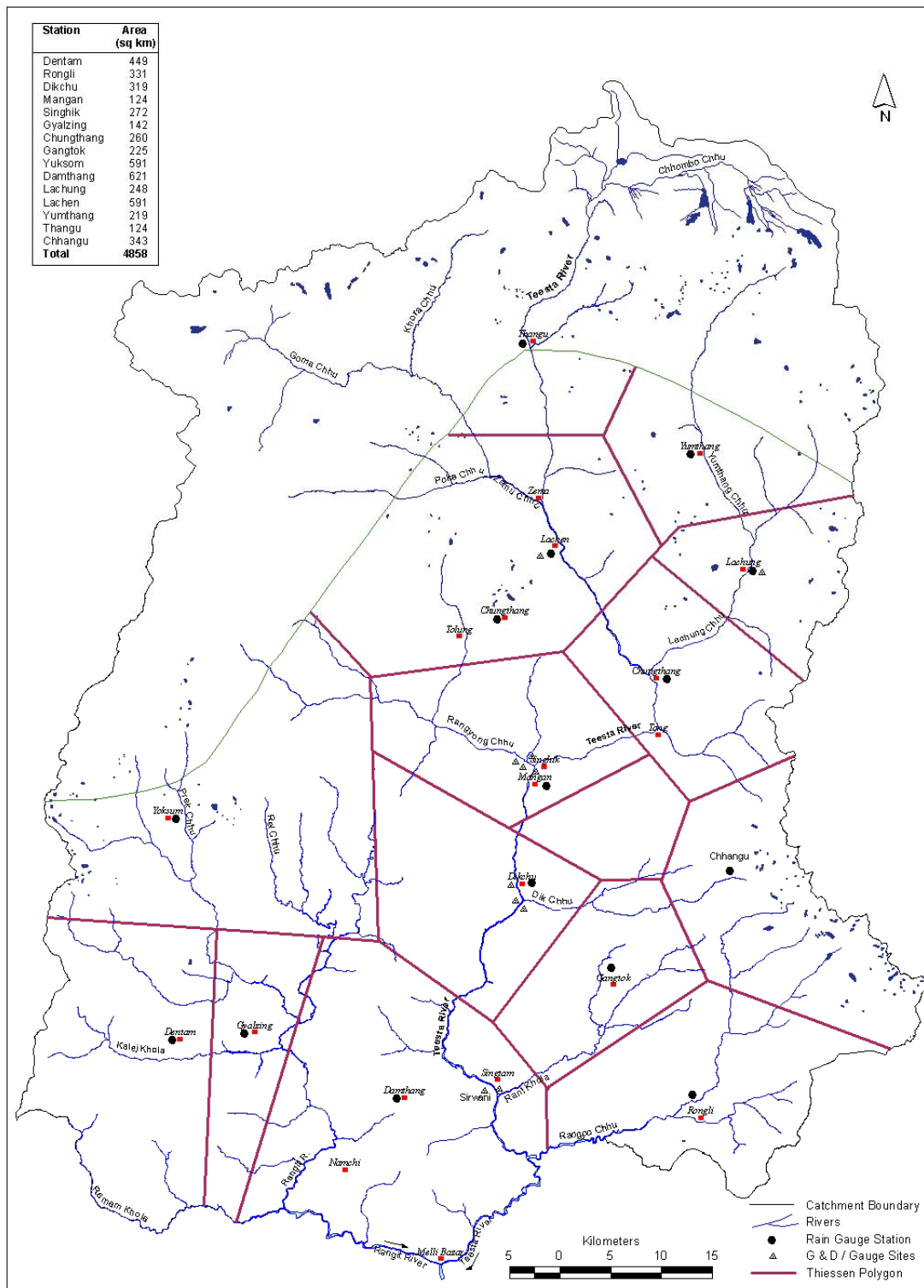
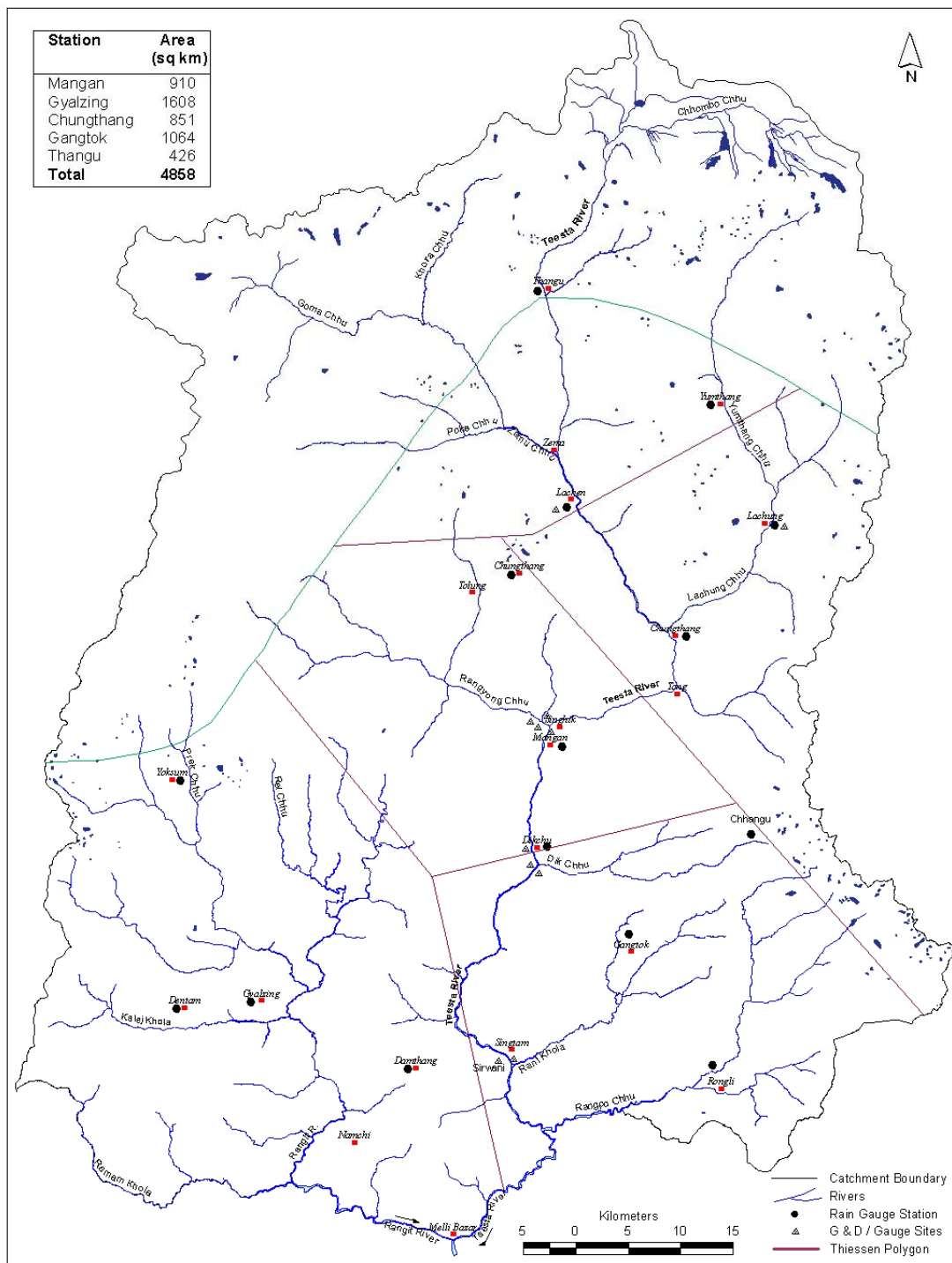


Fig.3.5(a) Thiessen Polygon Network (Period 1951-1956) in Teesta basin in Sikkim



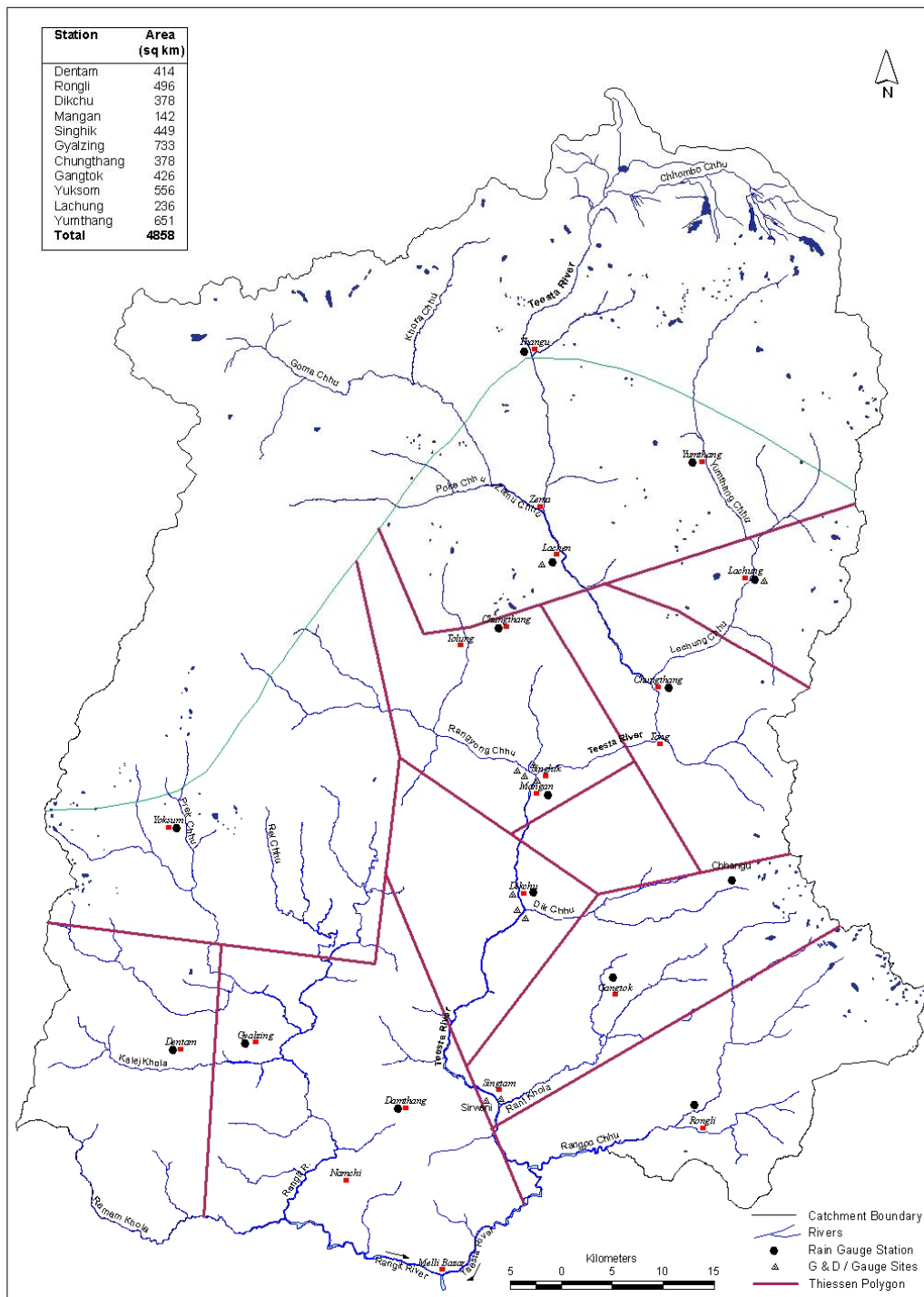


Fig.3.5(d) Thiessen Polygon Network (Period 1971-1979) in Teesta basin in Sikkim

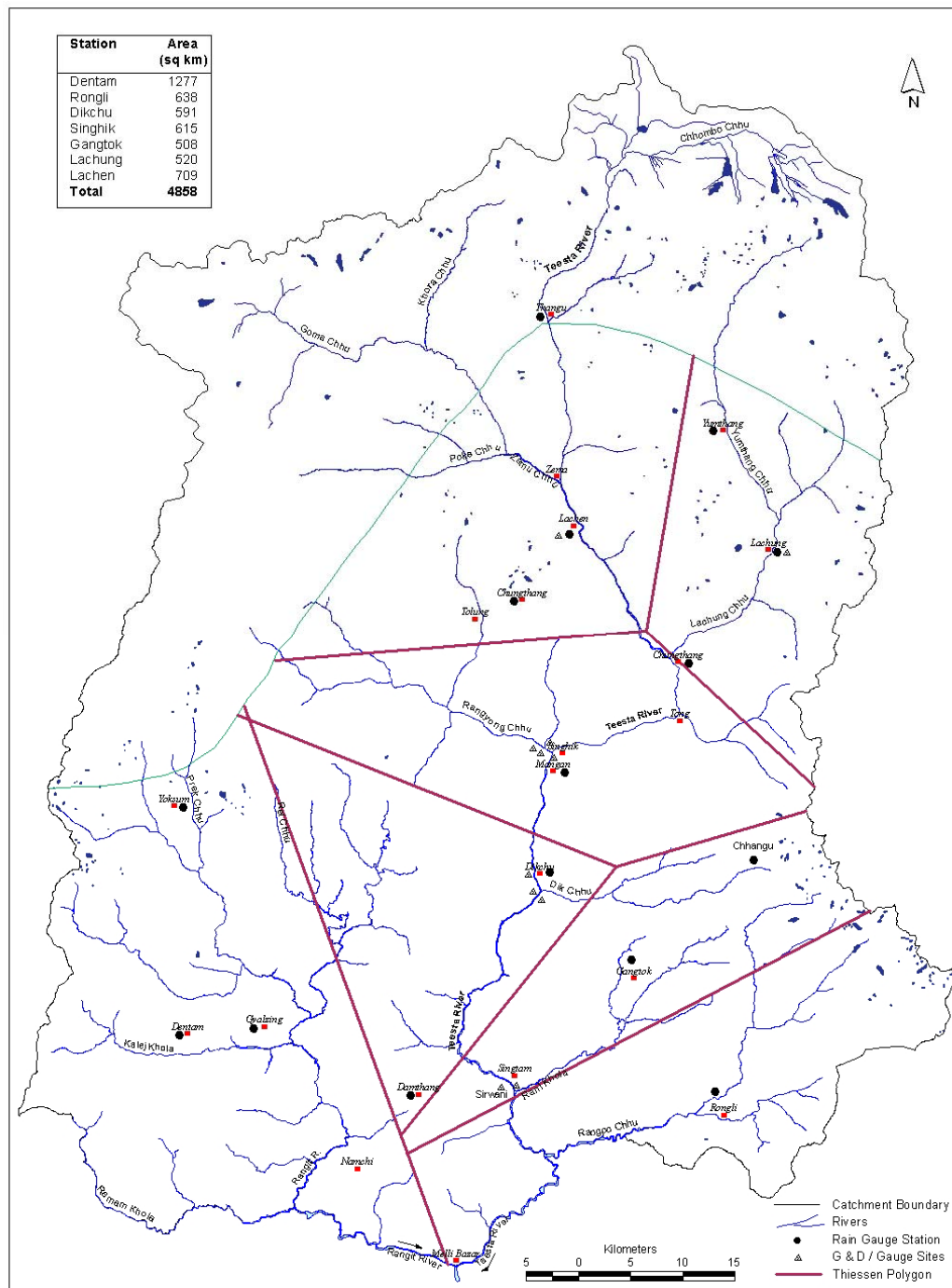


Fig.3.5(e) Thiessen Polygon Network (Period 1992-1999) in Teesta basin in Sikkim

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

District	Temp/RH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NORTH	Max	Data Not Available											
	Min												
	RH												
EAST	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
	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
WEST	Max	27.4	27.4	26.1	26.6	23	23.3	24.0	26.1	27.6	27.8	27.2	28.7
	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
SOUTH	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
	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

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 be 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

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 14 th 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	1976-95	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-priori. If the total number of years in the data series is N and the number of floods events exceeding the threshold, fixed a-priori, 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)		$(X-X)^2$	$(X-X)^3$	$Z=\log X$	$Z-Z$	$(Z-Z)^2$	$(Z-Z)^3$
		X	X-X						
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)		$(X-X)^2$	$(X-X)^3$	$Z=\log X$	$Z-Z$	$(Z-Z)^2$	$(Z-Z)^3$
		X	X-X						
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

\bar{X} = average of X values

\bar{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 $\bar{X} = \frac{1}{N} \sum_{i=1}^N x_i$

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

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

iv) Skewness co-efficient (unbiased), $C_s = \frac{N \sum_{i=1}^N (x_i - \bar{x})^3}{(N-1)(N-2)\sigma_{n-1}^3}$

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
\bar{X}	2531.89	3.38
σ_{n-1}	878.561	0.138
C_v	0.347	0.041
C_s	1.236	0.587

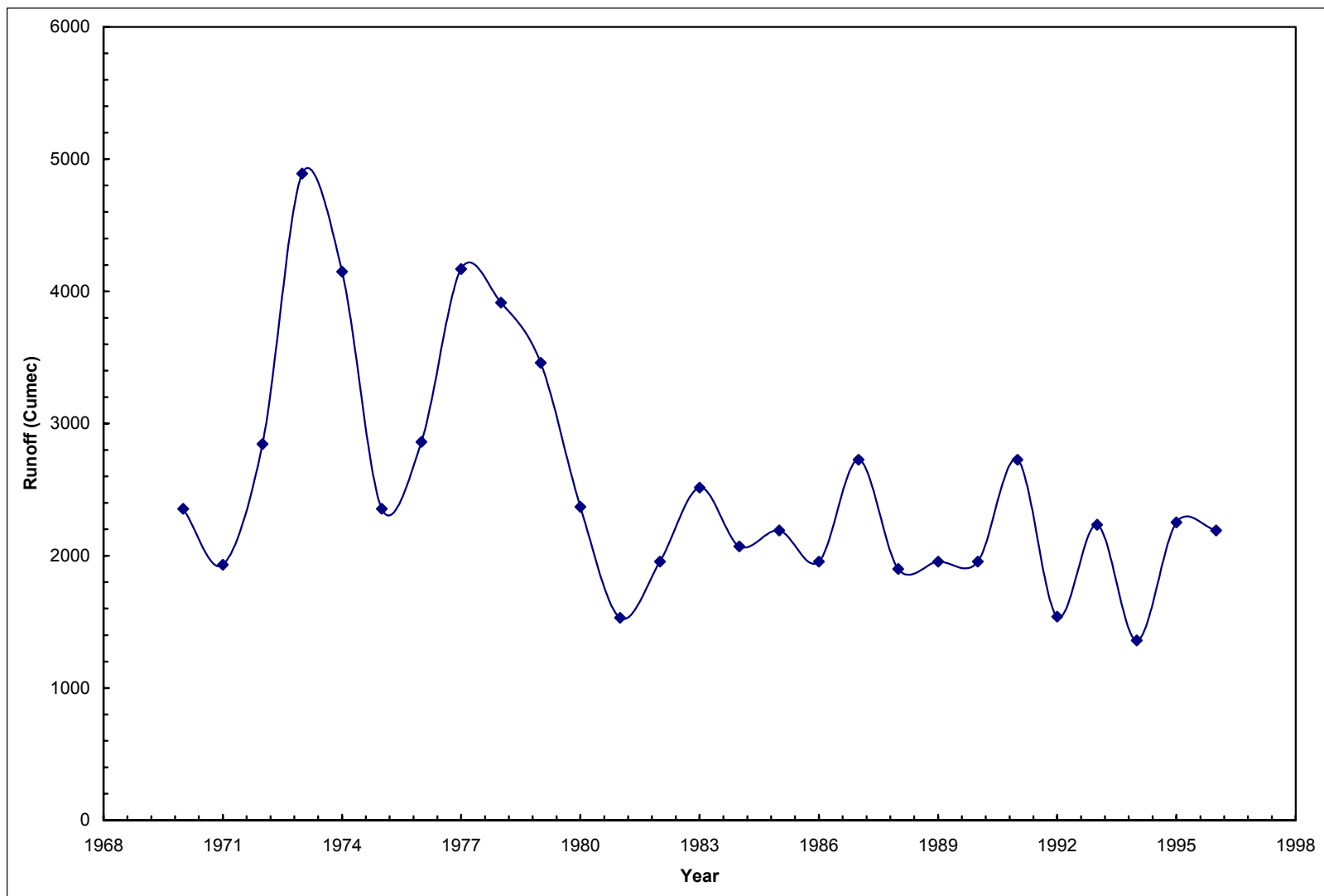


Fig.4.1 Annual flood hydrograph on river Teesta at Khanitar site

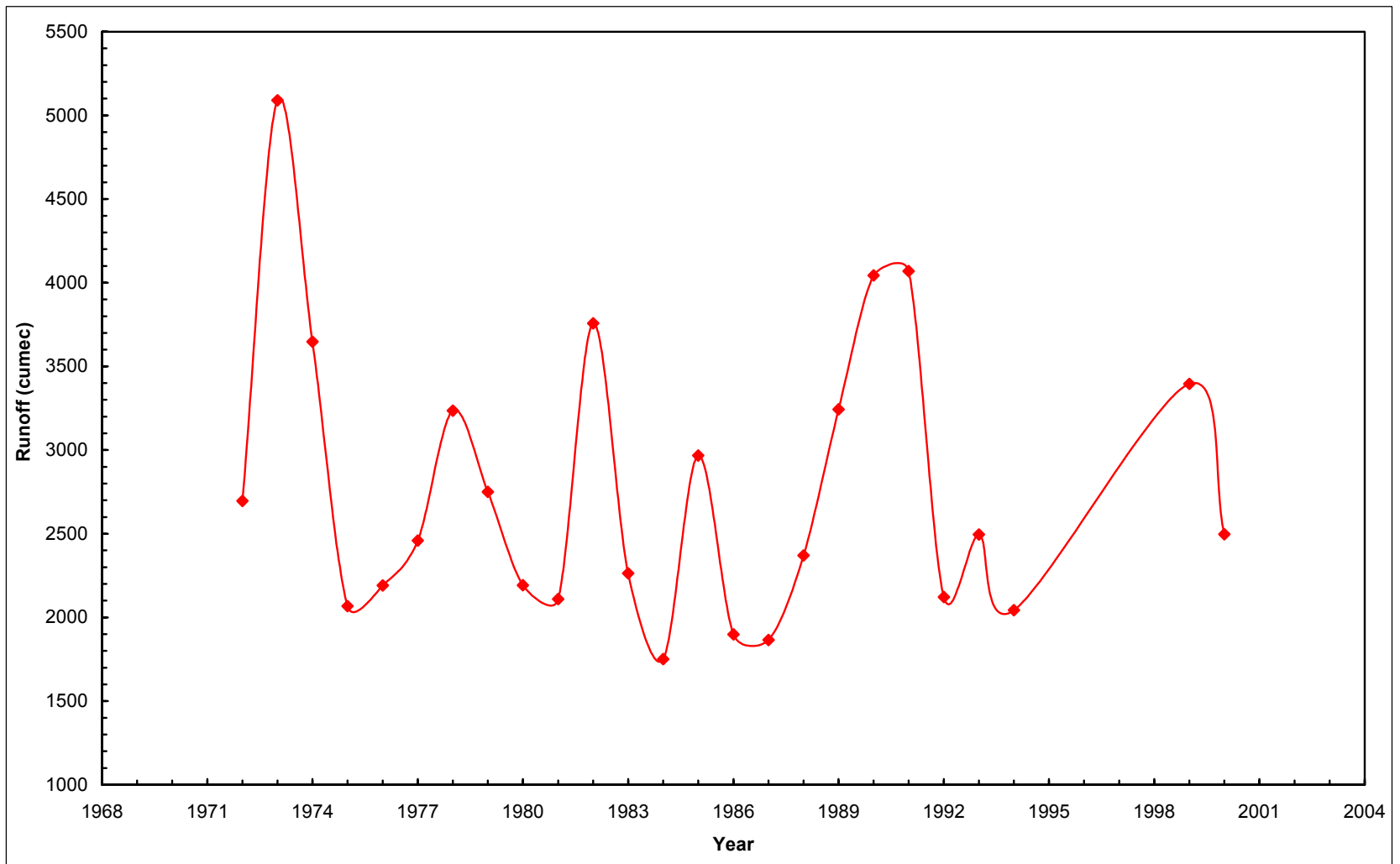


Fig.4.2 Annual flood hydrograph on river Teesta at Coronation bridge

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

Parameters	Original Series	Log Transformed Series
\bar{X}	2768.92	3.42
σ_{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 J is defined as follows:

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

where p = number of turning points in the AMS.

= number of peaks + number of troughs

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

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

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

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

$$P = 7 + 7 = 14 \text{ (Ref: Fig. 4.1)}$$

$$E_p = 15.33$$

$$\text{Var}(p) = 4.12$$

$$J = -0.65 < 1.96$$

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 J such as:

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

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

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

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

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

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

$|J| < 1.96$ 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 J 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:

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

Where X_T = flood of T year frequency

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

$$K = \text{frequency factor} = \frac{Y_T - \bar{y}_n}{S_n}$$

σ_{n-1} = standard deviation of the series

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

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

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

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

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

$$N \rightarrow \infty, S_n \rightarrow 1.2825$$

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

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

Where \bar{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

σ_z = standard deviation of the Z variate series

$$= \sqrt{\frac{\sum (Z - \bar{Z})^2}{N - 1}}$$

and C_s = coefficient of skew of variate Z

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

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	$Z_T = \bar{Z} + K_z \sigma_z$ $= 3.38 + K_z \times 0.1379$	$X_T = \text{Antilog}(Z_T)$
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	$Z_T = \bar{Z} + K_Z \sigma_z$ $= 3.42 + K_Z \times 0.123$	$X_T = \text{Antilog}(Z_T)$
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 Coronation 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 Availability 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 desiccator 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 is 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.

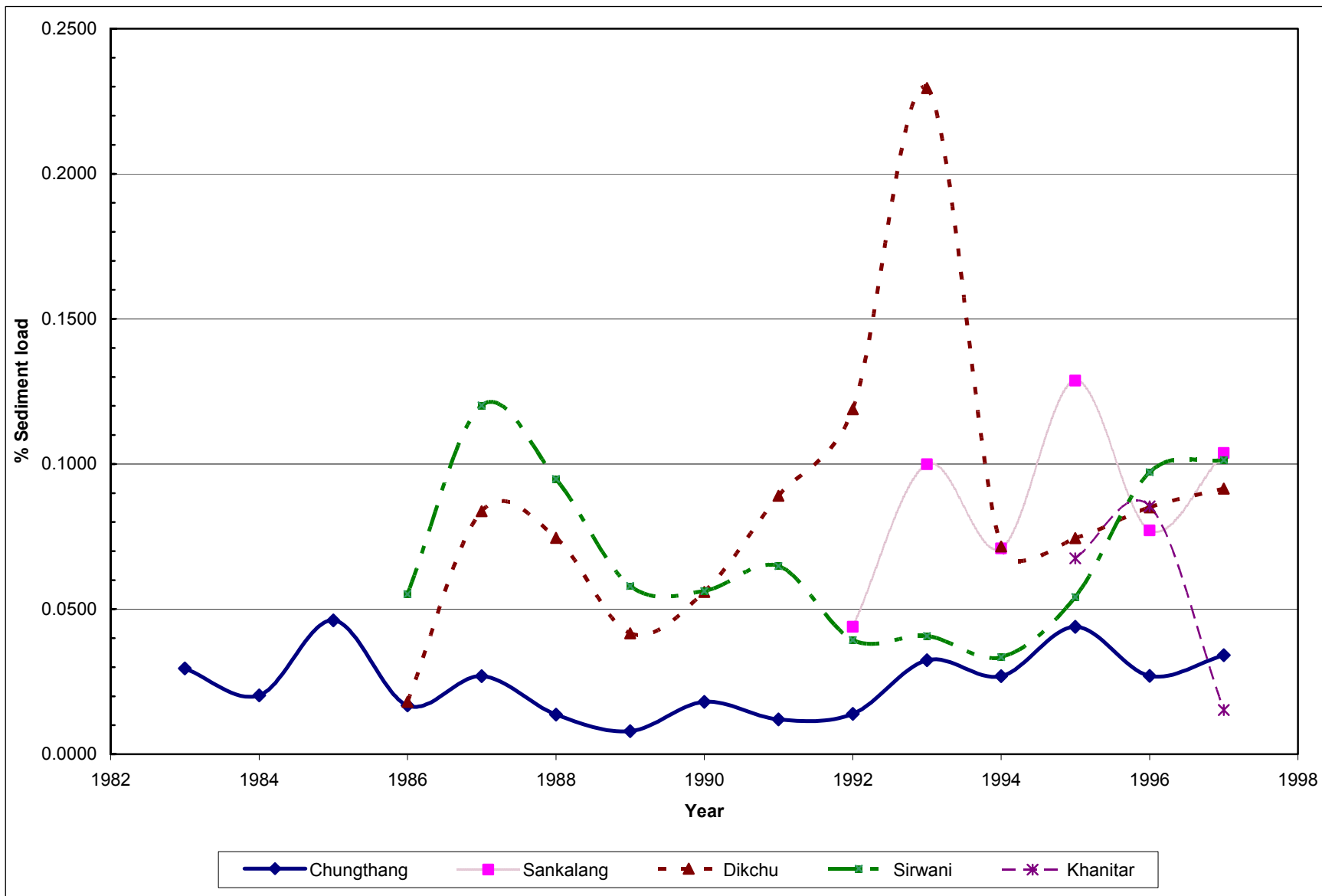


Fig.4.3 Percentage of sediment load with respect to runoff during monsoon

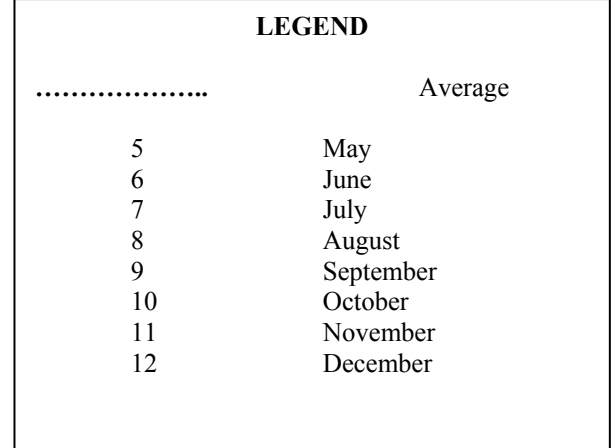
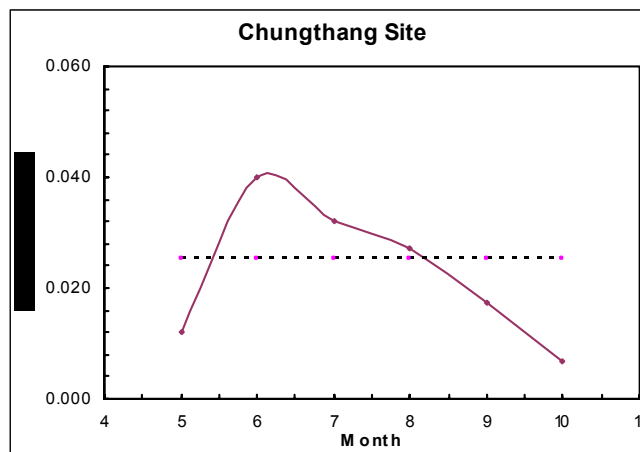
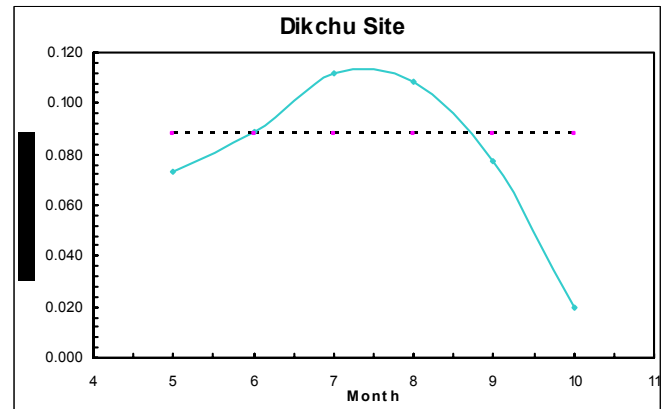
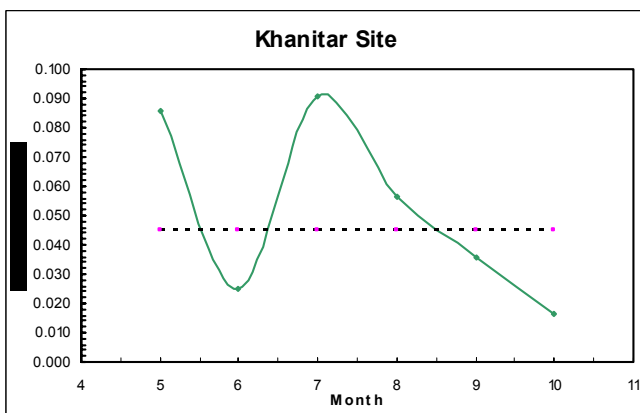
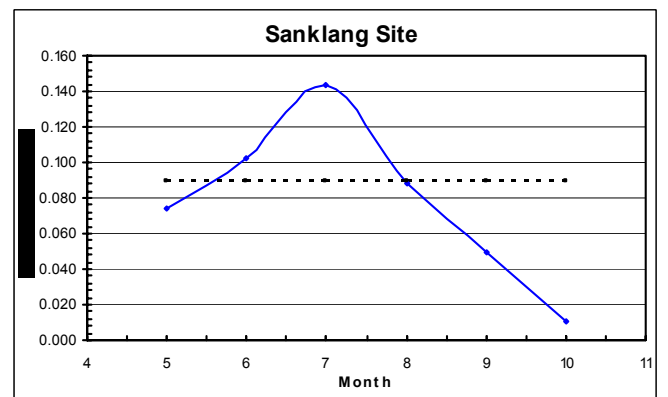
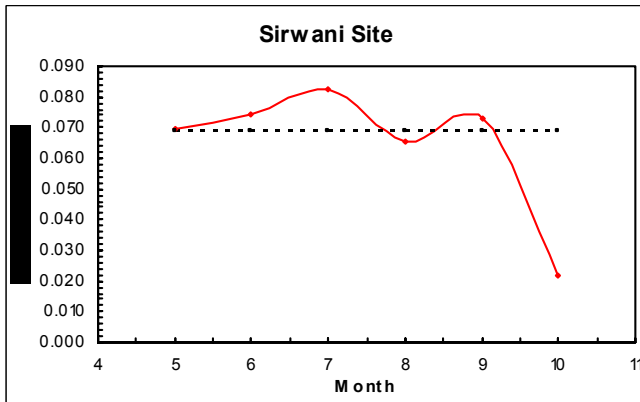


Fig.4.4 Monthwise average percentage of sediment load with respect to runoff

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, Dikchu	1995	51%	27%	22%
	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 unlevelled 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 VIIIth Plan (1992-97) are given in Table 5.1.

Table 5.1 Ultimate Irrigation Potential and Potential Created and utilized up to VIIIth 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 Xth 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 IXth 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 Xth FYP is also given in Table 5.3 as follows:

Table 5.3 Districtwise break-up of target of Irrigation Potential during Xth FYP

(Unit: ha)

District	Potential Creation	Potential Utilisation
East	25% 1150	950
West	27% 1200	1200
South	28% 1250	1050
North	20% 900	800
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 VIIIth and IXth 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 Xth 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 FYs 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 Distri ct	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. Perennial	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. Perennial	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

SI 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 interchangeability of some of the categories would be 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 untterraced. 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 tree 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 than 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	7.85	12.24	8.96	34.65
	(57.5% of NSA)	(43.3%)	(73.6%)	(51%)	(55.8%)
Current fallow	1.70	0.31	2.14	0.92	5.07
Fallow lands	3.89	7.54	10.09	8.05	29.57
Other than Current fallow					

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 soil 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 banded 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 erosion	water 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 erosion	water 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)

Category	(Unit: Percentage)									
	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.	10700 6 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, Clusterbean, 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 (ET_c), as the most important consumptive demand of a crop. According to this concept, crop evapo-transpiration is assessed through the following relationship:

$$ET_c = K_c \times ET_o$$

Here K_c 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 K_c 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-climatological 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 ($^{\circ}C$)

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 27⁰ 33'N, Long-88⁰ 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 (ET_o)

As stated in section 7.6, ET_o 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. = $(125 - 0.2 * \text{Total R.}) * \text{Total R.} / 125$ (Total R. < 250 mm/month)

Effective R. = $0.1 * \text{Total R.} - 125$ (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

<i>Date of Sowing</i>		<i>June</i>	<i>21-30</i>	<i>Duration</i>		<i>143 days</i>	
<i>Transplantation</i>		<i>July</i>	<i>21-31</i>				
<i>Harvest</i>		<i>Nov</i>	<i>11-21</i>				
Date of Start - 10 daily	ETo	Crop Coeff. Kc	CWR (Etc)	Perco-lation Loss	Req. for Land Preparation	Effective Rainfall	Net Irrigation Requirement
1	2	3	4=2*3	5	6	7	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 1	ET _o 2	Crop Coeff. K _c 3	CWR (Etc) 4=2*3	Effective Rainfall 5	Net Irrigation Requirement 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 E_c be the conveyance efficiency of the system, then E_c 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

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

For non-ponded crops, overall efficiency E

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

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 requirement	irrigation	Efficiency (%)	Gross requirement	irrigation
		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)

Crops	(Unit: tonnes)						
	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	1380	2000	2540	1740	6970	1690	1655
Wheat							
Finger	3840	4300	7310	4750		2090	3740
Millet							
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	1020/2000	2200/3100	6416/8747 + 36%
Maize	2230/2160	13450/6680	16620/18500	18500/18600	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	440/410	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 IXth Plan and the proposal for Xth 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	9 th Plan	10 th 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 IXth plan and proposal for Xth 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°C to 37.7°C (68° to 100° 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 coleoptiles 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_2O_5 (DAP 87 kgs)	-	40 kg
K_2O (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
NLD – White
Palmira
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 inbred 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 – hybrid – 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 $\frac{1}{3}^{\text{rd}}$ Urea can be applied at the time of sowing or before sowing $\frac{1}{3}^{\text{rd}}$ of Urea may be top dressed during first interculture. $\frac{1}{3}^{\text{rd}}$ remaining Urea may be applied at second interculture or earthing 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° - 23°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 solubilising 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 monocrotophos, dimethoate against thrips/ white flies etc. shall be done. Need based foliar application of endosulfan, chlorophosphos 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	Varities	Soil	Sowing Time	Seed Rate/ ha	Spacing (in cms)	Manure & Fertilizer/Ha	Irrigation	Harvesting (days)	Yield/ Ha tonnes	Remarks
1.	Cardamom	Ramsey High Sawney Medium & High Altitude 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 moderate land with moderate slopes is to be preferred	Sep.-Oct. in Nursery Scrolling Planting May- June	Seedling ha at the spacing of 15 mx 1 m 4445 nos	Pri Nursery 10x Sec. Nursery 15x10 Planting in Plot 150 x150	Forest soils are generally rich in organic matter and nitrogen. However, nondeivable oil Cakes may be applied @ 1kg / plant atleast 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 doses in April May and Sept. Application of bio-fertilizer may be highly beneficial.	For sustainable and better yield the crop may be irrigated during dry month.	Aug. Nov.	0.180-0.200	Pest : Leaf-eating 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% Quinalphos or Endosulfan is recommended. Chirkey and Furkey : Management As long as virus inoculum is 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 & Fertilizer/Ha	Irrigation	Harve sting (days)	Yield/ Ha tonnes	Remarks
											disease affected plants. Adopt regular rouging of infected plants as soon as symptoms appear (uproot and destory affected plants). Repect detection and rouging at regular intervals. Use seedlings produced in certitude nurseries. 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	Spacing (in cms)	Manure & Fertilizer /Ha	Irrigation	Harve sting (day)	Yield/ha tonnes	Remarks
1.	Gin- ger	Bhaisey Majholey a) Jorethangy 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 ltonne Neem cake and 75. kg N. : 80 kg P : 50 kg K Basal Dose : Urea : 45 kg Dap : 45 kg MOP : 83 kg	Rainfed	270- 280 (days) Nov. Dec.	10-15 tonnes	Toavoid disease problem use owngrownhealthy and discease free seed. Treat Rhizome with 0.3% (30 gm in 10 Ltr. water). Manoozeb (Dithan M 45 indofil or Tratr rhizome with Trichodema (one part TD & 5 Rhizone) Rhizome Rot. a) Soft Rot : Drechs soil with 0.2% (20 gm in 10 Ltr. water Dithone M 45 b) Dry Rot : Spray Bavistan (Carbendazime 0.1% 10 gm in 10 ltr. water c) Bacterial Wilt : d) Removeinfected plant and drench soil with copper fungicide 0.2 % (20 gms in 10 Ltr. Water) Nematode: e) Hot6 water treatment 51-52 C for 10-15 minutes 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 from 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 substantial 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 Ninth FYP

Particular	VIIIth Plan Expenditure						IXth Plan Expenditure					
	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 keeping, organic farming 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 on 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	12195	11371	15715	41276
		(4.8%)	(29.5%)	(27.6%)	(38.1%)	(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.

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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, cold 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 10th 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 than the target. The shortfall 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 achievement	Tenth Plan 2002-07 Target	Annual Plan 2002-03 Target	Anticipated Achievement 2002-03	Proposed Annual Plan 2003-04 Target
I	Fruit						
i)	Sikkim Mandarin	000 tonnes		6.800	4.983	3.500	5.480
ii)	Other Fruits	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 achievement	Tenth Plan 2002-07 Target	Annual Plan 2002-03 Target	Anticipated Achievement 2002-03	Proposed 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 IXth 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 introduction 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 in 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 Karfacter 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 Karfacter 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 strengthen 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		Annua I 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 ha Area						
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 tackling 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			1987			1988		
			Mean	Max	Min	Mean	Max	Min	Mean	Max	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			1990		
			Mean	Max	Min	Mean	Max	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 erratic 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	Geographical
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 0.2 ha / beneficiary (0.2 ha)	500	25.00
3	Ginger growing 0.2 ha / beneficiary (0.2 ha)	1000	50.00
4	Rabi potato 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 System development (No)	1500	30.00
9	Training of farmers – 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 IXth Plan i.e. March, 2002. During Xth 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 from 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 2nd and 3rd order streams. Hence on the basis of 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 0.1 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 0.1 m above the bed of this channel. A groove for a length of 0.6 m to 1 m will be left in the body wall of wier to serve as a scour vent. This scour vent will have sill level at 0.1 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 +0.1 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.

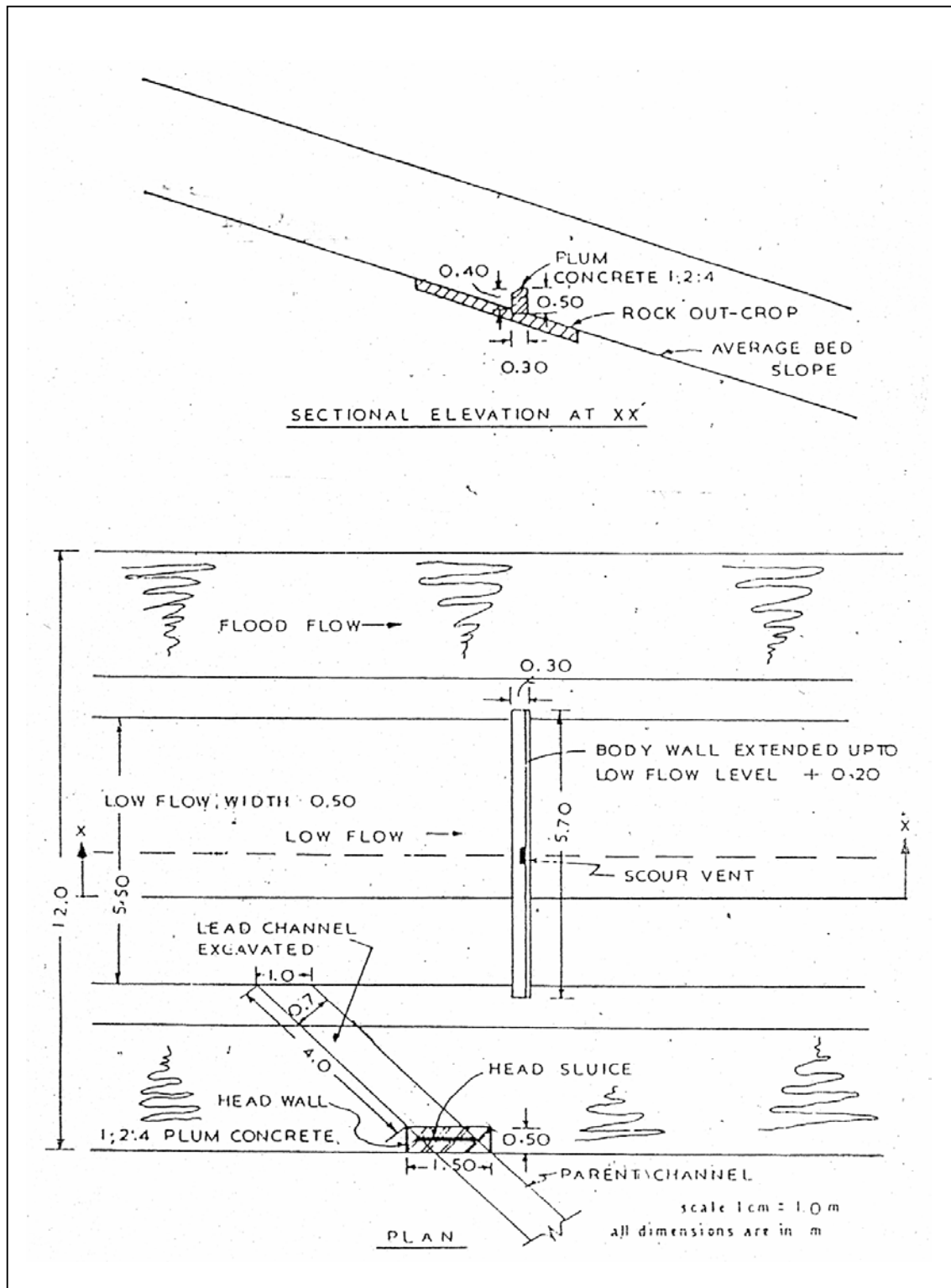


Fig. 10.1 Details of head work in areas where sheet rock is available in stream bed



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

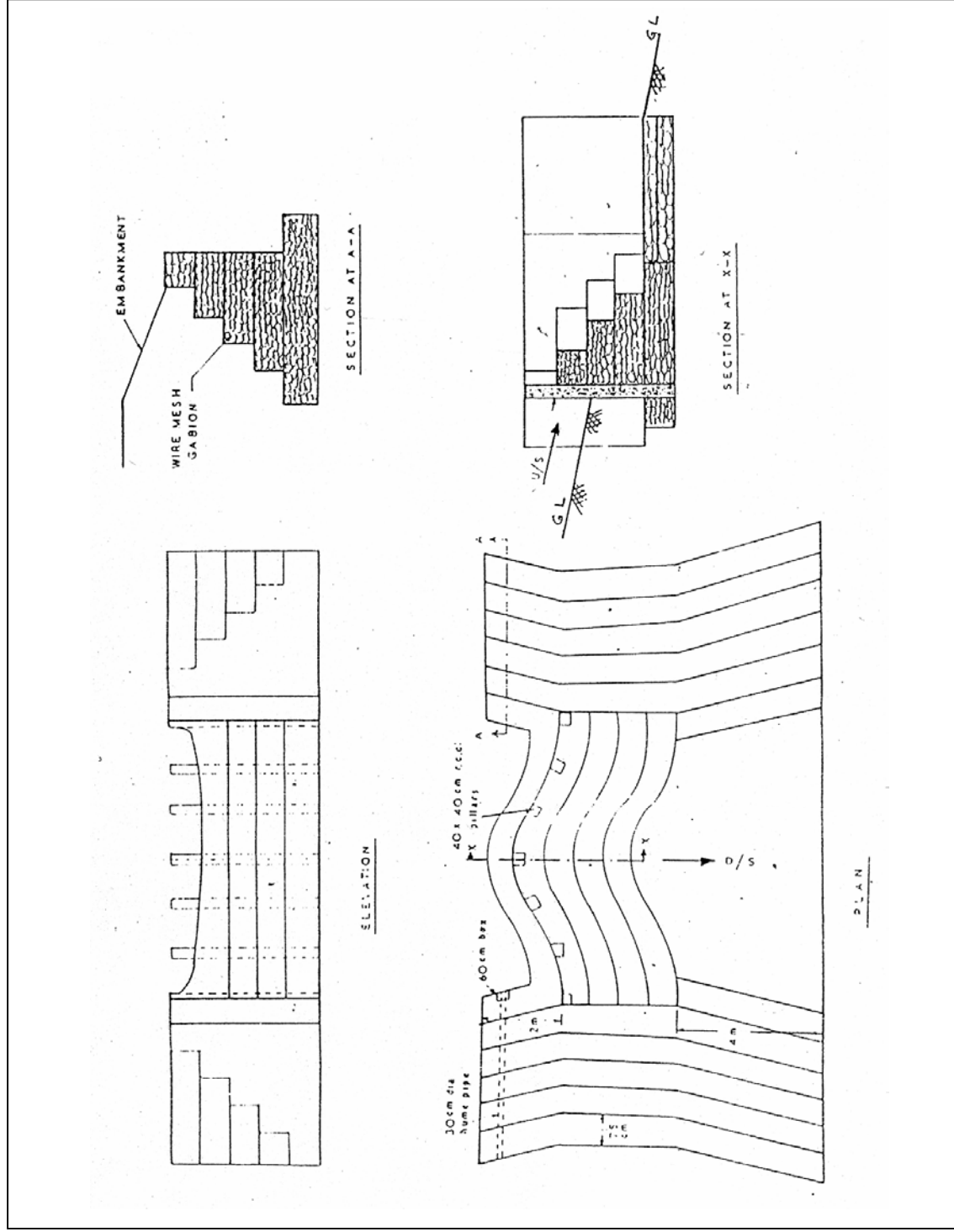


Fig. 10.3 Head works gabion drop structure

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

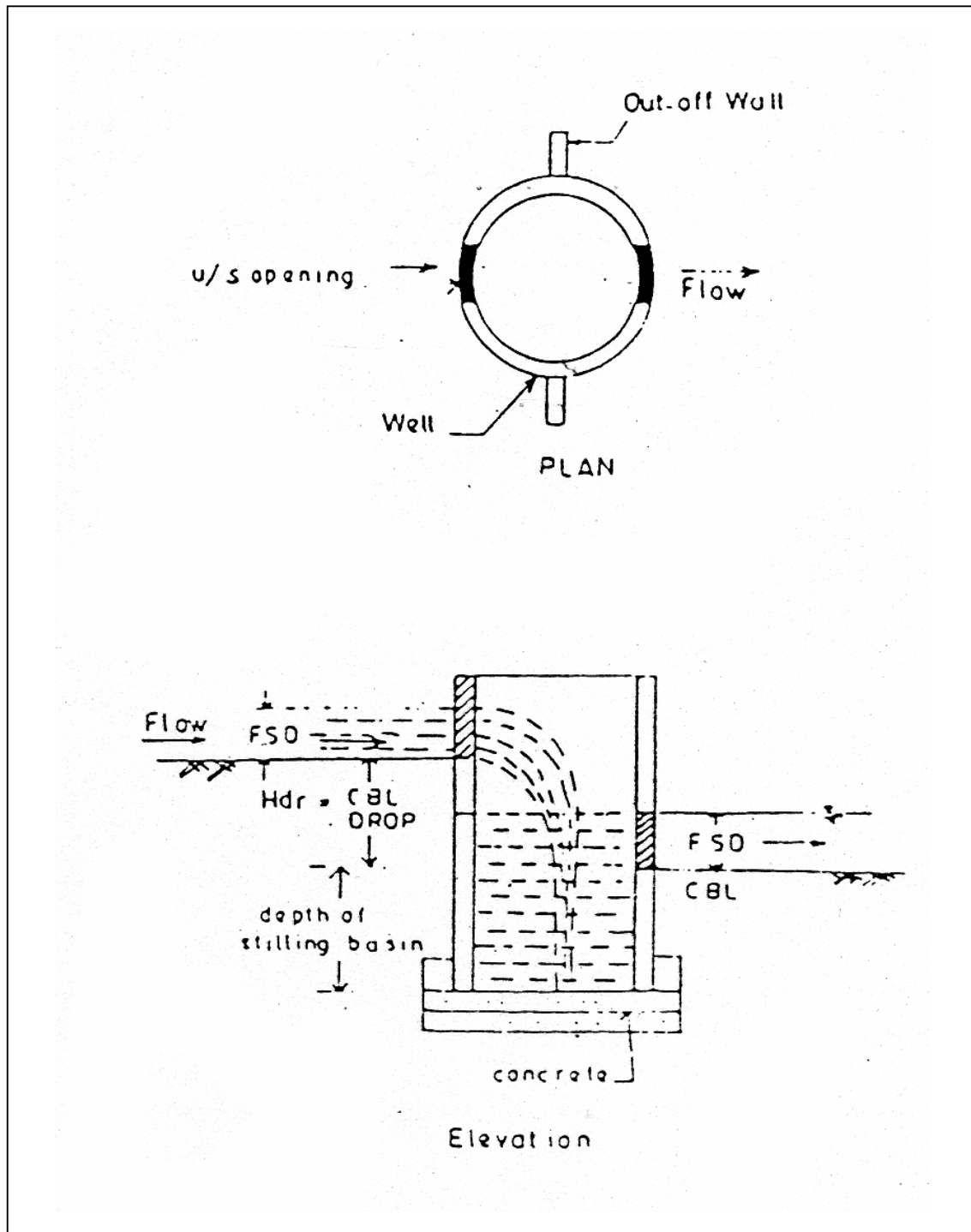


Fig. 10.5 Type design of vertical well type drop

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

On 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.

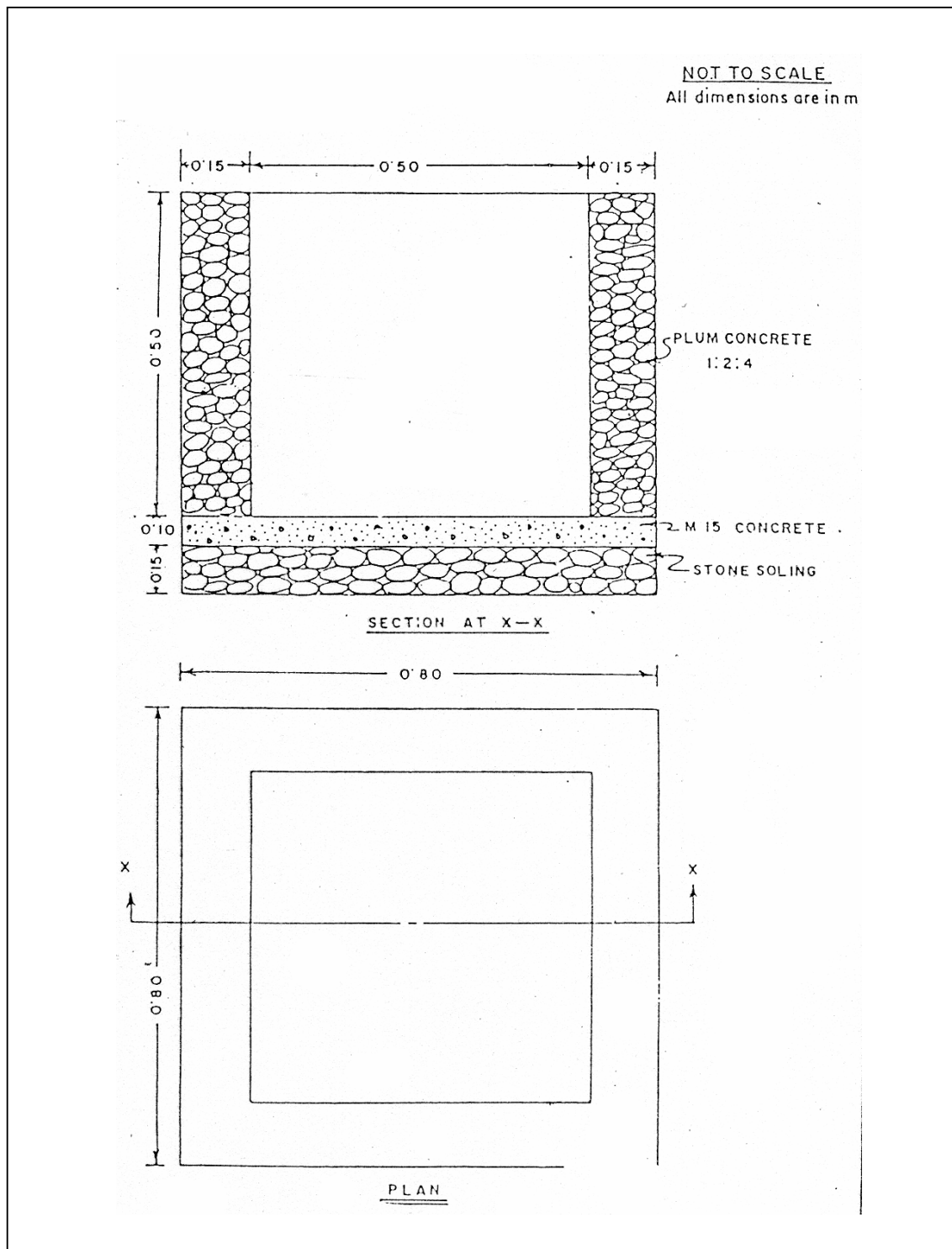


Fig. 10.6 Details of catch pit

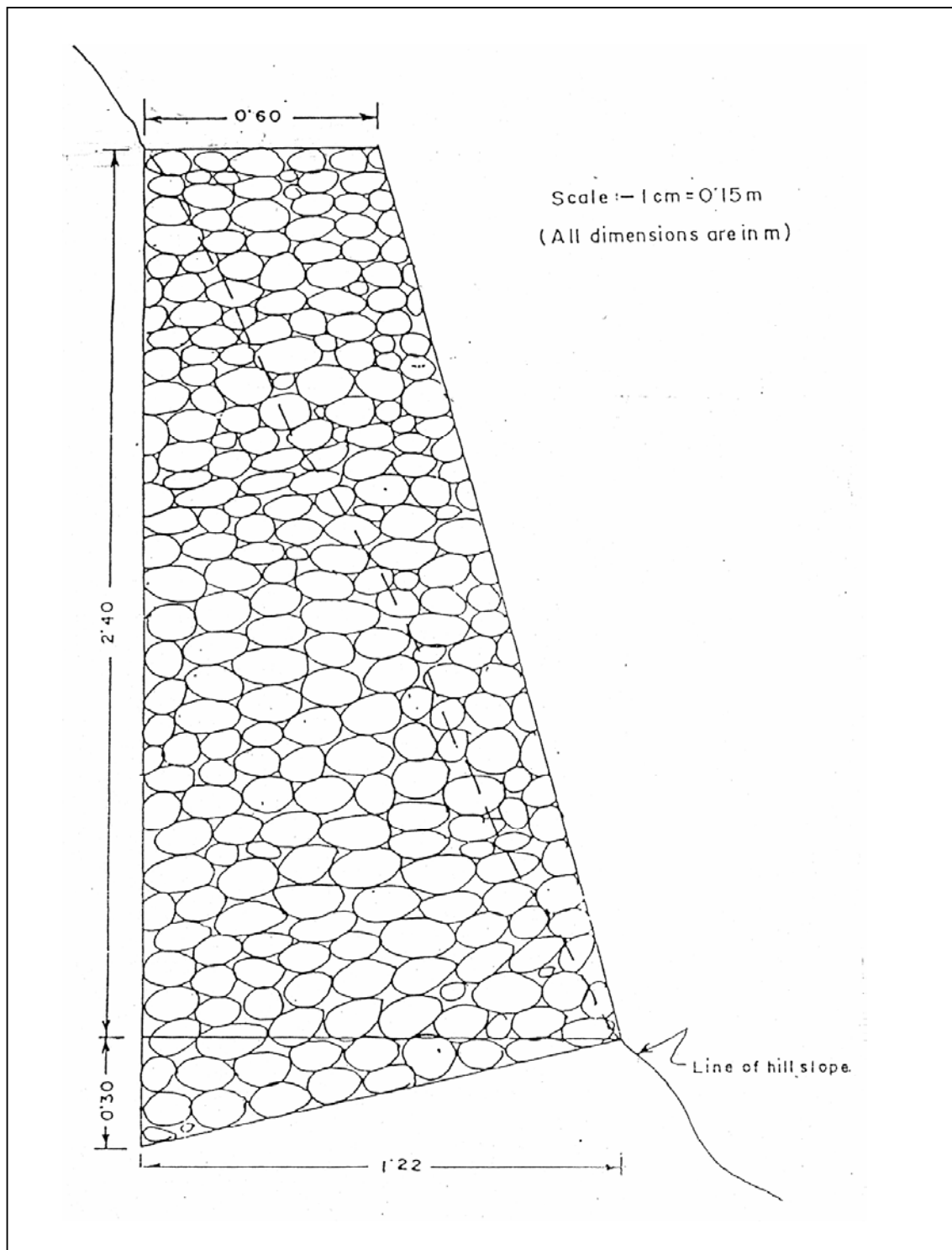


Fig. 10.7 Details of retaining wall

- (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 areas 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.

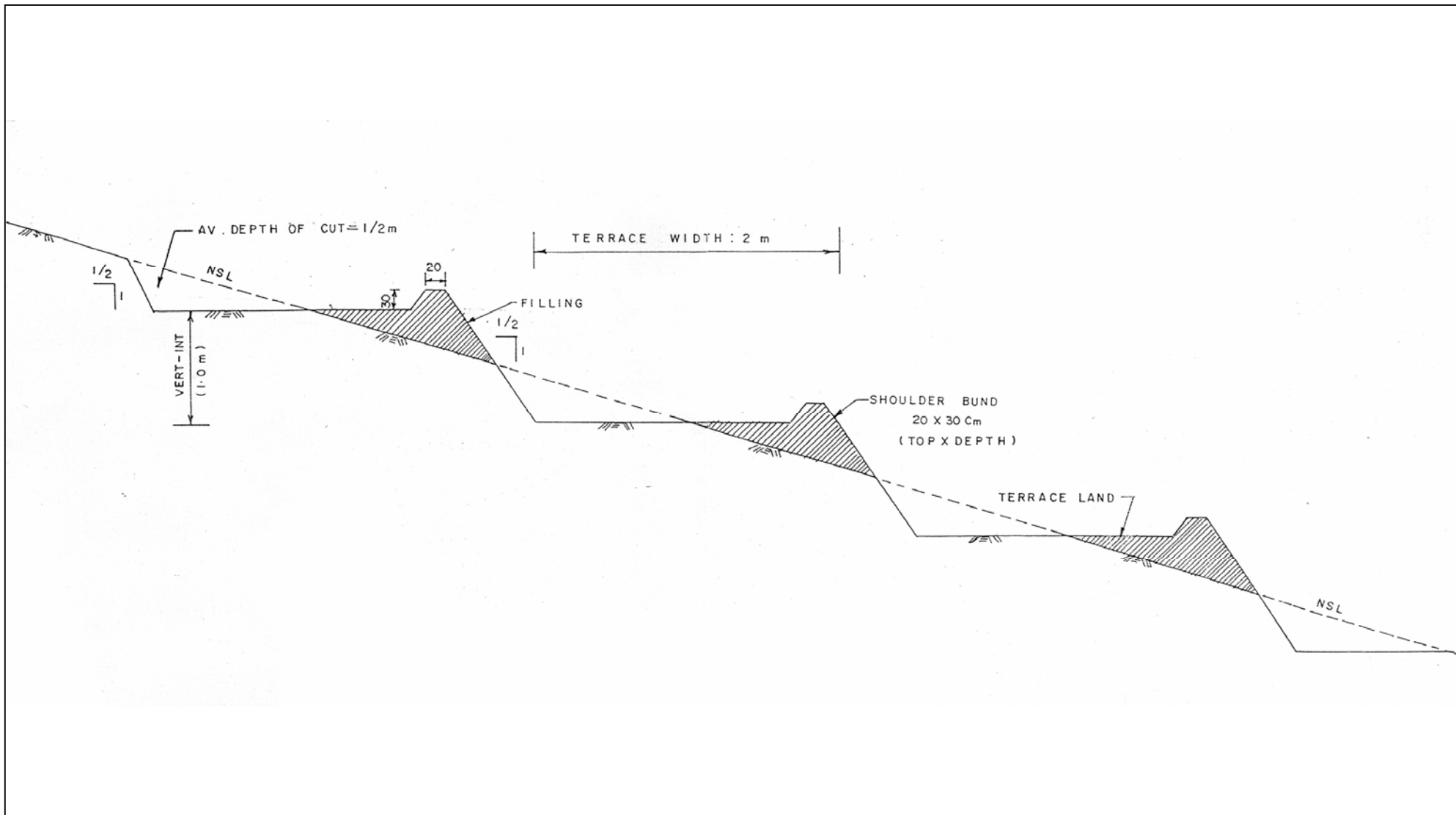


Fig. 10.8 Typical view of bench terracing for paddy cultivation

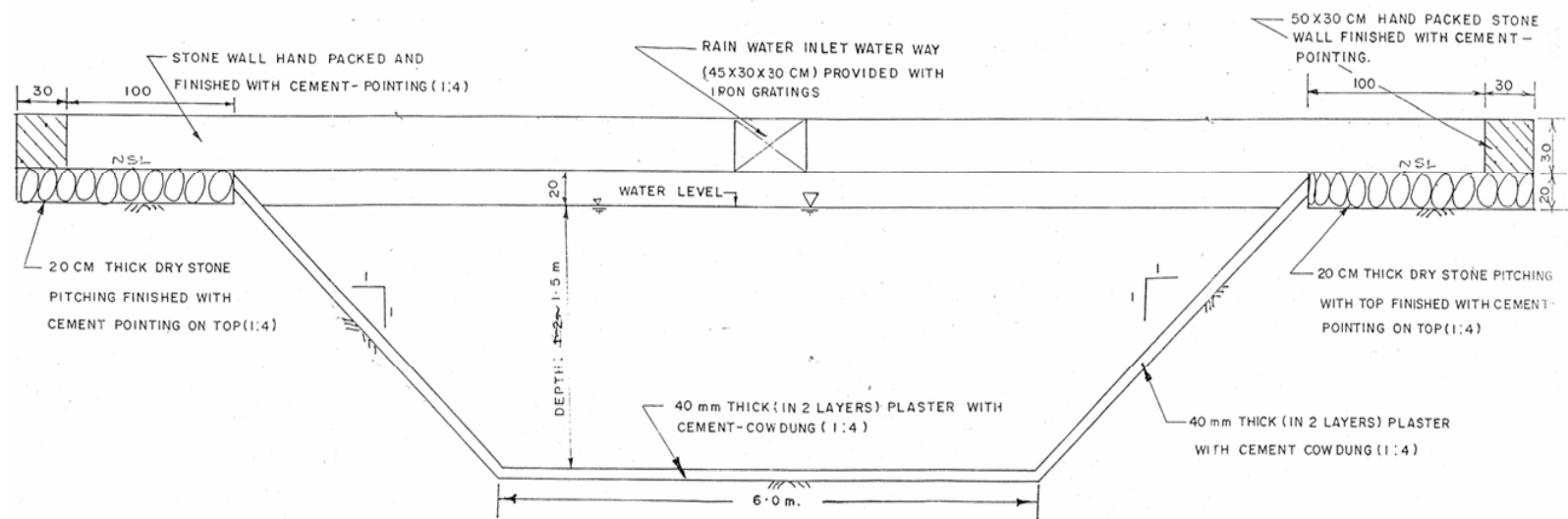


Fig. 10.9 Typical section of small water harvesting pond (6x4m)

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 lpd, the daily drinking water requirement would be $625 \times 40 = 25000$ 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:

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

Where v = velocity in the notch in ft/sec

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

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

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

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

$$\begin{aligned} \text{Discharge} &= \frac{12}{\text{Duty of Kharif}} \\ &= \frac{12}{15} = 0.8 \text{ cusec} \end{aligned}$$

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 23rd March, 2002 to 30th March, 2002. The same was duly assented to by the Governor of Sikkim on 3rd 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 were 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 reasons 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 started 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 $76.82 \times 1.80 = 138.30$ th ha. For working out the percent of cropped area under each crop, following points have been considered:

- (i) The area under paddy crop 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 irrigation 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	Proposed Production	
		2001-02	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 state 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 Medical 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)

Year	Actual				Projected	
	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 Sikkim. 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 some 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.

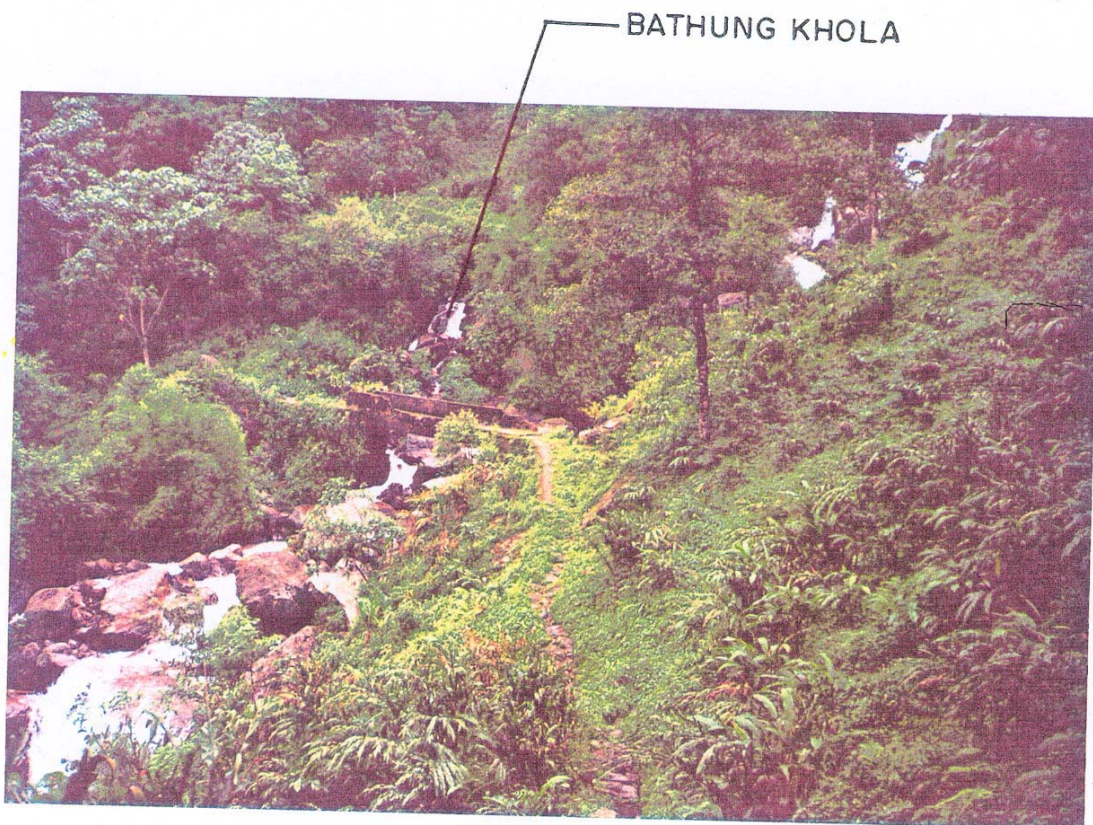
- Voluntary Health Association of Sikkim (VHAS) has organised the efforts in water resources development besides handling the environmental issues in a very professional and methodological manner. The association has sought public participation in identifying the schemes and has embarked upon 'Ahlay 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



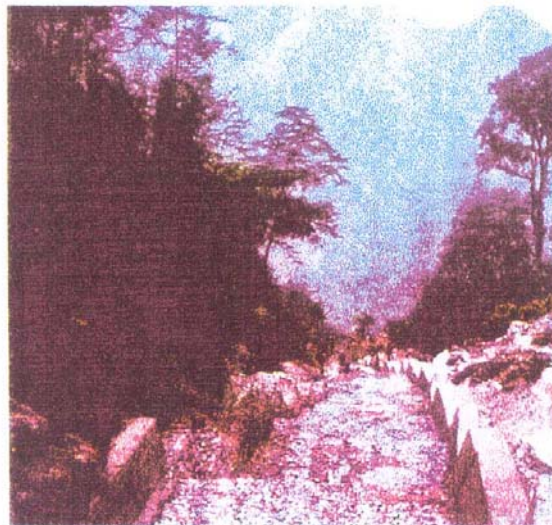
**Location of Restoration / Modernisation Scheme at
Bathung Khola - Pastanga Village, East Sikkim
(Reference: Para 14.5.1)**



Jhora training works at Bojoghari



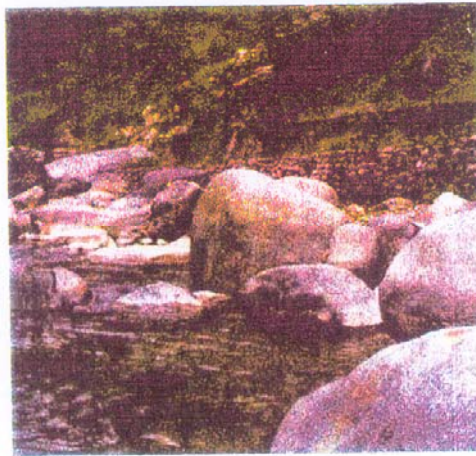
AEW/JTW/CWD at Kabi Tingda



Jhora Training Works of Rafong Khola



A.E.W below 16th 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	CHUNGTHAN G	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

Annexure-3.3 (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	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

Annexure-3.3 (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
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

Yearwise data availability Status

Year	Station													
	DENTAN	RO NGU	DIKCHU	MANANG	SINGHIK	GYALZING	CHUNGTHANG	GANGTOK	YOKSUM	DANATHANG	LACHUNG	LACHEN	YUMTHANG	THANGU
1961														
1962														
1963														
1964														
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1999														

Data not available

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
3050	0.628	449	0.09	910	0.19	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			142	0.03				
		272	0.06			449	0.09			615	0.13
		142	0.03			733	0.15				
		260	0.05			378	0.08				
		225	0.05			426	0.09			508	0.10
		591	0.12			556	0.11				
		621	0.13								
1619	0.333	248	0.05			236	0.05			520	0.11
		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	Dependability		
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
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	50 percent
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	2476
1980														30	2471.17	78.95	75 percent
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

Annexure-4.3 (a)

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		Sediment load	Total Runoff	% Sedime nt wrt 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	
% Sedime nt 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**

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	Rigmeey 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 at Martam	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 Khola MIC 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	Chotamg MIC at Tirkutam	Martam	Functioning	
227	Lower Barmi Gaon MIC at Martam	Martam	Functioning	
228	Lower Bhutey Jhora MIC at Rabdong	Martam	Functioning	
229	Hukey Olee khola MIC at Yanthang Martam	Martam	Functioning	
230	Chomerey Khola MIC at Tirkutam	Martam	Functioning	
231	Dong Khola MIC at 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 Tirkutam	Martam	Functioning	
235	Masha Khola MIC at Tirkutam	Martam	Functioning	

236	Fekcha Khola MIC at Nazitam	Martam	Functioning	
237	kabrebotey MIC at Patim Nazitam	Martam	Functioning	
238	Tshalamthang MIC at Tshalamthang	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	

276	Kholsa Luing MIC	Ranka	Functioning	
277	Lower Pachu Kholo 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 Kholo MIC	Ranka	Functioning	
285	Maley Tami Kami Dara	Ranka	Functioning	
286	Dami Kholso 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 Kholso 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	DhangDhangay 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	DhangDhangay MIC below Curior Shop	Rawtey Rumtek	Functioning	

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	

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	

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

7	Zorrong kutch 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 kutch	Ben Namphrik	Functionual	
14	Ben Nampruk MIC	Ben Namphrik		Defunct
15	Ben Gabghha kulo	Ben Namphrik		Defunct
16	Nampruk kutch kulo	Ben Namphrik	Functional	
17	Gayree khet kutch channel	Borong Phamtam		Defunct
18	Polok MIC	Borong Phamtam		Defunct
19	Borobng kutch kulo	Borong Phamtam	Functional	
20	Sada kutch kulo	Borong Phamtam	Functional	
21	Chil khota kutch	Borong Phamtam		Defunct
22	Borong kutch 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 kutch kulo	Kewzing Bhakhim	Functional	
28	Kewzing kutch kulo	Kewzing Bhakhim		Defunct
29	Lingzo kutch channel	Kewzing Bhakhim	Functional	
30	Dalop MIC	Kewzing Bhakhim	Functional	
31	Lizzo MIC	Kewzing Bhakhim	Functional	
32	Hingdan kutch kulo	Lamating Tingzo		Defunct
33	Lower Hingdan kutch kulo	Lamating Tingzo		Defunct
34	Tingmo kutch kulo	Lamating Tingzo	Functional	
35	Upper tingmo kutch kulo	Lamating Tingzo	Functional	
36	Kazi kulo Tingmo	Lamating Tingzo	Functional	
37	Middle Tingmo kutch kulo	Lamating Tingzo	Functional	
38	Gairi khet kutch kulo	Lamating Tingzo		Defunct
39	Lower Tingmo Kutch kulo	Lamating Tingzo		Defunct
40	Sajbotey kutch kulo	Lamating Tingzo		Defunct
41	Tingmo MIC	Lamating Tingzo	Functional	
42	Kawkhola MIC	Lingi Payong	Functional	

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 kutedha 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	

80	Kaw kutchu kulo III	Lingmo Kolthang	Functional	
81	Kaw kutchu kulo IV	Lingmo Kolthang		Defunct
82	Kaw kutchu kulo V	Lingmo Kolthang	Functional	
83	Kaw kutchu kulo VI	Lingmo Kolthang	Functional	
84	Kaw kutchu kulo VII	Lingmo Kolthang	Functional	
85	Kaw Kutchu kulo	Lingmo Kolthang	Functional	
86	Kaw Khola kutchu kulo	Lingmo Kolthang		Defunct
87	Tokday Kutchu Kulo	Lingmo Kolthang		Defunct
88	Lower Lingmo MIC	Lingmo Kolthang	Functional	
89	Lingmo Kutchu kulo I	Lingmo Kolthang		Defunct
90	Lingmo Kutchu Kulo II	Lingmo Kolthang	Functional	
91	Khumbrangey kutchu 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 kutchu channel	Mamley Kamrang		Defunct
96	Rangap MIC	Mamley Kamrang	Functional	
97	Mamley MIC	Mamley Kamrang	Functional	
98	Pakzer MIC	Mamley Kamrang		Defunct
99	Nangdang kutchu 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 kutchu kulo	Mellidara Payong	Functional	
107	Payong Kutchu kulo	Mellidara Payong		Defunct
108	Khani khola to payong	Mellidara Payong	Functional	
109	Rabi khola to lower payong	Mellidara Payong	Functional	
110	Tanam Khola kutchu kulo	Mellidara Payong		Defunct
111	Salleybong MIC	Maniram Phalidara	Functional	
112	Manpur kitam MIC	Mikhola; Kitam	Functional	
113	Mikhola MIC	Mikhola; Kitam	Functional	
114	Salbotey kutchu kulo	Mikhola Kitam		Defunct
115	Lowe kitam kutchu kulo	Mikhola Kitam		Defunct

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		Ddefunct
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

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	Sukrabagrey 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

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	
199	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	Subingchor 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 kulo I 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	Functiononal	
257	Gangatey dara MIC	Temi Tarku		Defunct
258	Pabong MIC	Temi Tarku	Functional	
259	Temi Devithaney MIC	Temi Tarku	Functional	

260	Tanak kutchu kulo	Temi Tarku		Defunct
261	Dara khet kutchu kulo	Temi Tarku	Functional	
262	Sajbotey kutchu kulo	Temi Tarku	Functional	
263	Tarku kutchu kulo I	Temi Tarku	Functional	
264	Tarku Kutchu 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 Kutchu kulo I	Yangang Rangang	Functional	
271	Rangang kutchu kulo II	Yangang Rangang	Functional	
272	Rangang kutchu kulo III	Yangang Rangang	Functional	
273	Rangang kutchu kulo IV	Yangang Rangang		Defunct
274	Rangang kutchu kulo V	Yangang Rangang	0	Defunct
275	Satam Kutchu kulo	Yangang Rangang		Defunct
276	Yangang kutchu kulo I	Yangang Rangang	Functional	
277	Yangang kutchu 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 Putter 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

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 MIC Rhenock 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	

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	

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	Kabirthing 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 kabirthing	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	Kabirthing 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	

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	Knagri Labdang	Functioning	
228	Lower Kongri Mic	Knagri 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	Simpbok 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 kutchu	Arithang Chon		Defunct
244	Tinzering khola MIC	Arithang Chon		Defunct
245	Nesha khola to Chon	Arithang Chon		Defunct
246	Chagey kutchu 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

SINo.	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 Rejeey 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

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	Laseything Mamring MIC	1.50	6.50
37	Simik Lingzey MIC	1.50	6.50
38	Chothing 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

SINo.	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 Kholas 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

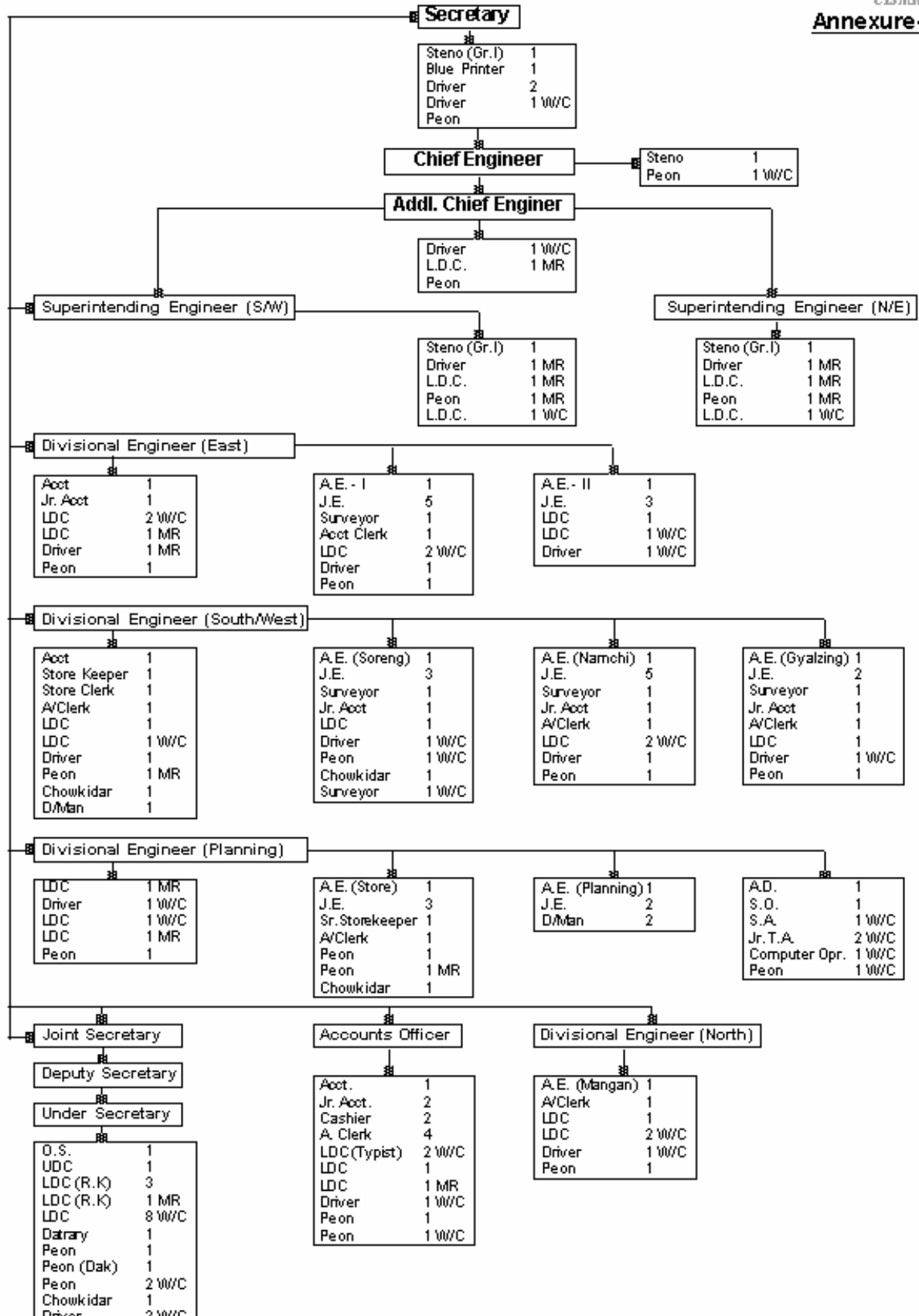
24	Const. /Extension of Khalbaley MIC (D.P.Rai)	2.00	8.00
25	Const. of Lower Namlung MIA	3.00	12.00
26	Const.of Nangdang TIRI KHOLA	3.00	11.00
27	Const of Devithaney Tanak MIC	4.00	18.00
28	Const of Jugdum Khola MIC at Aroobotey	2.00	12.00
29	Const of MIC Devithaney to Tholo Khet Tanak	1.75	7.00
30	Const 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



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