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CONSULTING ENGINEERING
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North Bengal Terai Development Project
Phase III

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ENVIRONMENTAL IMPACT ASSESSMENT

AUGUST 1995

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ACRONYM AND TERMINOLOGY

ADHC	Additional Director of Health Services
BCKV	Bidhan Chandra Krishi Viswavidyala
BOD	Bio-chemical Oxygen Demand (wate
CEC	Cation Exchange Capacity
CGWB	Central Ground Water Board, Govt
CWC	Central Water Commission, Govt.
DAH	Department of Animal Husbandry
DOA	Department of Agriculture
DOF	Department of Forests, West Bengal
DOMI	Department of Minor Irrigation
DTW	Deep Tubewell
DW	Dug Well
EC	Electrical Conductivity
FAO	Food and Agricultural Organisation
FMC	Forest Management Committee
GOI	Government of India
GoWB	Government of West Bengal
GWEC	Ground Water Estimation Committee, Ministry of Agriculture, Govt. of India
HFC	Hindusthan Fertilizer Corporation
HTW	Hand Tubewell
HYV	High Yielding Variety
IBFEP	Indo-British Fertilizer Education Project
IS	(Bureau of) Indian standards
KPS	Krishi Prajukti Sahayak (extension worker)
KVK	Krishi Vigyan Kendra (Farm Science Centre)
LCSU	Low Cost Sanitation Unit
MWD	Mean Weighed Diameter (mm)
NA	Not Available
NBSS-LUP	National Bureau of Soil Survey and Land Use Planning, Govt. of India
NARP	National Agricultural Research Project
NBTDP	North Bengal Terai Development Project
NGO	Non-Governmental Organisation
NLG	Dutch guilders (1/1/1995: Rs 18)
PDW	Pumped Dug Well
PSU	Project Support Unit
RLI	River Lift Irrigation System
Rs	Indian Rupees (1/1/1995: NLG 0.055)
RSC	Residual Sodium Carbonate
SAR	Sodium Absorption Ratio
SC	Scheduled Caste
ST	Scheduled Tribe
STW	Shallow Tubewell
TOR	Terms of Reference

WHO	World Health Organisation
WSA	Water Stable Aggregate
Acre	0.4 hectare
Aus	Pre-kharif paddy
Aman	Kharif paddy
Bigha	0.33 acre = 0.13 ha
Block	Administrative unit (the project area covers 27 blocks)
Boro	HYV Rabi paddy
Gram Panchayat	Village level elected government body
Kharif	The period for June-November, rainy season (monsoon)
Panchayat Samity	Block level elected government body
Pre-kharif	The period March-June, spring/summer, occasional showers
Rabi	The period December-March, winter, dry season: irrigation is essential to crop growing
Spout	Water outlet in subsurface water transmission system connected to DTW and RLI
Zilla Parishad	District level elected government body

General

This EIA Report is presented in 8 (eight) chapters : *Introduction* (Chapter 1), *Project Area* (Chapter 2), *Project Description & Environmental Issues* (Chapter 3), *Collection of Primary Data* (Chapter 4), *Findings from Primary & Secondary Data* (Chapter 5), *Problems Observed & Proposed Remedies for the Project Components* (Chapter 6), *Assessment of Environmental Impacts* (Chapter 7) and finally *Environmental Management Plan & Monitoring* (Chapter 8).

Project Area

The Project Area, located south of the foothills of the Himalayas, covers Siliguri Sub-division of Darjeeling District (4 Blocks) Jalpaiguri District (13 Blocks) and Cooch Behar District (12 Blocks) with a total area of about 10,382 sq km. The topography is rather flat with coarse grained soils towards the north (primarily sandy), and gradually turning to loamy sand and sandy loam towards the south. The soil is in general, slightly acidic. The area receives heavy rainfall during the monsoon resulting in leaching of salts. Thus, salinity is no problem. Forest cover has been heavily degraded and reduced in spread with encroachment of tea gardens and agriculture. Wild life is substantially depleted. Sedimentation of the rivers and consequent flooding are quite common. In the upper reaches, the sediment being mainly sandy causing degradation of the land which calls for extensive land reclamation measures.

Project Components

The Project (NBTDP) was initially started in 1985 with Phase I covering upto the year 1987-88 and Phase II upto the year 1992-93. Phase III is currently in progress. The project concerns with economic development of the beneficiaries through

- Construction of minor irrigation facilities such as Hand Tubewells (HTW), Pumped Dug Wells (PDW), Shallow Tubewells (STW), Deep Tubewells (DTW), River Lift Irrigation Systems (RLI) and lining of field channels of 4 ha Units in DTW and RLI command areas.
- Agricultural extension and training of farmers and government officials
- Land reclamation and soil conservation
- Improvement of output of facilities already created through emphasis on management skill, beneficiary participation, gender benefits and environmental protection

Target groups of the project are marginal and small farmers owning less than 1 ha and between 1 and 2 ha of land respectively.

Environmental Impacts

Environmental impacts in the project area are primarily due to natural forces and man-made actions outside the ambit of the current project. The impacts of the current project are relatively minor and are also common with impacts from interventions of other similar projects in the area. No serious project specific environmental impact has been detected

Impacts due to natural forces and cultural practices

- Rainfall : Flooding and sand deposition
  : Leaching of soil matter and nutrient, changes in soil texture
  : Accelerated movement of bacterial pathogens underground
- Ground Water Extraction : No impact anticipated within project horizon.
- Quality of Ground Water : Suitable for agricultural use, no adverse impact
  : Higher level of RSC in some areas indicates possibility of carbonisation to be remedied through use of lime
- Quality of Surface Water for agricultural use : No adverse impact
- Quality of Drinking Water : Chemical constituents within acceptable limits except for iron & fluoride. No adverse impact at the present stage.
- Pesticides & Nutrient Enrichment : Current level of fertilizer and pesticide use being low, no adverse impact observed from pesticides or nutrient enrichment.
- Biodiversity : With input of irrigation, multiple cropping is becoming popular with use of HYVs, fertilizers and pesticides threatening erosion of old and local genotype of different crop species. Cropping schedules heavily tilted in favour of immediate cash returns has led to virtual exclusion of animal husbandry and livestock in the farming schedule. Quality of breed is steadily deteriorating.
- Deforestation : Possibility of decrease in confined aquifer recharge with deforestation in the foothill areas.
  : Erosion of forest areas leading to siltation of the river beds and flooding
- Impacts due to Project Interventions : (a) *Positive Impacts*
  - Increase in supply of water in times of need leading to increase in crop production and consequent economic benefits.
  - Use of project structures as source of drinking water assures availability reducing human drudgery of carrying water from distance.
  - Soil conservation measure including reclamation of degraded land to agriculture provides economic benefits.

- Improved irrigation facilities and available extension services have exposed the farmers to improved farming practices using better seeds, fertilizers and crop combination. Vegetable cultivations have come up in a big way.

All these have improved the quality of life of the farmers which will have positive influence on education, family welfare and betterment of life of the females.

(b) *Negative Impacts*

- Lack of knowledge results in use of fertilizer and pesticides without proper assessment and requirement of types, which may result in damage to soils. Increase in stiffness of soil has already been reported by 90% of the project beneficiary farmers doing triple cropping.
- Improper crop combination may lead to damage of soil quality and plant ecology.
- Inadequate design of structures and poor level of maintenance have led to bacterial contamination of water and increase in vector breeding.
- Improper maintenance of pumps and equipment may lead to serious accidents affecting the effectiveness of the project.

Environmental Management Plan

To reduce adverse impacts of natural forces and man-made actions, nine management components are proposed. These include management of

- Water at the macro level
- Project interventions
- Water quality (drinking)
- Groundwater extraction
- Soil & soil fertility
- Biodiversity
- Forest
- Pesticide use
- Extension services

Steps have been suggested to improve the performance of the project and to control the vagaries of nature through use of improved management techniques and provision of extension services to create appropriate knowledge, attitude and practice (K.A.P.) in the project area. Management policies and practices are to be formulated and implemented by different Government Agencies through an inter-departmental extension group with the assistance from research and academic institutions, local bodies and non-governmental organisations.

Monitoring Plan

A Monitoring Plan has been proposed to monitor the effects of the Management Plan on the environment and to create a data base for future use. The monitoring will include :

- Quality assessment of water for irrigation and drinking
- Assessment of soil quality and fertility status
- Assessment of ground-water fluctuations
- Progress in biodiversity
- Monitoring the improvement of performance of the project interventions
- Monitoring of effects of extension messages

Monitoring will be done through field checks, collection and analysis of primary data from structured sampling under supervision of surveillance unit. Formation of an inter-disciplinary team of experts to supervise monitoring, is proposed.

1.0 INTRODUCTION

1.1 Background

This Environmental Impact Assessment (EIA) Study of the North Bengal Terai Development Project (NBTDP) has been prepared as a part of the NBTDP Phase-III Programme in compliance with the requirements of the Government of the Netherlands, who is financing the project. Phase-I of the Project covered the period 1984-88 and Phase-II covered the period 1988-93 with an extension till 31.12.1994. These phases comprised the implementation of small scale irrigation schemes, training of water users, implementation of soil conservation schemes and researches on evaluation of the impact of the project on the beneficiaries. Phase-III includes, among others, an Environmental Impact Assessment (EIA) of the completed and planned project interventions in the early stages of Phase-III.

1.2 Objectives

The objectives of the EIA study is to assess and identify the areas of environmental impacts that may result out of the completed and proposed irrigation facilities. The scope is to include both positive and negative effects and the results emanating from the studies are to identify the impacts as much as possible supported by tables and maps. The Terms of Reference (TOR), prepared for the Study, (*1) attempts to list out the priority areas and to outline the most practical approach to the impact assessments leading to the preparation of a framework for the study based on existing information and limited number of field checks.

1.3 Report Format

The Report format first deals with the baseline data, as collected from the secondary sources, to arrive at the existing environmental set-up and placing it in the geological time-frame covering the physical conditions of the project area, i.e. physiography, climate, geology, geohydrology, soil as well as biotic components of the ecosystem - such as vegetation, forest cover, wild life etc. This is covered in Chapter 2.0 of this Report. Chapter 3.0 deals with the project components. This chapter also sets out the environmental issues related to 'without project' and 'with project' situations. Formulation of the sample frame for collection of primary data as well as the procedure for collection and analysis of data are discussed in Chapter 4.0. In Chapter 5.0, the findings from the sample survey as well as from the secondary data and field visits are collated and these are related to the different priority areas of the TOR. Since the project components occupy the same space frame with other similar components of different on-going projects, the findings in many cases are not NBTDP specific, but are generally applicable for similar projects in the area. All these components have more or less similar positive and negative aspects of implementation and operation & maintenance. Obvious lessons have been stressed in this chapter. A critical appreciation of the project components based on field visits and discussions with the participants and beneficiaries of the project is given in Chapter 6.0. Chapter 7.0 draws conclusions from the findings of the earlier chapters to identify their impacts on the

environment. Here the impacts of the existing physical attributes of the area, which would be there with or without the project, have been delineated side by side with the impacts of the project components - both NBTDP and others. Finally, in Chapter 8.0 the need for monitoring of the environment both from the point of view of the NBTDP and from the overall environmental scenario are listed, preceded by an Environmental Management Plan (EMP), to ensure that future conclusions could be drawn from a stronger data base.

1.4 Data Base

A major part of the study is based upon information contained in various documents prepared regularly by the different Government Departments - both Central and State (Annexure 1.4). Unfortunately many of them are prone to be secretive as regards data available, resulting in incompleteness of the data collected. Information have also been collected from existing academic institutions and research organisations. As discussed earlier, this has been supplemented by few field checks with collection of primary data and their analysis. Repeated field visits were made to familiarise the Consultants with the field realities. These have been supplemented by a questionnaire survey of about 90 farmers, who are recipients of the NBTDP facilities.

2.0 THE PROJECT AREA AND ITS PEOPLE

2.1 Geography

The project area covers the northern part of the State of West Bengal. It is bordered by Bhutan and the State of Sikkim in the north, by the State of Assam in the east, by Nepal in the west, and by Bangladesh and the State of Bihar in the south. The project area is located in the Terai, the flat area which is flanked by the foothills of the Himalayas in the north. It is slightly sloping from an average altitude of 100 m in the north to 80 m at the southern border. It is intersected by several rivers running in a southerly direction, the largest of them being the Teesta River. The project area covers the Siliguri subdivision of Darjeeling District (4 Blocks) and the Districts of Jalpaiguri (13 Blocks) and Cooch Behar (12 Blocks). The total area is about 10,382 km^2, of which 8% lies in Darjeeling district, 60% in Jalpaiguri and 32% in Cooch Behar.(Fig.2.1.)

2.2 Geolithological Succession

2.2.1 Hard rock exposures primarily constitute the eastern part of the northern edge of the project area. The oldest formations are Pre-Cambrian in date and consist of quartzite, phyllite and schist. These have been affected by the Himalayan orogenic forces. Structurally, these formations are monoclinal in most places with various order of folded contortions. These produce landslides when disturbed by road cuttings as also through under-towing by rivers. In geological literature, these are known as the Daling Series.

2.2.2 During the Algonkian period (Palaeozoic Era) were formed the dolomites, phyllites and variegated quartzites. These are known as the Buxa formations and have been affected by Himalayan tectonics. These are found close to the Daling formations and are subjected to mass wasting processes.

2.2.3 During Permo-Carboniferous period, the Gondwana formations containing coal, carbonaceous shale and micaceous flaggy sandstone were deposited. However, these formations are not exposed on the surface within the project area, being probably buried under the deposits of Mio-Pliocene period. These deposits are known as the Siwaliks in the geological literature.

The Siwalik formation consists of pebbles, conglomerates mixed with micaceous sandstones and clays. These show signs of limited folding. The unconsolidated lithology is subjected to vigorous mass wasting processes. These are mostly found along a narrow strip near the northern boundary of the project area. These exposures are shown in Fig.-2.2.3.

2.2.4 The hard rock formations cover not more than 5% of the project area. More extensive occurrences are found in the north in the shape of the Himalayan mountain system. The materials derived from these formations constitute the lithology of the rest of the project area. The topography, is in general, gentle and can be defined as plain. However, there are many terraces, giant alluvial fans and flood plains in this part of the project area. The slope is distinctly southern with inclination towards west in the western part and towards east in the eastern part of the area.

2.2.5 The land forms in the plains bear complex evidences of their origin. All the components of landscape originated during the Pleistocene and Holocene periods. This was the period in geological history known for cyclic repetition of ice-age. During the cold phases, the valley glaciers in the high Himalayas extended their tongues towards lower altitudes, due to shift of glacial debris (moranes). During the warmer period, these

glacial debris were washed down by the rivers. Such was the vigour of mass-wasting that, in many instances, the debris brought down by fluvial process as filled up the valleys. At a later period, these rivers cut their beds into these debris and produced terraces made of glacio-fluvial deposits. The best example of such climactic terraces is found in the Jaldhaka valley near the hydro-electric power station. Smaller terraces are found in many other valleys depending on the hydraulic gradient of the respective rivers. The Teesta valley has now the least representation of such terraces. Obviously, the most materials have been transported by the vigorous river to produce the giant Teesta alluvial fans.

2.2.6 The giant alluvial fans have caused the mother rivers to shift from their principal axes. Possibly, these shifts might be associated with isostatic adjustment and tectonic movements. All the rivers in the eastern part of the project area have turned towards east, may be due to down turn of the block west of the 90 deg. E fault line --- the geologists have identified a number of fault-lines running parallel to the alignment of the Himalayan boundary fault. There are also several transverse faults running perpendicular to the boundary fault. In Fig.-2.2.6, the locations of these buried faults within the project area have been shown. These faults have defined the alignment of many rivers of the area, the most striking example of which is given by the Mahananda river.

2.2.7 The above observations clearly suggest that two sets of forces were operating rather simultaneously and continuously influence the pattern of sedimentation and consequent emergence of two landforms within the plain region. In the first instance, there was cyclical repetition of warmer and cold climatic conditions with alternate variations in the nature and volume of deposited sediments. This means that the debris from the Himalayas were transported over finite distances before deposition and such deposits were reworked to form different types of lithology along a given hydrological gradient. The next phase was tectonic in nature causing variable alternations of the earlier hydrological gradients to induce faster erosion or faster deposition of the earlier fluvial deposits according to local circumstances. The existence of parallel and transverse faults imply that the basement could rise or fall in smaller blocks as to cause variation in the realm of local geographical ambiance. As a result, striking alterations in the spatial orientation of the geohydrology are noticeable.

2.2.8 Fig.-2.2.8, shows the spatial orientation of terraces formed due to repeated resorting of the materials acted upon by the forces noted in the previous section. Five distinct phases of terrace formation are recognisable. All these have been formed during the Pleistocene until recent times.

The materials constituting the oldest terraces are known as the Samsing Formation. These are exposed in small patches between the rivers Jaldhaka and Balason, resting against the Pre-Quaternary lithology to the north. The materials are generally composed of boulders of various sizes, some measuring more than 2m in diameter, with feeble binding matrix. The top soil layer is about 1.5cm thick and appears chocolate brown in colour. This colouration is a product of mixing of originally rich (black) soil with highly oxidised (red) soil.

The next younger terrace system comprise of the Matiali Formation. These occur once again between the Jaldhaka and Balason rivers, generally extending as an apron southwards from the Samsing Formations. It is composed of small boulders (pebbles) and a lot of fine sands The finer particles, appearing reddish brown, overlie the cobble-boulder layers of orange to red in colour. The cobble-boulder bed is the weathered zone.

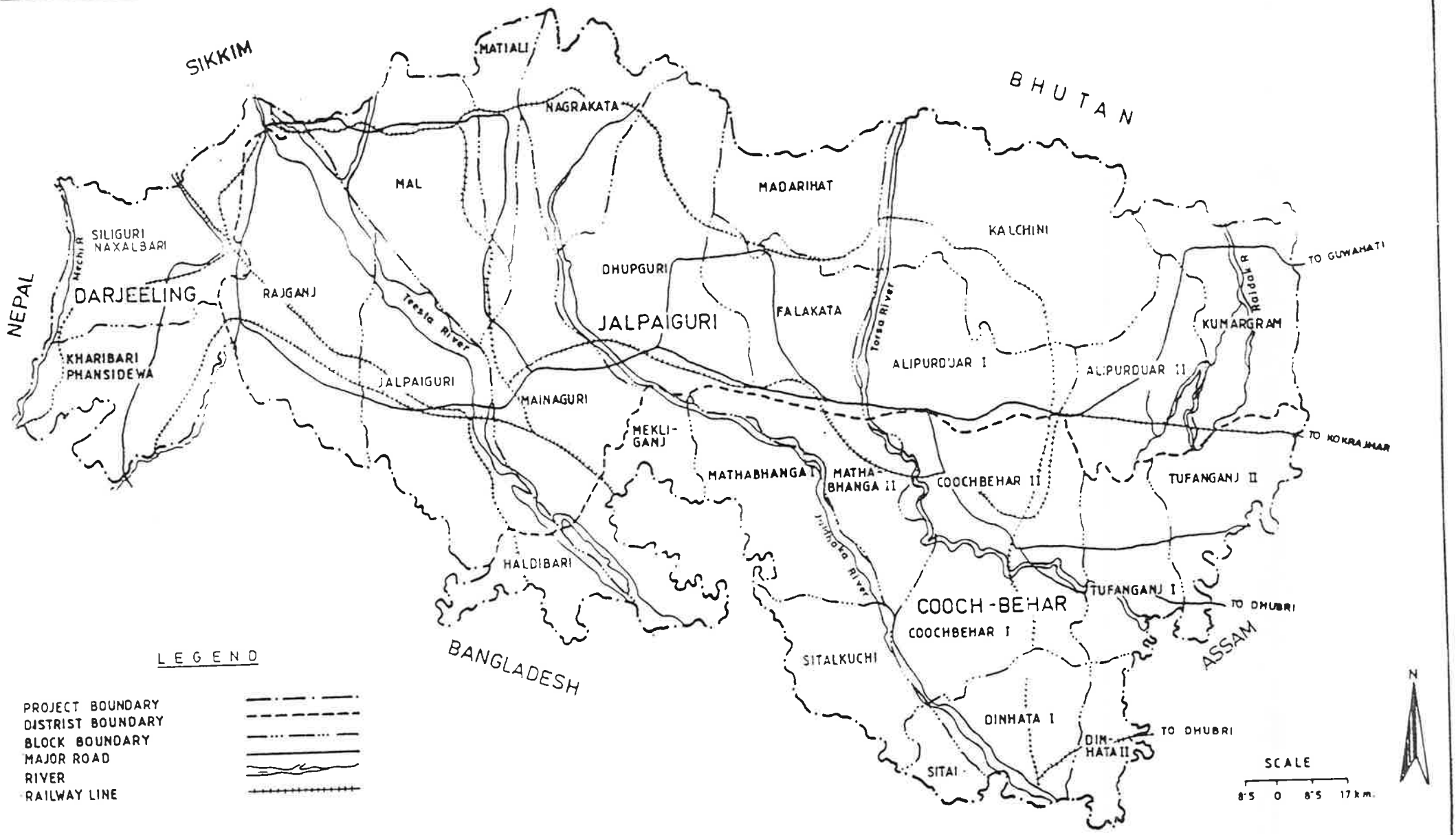
A zone of varying thicknesses mark the boundary between the cobble-boulder layers and the reddish brown layer, indicating accumulation of leached materials.

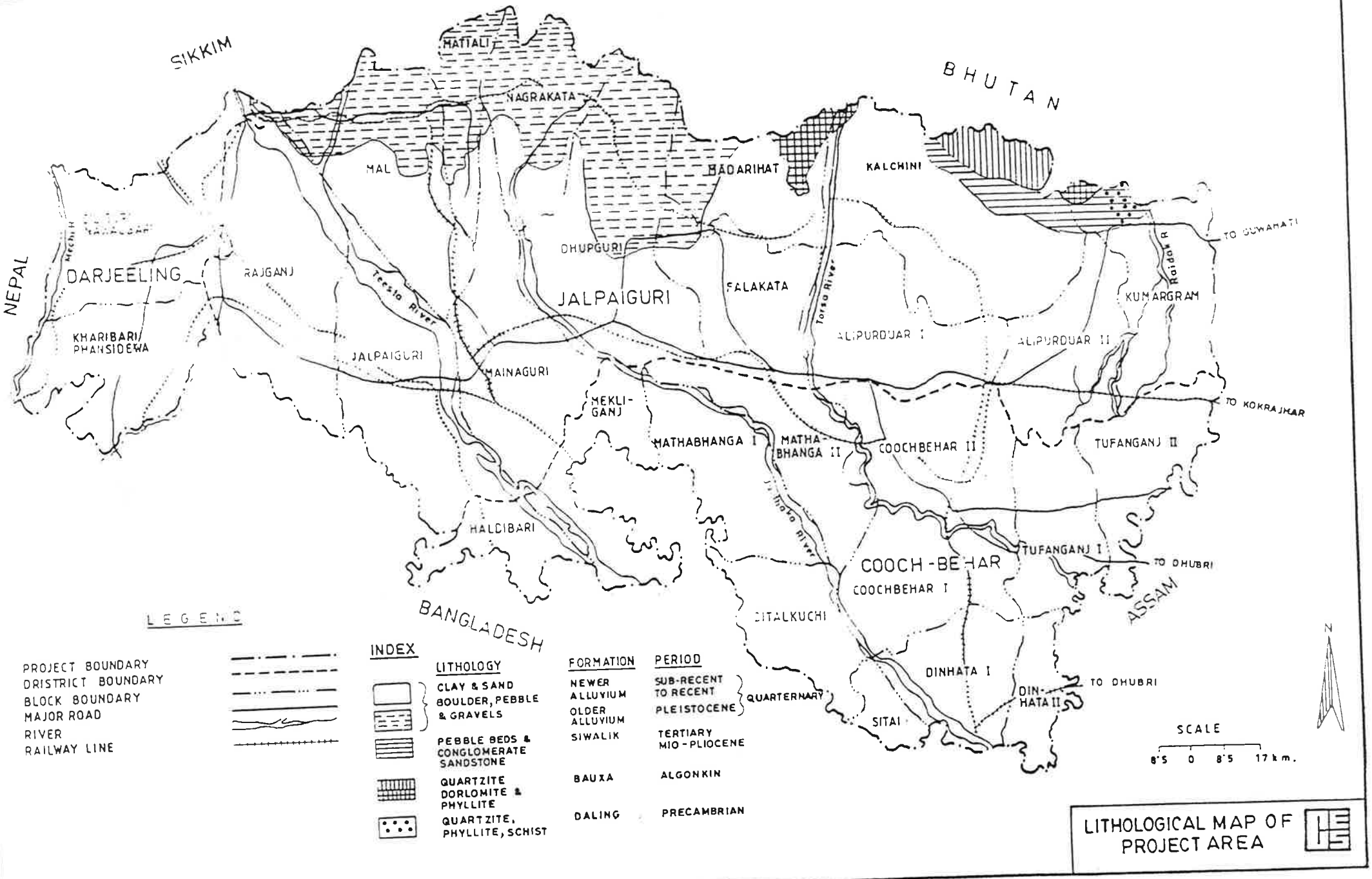
Further south, the Chalsa Formation extend like tongues covering a substantially large ground. Here also, boulders and sand constitute the formation. The top soil is permanently yellow in colour. At depth, the colour changes into brown, indicating mixing of organic matter (black) with oxidised (yellow) material. Under the brown layer are the cobble-pebble beds marking the weathering zone.

The next younger lithology is the Baikunthapur Formation. These are composed of coarse to fine sand grading southwards into silt and clay. The materials are deep. On the top, dark greyish black soil, containing organic matter, overlie yellowish sand. This yellowish colour fades off as sands grade into clay. It is clear that acidic ground water (pH less than 5) causes iron-hydroxides to rise in solution by capillary action to get deposited near the surface. The organic materials are slowly decaying. The clay fractions impart capillary movement of the iron-hydroxides.

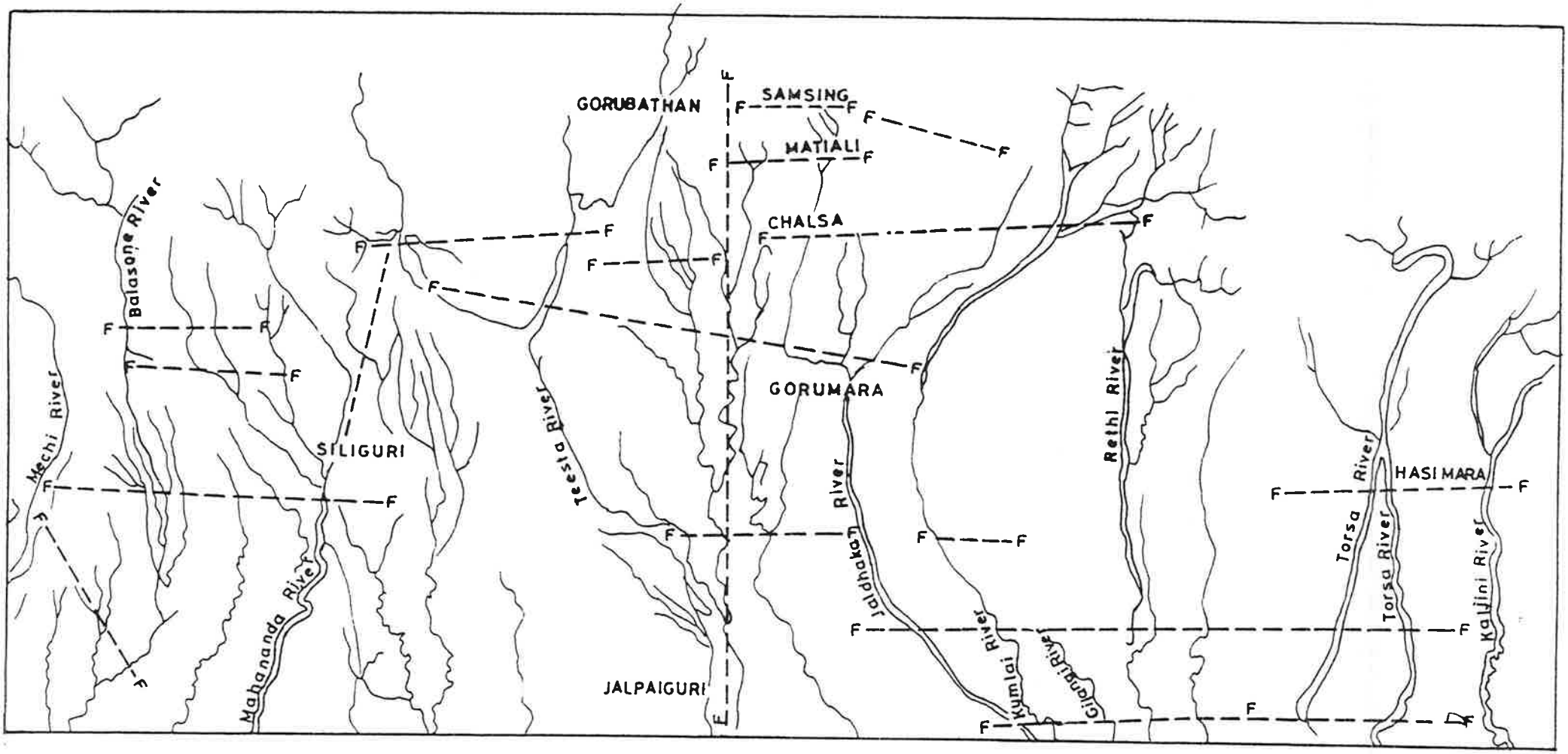
Younger materials are known as the Shaugaon formation. These hug the river channels. The sediments are rather fresh, unoxidised and greyish white in colour. No pedologic horizon is visible.

2.2.9 The above mentioned Pleistocene and Holocene lithology are forming terrace-like landforms. The terrace-tops invariably slope towards south, implying that these are remnant's of earlier alluvial fans. The rivers have interacted themselves due to rise in the base levels of erosion, a possibility that arises from the identification of many parallel and transverse faults. Wherever, the southern block has been thrown up, the rivers have changed direction through sharp elbow bends. In the other cases, the up-thrown block appears as scarps. The lateral shifts of rivers have also produced scraps parallel to the channels in many places. However, such terraces are not found in the Shaugaon formations. Further south, the drainage is impeded and has given rise to flood plains, especially in the southern part of Cooch Behar district. In the flood plains, silt and clay fractions domains over sand.


SIKKIM
MATIALI
NAGRAKATA
BHUTAN
MAL
MADARIHAT
KALCHINI
NEPAL
SILIGURI
NAXALBARI
Mechi R
DARJEELING
RAJGANJ
Teesta River
DHUPGURI
JALPAIGURI
FALAKATA
Torsa River
Raidak R
KUMARGRAM
TO GUWAHATI
KHARIBARI
PHANSIDEWA
JALPAIGURI
MAINAGURI
ALIPURDUAR I
ALIPURDUAR II
MEKLI-
GANJ
TO NOKRA JHAR
MATHABHANGA I
MATHA-
BHANGA II
COOCHBEHAR II
TUFANGANJ II
Jaldhaka River
HALDIBARI
TUFANGANJ I
TO DHUBRI
COOCH-BEHAR
COOCHBEHAR I
ASSAM
BANGLADESH
SITALKUCHI
DINHATA I
TO DHUBRI
DIN-
HATA II
SITAI
N
SCALE
8·5 0 8·5 17 km.
LEGEND
PROJECT BOUNDARY
DISTRIST BOUNDARY
BLOCK BOUNDARY
MAJOR ROAD
RIVER
RAILWAY LINE
PROJECT AREA



LITHOLOGICAL MAP OF PROJECT AREA

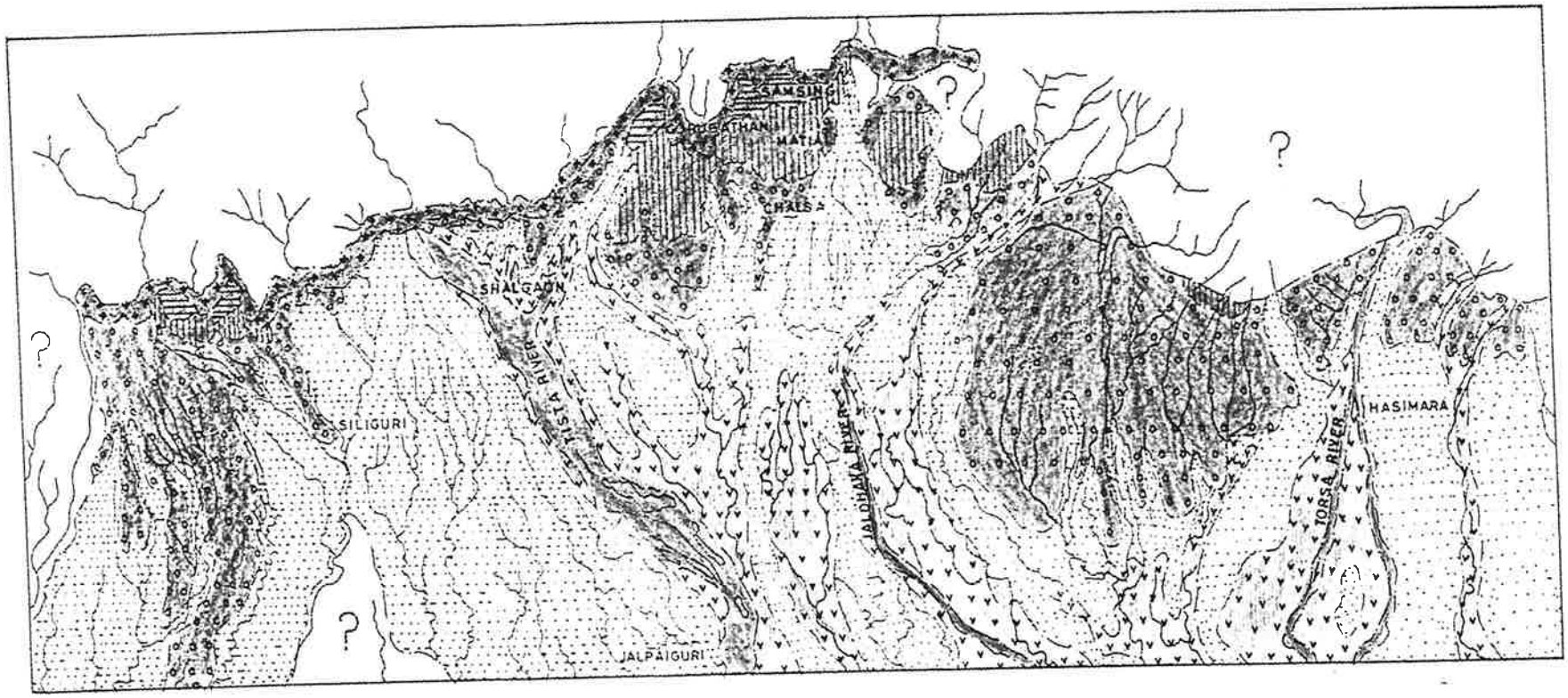


INDEX

F— — — — — —F TENTATIVE FAULT LINES

SOURCE: GEOLOGICAL SURVEY OF INDIA
RECORD VOLUME NO. 121
PART NO. 2-8

MAP SHOWING QUATERNARY LINEAMENTS
IN THE TISTA-TORSA INTERFLUVE BELT



INDEX

- ? NOT SURVEYED
- SHAUGAON FORMATION
- BAIKUNTHAPUR FORMATION
- CHALSA FORMATION
- MATIALI FORMATION
- SAMSING FORMATION
- SURVEYED EDGE OF PRE-QUATERNARY SIWALIKS, GONDWANAS, DALINGS

SOURCE : GEOLOGICAL SURVEY OF INDIA RECORDS VOLUME NO. 121, PART NO. 2-8

QUATERNARY GEOLOGICAL MAP OF NORTH BENGAL

2.3 CLIMATIC FEATURES

2.3.1 Fluvial agencies are one of the principal actors in sculpturing the present day landforms. The source of water is, of course, the atmosphere. Apart from the Teesta, none of the rivers are snowfed. Atmospheric precipitation comes in the shape of rain. Although hail storms are quite frequent, these contribute insignificant amounts of water to the drainage system. Rainfall is distinctly seasonal in distribution, being governed by the atmospheric pressure and wind systems.

2.3.2 Reliable data on the behaviour of atmosphere in this part of the world are rather scanty. There are only three meteorological stations within or near the project area, namely at Darjeeling, Jalpaiguri and Cooch Behar towns. Of these three stations, that of Darjeeling, being located on high mountains, do not reveal the conditions of the plains. There are, of course, a large number of rain-gauge stations within the project area. However, the records at these rain-gauge stations are not accepted by the Indian Meteorological Department as suitable. Hence, the properties of climate is discussed below from a study of the data available at Jalpaiguri and Cooch Behar 2.3.3. The patterns of monthly variations of atmospheric pressure at these two stations are nearly identical. During June-July, it records the lowest and in December-January it is the highest pressure. However, distribution is given by the months of occurrence of the lowest and highest monthly average pressures in these stations. The lowest pressure occurs in June at Cooch Behar, while it so happens in July at Jalpaiguri. Similarly, the highest pressure occurs in January at Cooch Behar, while it so happens in December at Jalpaiguri. This means that the domain of low pressure system is more prolonged in the east (Cooch Behar) than in the west (Jalpaiguri).

2.3.4 The pattern of monthly variation of pressure systems in both the stations justifies describing the climate of this area as belonging to the Tropical Monsoon System. The pattern is governed by the conditions prevailing over a much lower region than the project area. This is indicated by the small range of pressure variation between the morning and afternoon situations in all months in both the stations. This means that day time heating of the earth's surface has little to contribute in influencing monthly pressure variations. However, the diurnal pressure variation is the highest in the month of April at Jalpaiguri, while it is so in May at Cooch Behar. In both the places, the average monthly wind speed becomes higher in the months of April to May.

2.3.5 The pattern of temperature variations at both stations are almost identical. Mean daily maximum temperature is the highest in the month of April in both the stations. Similarly, mean daily minimum temperature is the lowest in January in both the stations. The diurnal differences show similar patterns between both the stations. The highest and the lowest temperature in any given month may be several degrees higher or lower than the respective monthly means in any station. Such a wide range of differences imply that heating of the local air is influenced by regional air masses.

2.3.6 In both the stations, relative humidity declines with the progress of day. However, the order of diurnal variation is decidedly higher in Jalpaiguri than in Cooch Behar. This means that potential loss through evaporation is higher in the western part of the project area than in the east.

2.3.7 The five months from May to September are the rainiest period in both the stations. About 95.24% of total annual rainfall occurs during these five months at Jalpaiguri, while it accounts for only 85.60% at Cooch Behar. This means that the rainy season in the east is more prolonged than in the west. Both these features are concordant with what has been stated in the previous paragraph.

There is another important feature of rainfall that deserves attention. Cloud bursts may cause unusual high precipitation in a single day. Such bursts may cause rainfall in a single day that may be many times more than the monthly average between months of October to April in both the stations. During the rest of the months, the possibility of getting in a single day more than half of the month's average rainfall is also high. On such occasions, loss through phenomenal run-off leading to floods, is a common feature in the project area.

Events of cloud bursts are matched by having no rainy day in a given month. In other words, variations from the monthly average rainfall is wide in the part of the world. This feature has been captioned in Tables 2.3.7(i) & 2.3.7(ii) respectively for Jalpaiguri and Cooch Behar for the years between 1980-92. These show that the event of no rainfall in a given month is a feature of the period between November to April at Jalpaiguri, whereas it is so between November to February at Cooch Behar. Deviation from normal rainfall causes stress upon the biotic system. An attempt has been made to indicate the character of stress in the above tables for both Jalpaiguri and Cooch Behar.

Table 2.3.7(i)
Climatological Data : Rainfall 1980-1992
Station : Japaiguri

Month	Rainfall in the Month in a Given Year (in mm)		Difference between Maximum & Minimum Rainfall (in mm)	No. of Years with no Rainfall
	Maximum	Minimum		
January	32 - (1984)	0	32	6
February	58 - (1988)	0	58	2
March	55 - (1990)	0	55	1
April	237 - (1981)	0	237	1
May	567 - (1989)	143 - (19 86)	424	0
June	1111 - (1989)	403 - (1981)	708	0
July	1291 - (1982)	566 - (1986)	725	0
August	1998 - (1987)	154 - (1982)	1844	0
September	1324 - (1991)	233 - (1992)	1091	0
October	236 - (1984, 1985)	13 - (1981)	223	0
November	48 - (1989)	0	48	7
December	39 - (1985)	0	39	3

Table 2.3.7(ii)
Climatological Data : Rainfall 1980-1992
Station : Cooch Behar

Month	Rainfall in the Month in a Given Year (in mm)		Difference between Maximum & Minimum Rainfall (in mm)	No. of Years with no rainfall in mm
	Maximum	Minimum		
January	36 - (1991)	0	36	6
February	105 - (1990	0	105	1
March	102 - (1987)	1 - (1989)	101	0
April	364 - (1981)	30 - (1989)	334	0
May	781 - (1989)	143 - (19 86)	638	0
June	1107 - (1991)	404 - (1980)	703	0
July	1427 - (1988)	499 - (1986)	928	0
August	1856 - (1988)	274 - (1989)	1582	0
September	1132 - (1984)	214 - (1980)	918	0
October	258 - (1987)	4 - (1981)	254	0
November	45 - (1986)	0	45	9
December	28 - (1985)	0	28	5

2.3.8 There is a popularly shared feeling that the pattern of rainfall has been changing over the years. To verify this, an attempt was made to compare the pattern of monthly distribution of rainfall of 1931-60 with that of 1980-92 in Tables 2.3.8(i) & 2.3.8(ii) for Jalpaiguri and Cooch Behar. The same information has been used to construct Figures 2.3.8(i) & 2.3.8(ii). These may indicate as if a shift has taken place at both the stations in the distribution pattern. Amplitude has also been greater. However, it is necessary to mention that variations in the monthly distribution of rainfall is a common feature of any tropical climate systems. Researcher's task is to study the cyclical pattern. The data in hand do not necessarily cover the lengths of such cycles. In short, it will be unwise to give credence to the common belief from the data in hand. What is more important to note is that any variation from the normal pattern makes prediction of flood amplitude an uncertain exercise.

Table 2.3.8(i)
Comparison Between the Pattern of Rainfall (1931-1960) & (1980-1992)
Station : Jalpaiguiri

Month	Period 1931-1960		Period 1980-1992	
	Average Rainfall (mm)	Monthly Cumulative (mm)	Average Rainfall (mm)	Monthly Cumulative (mm)
January	9	9	7	7
February	14	23	18	25
March	30	53	29	54
April	115	168	87	141
May	340	508	289	430
June	710	1218	666	1096
July	776	1994	945	2041
August	663	2657	638	2679
September	537	3194	646	3325
October	143	3337	109	3434
November	14	3351	7	3441
December	3	3354	13	3454
Over the Year	3354		3454	

Table 2.3.8(ii)
Comparison Between the Pattern of Rainfall (1931-1960) & (1980-1992)
Station :Cooch Behar

Month	Period 1931-1960		Period 1980-1992	
	Average Rainfall (mm)	Monthly Cumulative (mm)	Average Rainfall (mm)	Monthly Cumulative (mm)
January	11	11	8	8
February	17	28	24	32
March	31	59	31	63
April	134	193	139	202
May	440	633	370	572
June	767	1400	690	1262
July	702	2102	1031	2293
August	506	2608	648	2941
September	502	3110	575	3516
October	168	3278	119	3635
November	10	3288	7	3642
December	4	3292	12	3654
Over the Year	3292		3654	

Comparison Between Patterns of Rainfall Between 1931-60 & 1980-92

Figure 2.8(a)
Station : Jalpaiguri

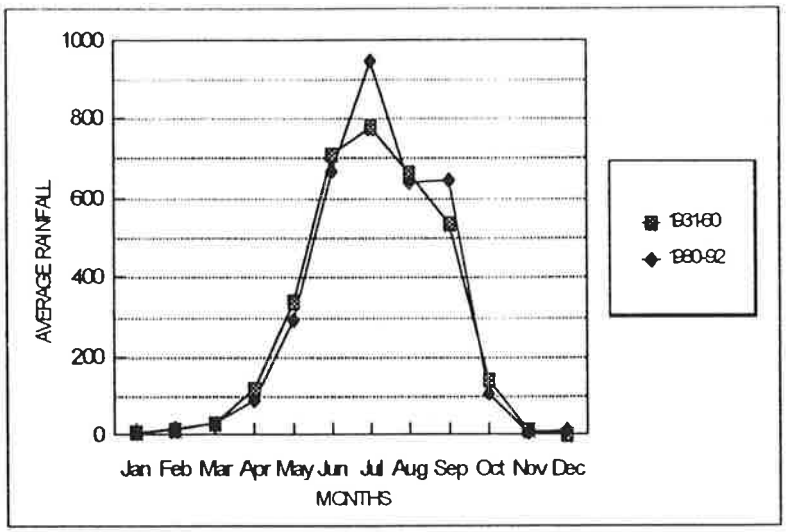
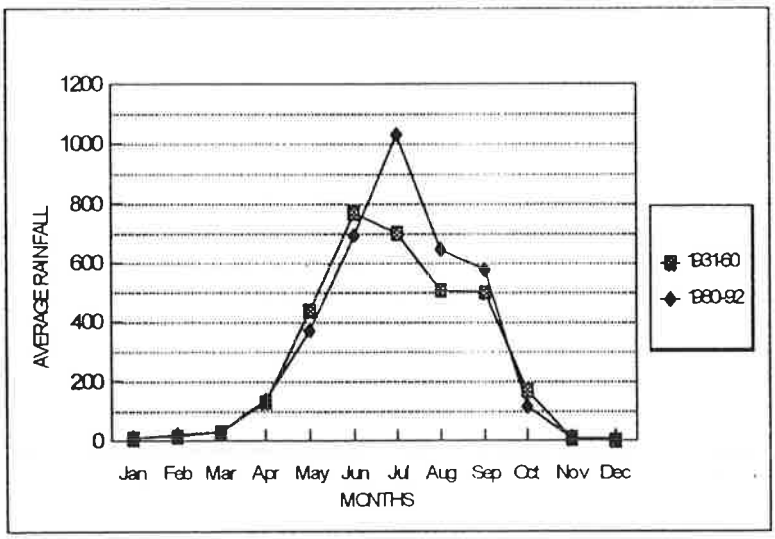


Figure 2.8(b)
Station : Cooch Behar



2.3.9 Data available from the other rain gauge stations, in spite of their unreliable nature, do confirm the local understanding about regional pattern of rainfall. Rainfall increases as one approaches the mountains from south. This is decidedly an orographic influence. Rainfall also increases from west to east.

2.4 HYDROLOGY

2.4.1 Within the project area, local relief decreases from north to south. So also does the porosity of surface lithology. Silt and clay fractions are decidedly higher with the Shaugaon and Baikunthapur formations than with the Matiali and Chalsa formations. The Samsing formation has no binding matrix and the variable size of boulders and sand has produced large annular spaces. This means that percolation is higher in the north though surface run-off speeds up due to higher order of local relief. In the south, however, percolation is slower, leaving a larger share of received rainfall to flow down as surface run-off. It is not surprising, therefore, that many rivers have their sources right within the gentle plains. So also are the many streams originating from the flanks of the mountains where the local relief is high.

2.4.2 The project area has many streams. In terms of their sources, these can be classified into four groups. There are the rivers originating in the high mountains, from the forested tracks at the foot of the hills originate a number of streams, from the contact zone of the Chalsa and Baikunthapur formations. The rest has originated in the contact zone between the Baikunthapur and Shaugaon formations almost from the flat plains. The first two groups of streams are perennial. Others dry up during the pre-monsoon season.

Almost all streams within the project area have reached the stage when valley side widening over-shadows their capacity to valley bottom deepening. Through lateral sweeps, the channels with high banks are widening. Hence sediment load is high, but sluggish to move. Shoaling with inter-lacing channels are widely seen in all rivers, especially with all the major streams. These channels often change their courses after the monsoon floods, obviously due to changed disposition of the deposited materials.

2.4.3 The surface drainage system is integrated with the Ganga and the Brahamaputra basins. The share of the Ganga basin in the project is small, being restricted to the terrain extending westward from the Mahananda river. The rest belongs to the Brahamaputra basin. This part is shared by five rivers, all originating in the Himalayas. These are the Teesta, Jaldhaka, Torsa, Raidak and Sankosh.

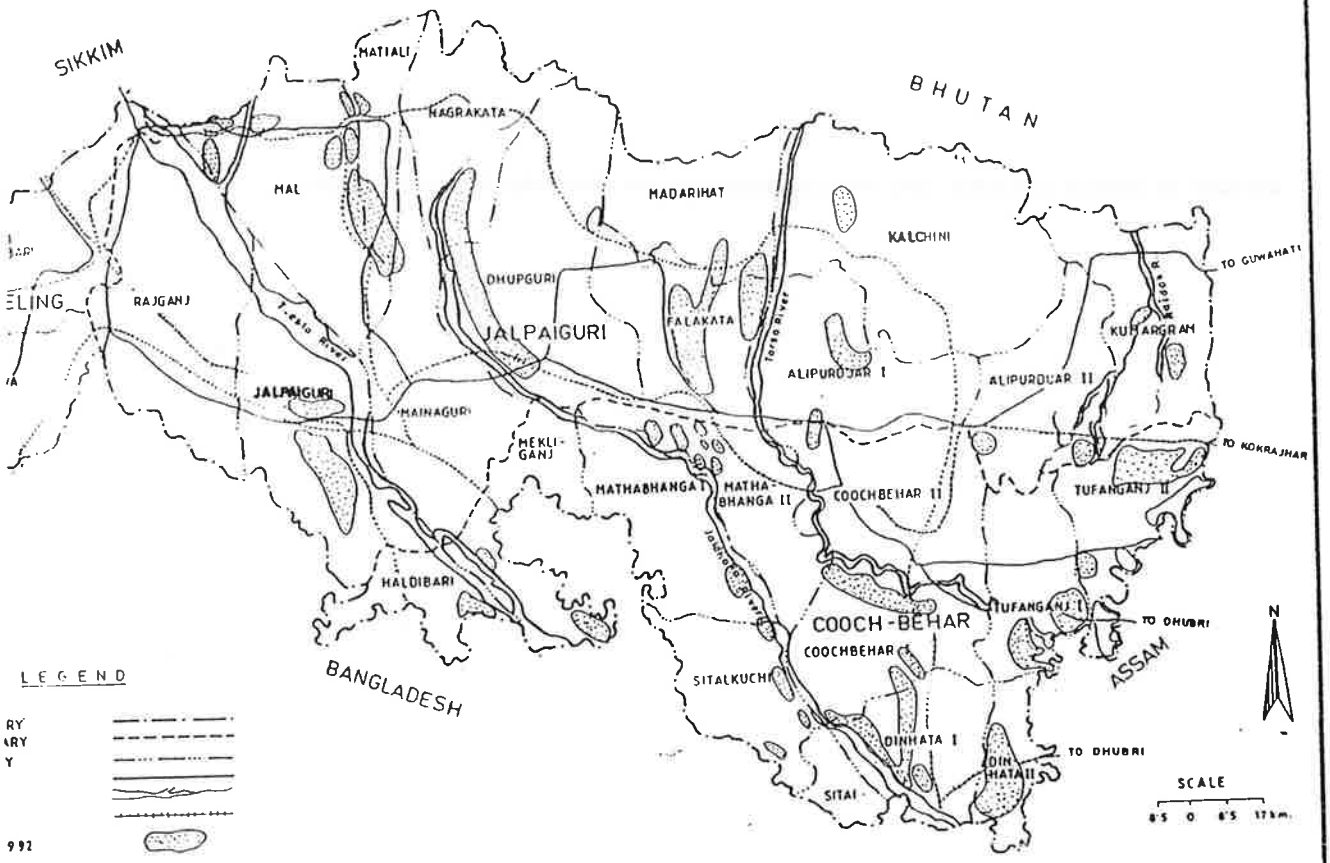
Hydrograph stations have not been established in many of the rivers of the project area. It is difficult, therefore, to provide any data on the quantum of rainfall flowing as run-off. Nevertheless, Table 2.4.3 may indicate how disastrous floods can be. The data refers to the 1993 flood. The Central Water Commission (CWC) of the Government of India has prepared the estimate.

Table 2.4.3
Estimated Peak Discharge During 1993 Flood

River	Reference Point	Catchment Area (Km^2)	Peak Discharge (Cusec)
Teesta	Coronation Bridge	9,350	616,900
	Jalpaiguri Town	10,205	712,870
Torsa	Hashimara	3,968	445,360
	Railway Bridge	4,432	478,490
Raidak	Bhutan Gate	4,660	467,600

2.4.4 It is difficult to draw any generalised relationship between rainfall and peak discharge from the data in hand. One can only state that floods may occur in any month between June and October. Within that period, the event of cloud bursts are particularly dangerous. The areas flooded during 1992 and 1993 are shown in Fig. 2.4.4. 1993 was the year of a heavy flood which is reflected in the extent of area inundated that year.

FIG 2·4·4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DHUPGURI
RAJGANJ
JALPAIGURI
FALAKATA
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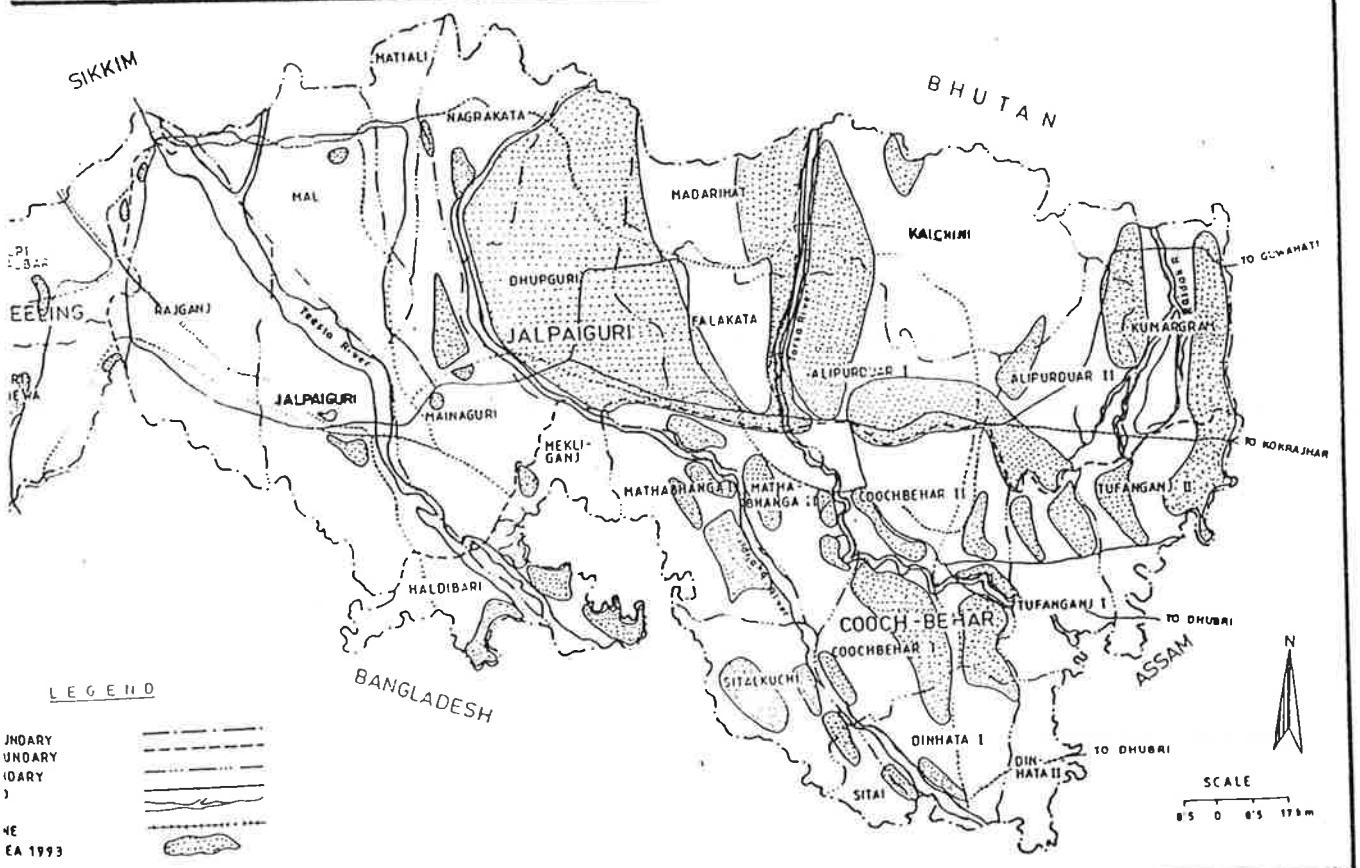
HALDIBARI
TUFANGANJ I
TO DHUBRI
COOCH-BEHAR
COOCHBEHAR I
ASSAM
SITALKUCHI
BANGLADESH
DINHATA I
DIN-HATA II
TO DHUBRI
SITAI
SCALE
LEGEND
SOURCE : NORTH BENGAL FLOOD CONTROL COMMISSION, JALPAIGURI
MAP SHOWING THE FLOODED AREA 1992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DIN-HATA II
TO DHUBRI
SITAI
SCALE
LEGEND
SOURCE : NORTH BENGAL FLOOD CONTROL COMMISSION, JALPAIGURI
MAP SHOWING THE FLOODED AREA 1993

2.5 SOIL TAXONOMY

2.5 The entire project area, except a small part with hard rock formations, is formed of alluvial soils contributed by the mountains under the impact of fluvial forces. As the velocity of the flowing waters down the rivers declined, the heavier fractions of the traction and suspended loads got deposited. Hence the finer and lighter fractions of the soil are deposited further away from the hills. Repeated flood alluviation would deposit similar materials upon the surface year after year. The vertical cross-sections would fail to reveal any structural orientation that is the normal feature of any *in situ* soil.

2.5.1 Within the project area, the transported soils have been deposited over many thousands of years. Not all parts of the terrain are now under the ambiance of annual flood alluviation. Consequently, the process of leaching and translocation of solutes (through capillaries) are operating on most of the soils except those constituting the Shaugaon formation. Leaching during rainy season carries the soluble bases upto the top of the ground water table. During the drier months, oxidised chemicals travel upwards through capillaries to reach the surface in many instances. Hence accommodation of sesqui-oxides in the upper layers and that of bases in the lower layers produce a feature that often leads one to discover structures in the older formations. The degree of oxidation is closely related to the age of the formations.

2.5.2 The older transported soils are, however, getting eroded at the surface by the surface drainage systems leading to further sorting of materials spatially. The surface drainage is also responsible for removing the oxidised materials. Hence the surface of any formations is not uniformly oxidised nor are the framework materials same everywhere. It is also conceivable that the seasonal rise and fall of ground water table is leading to further sorting of materials by grain size vertically, however slow the acting processes might be. Hence in nearly all the older formations, at or near the ground water table, materials larger in size than those above are found. These can be large boulders, as in the Samsing Formation, and small cobbles or pebbles as in the Baikunthapur Formations. Such structural distinctions are not generally visible in the Shaugaon Formations.

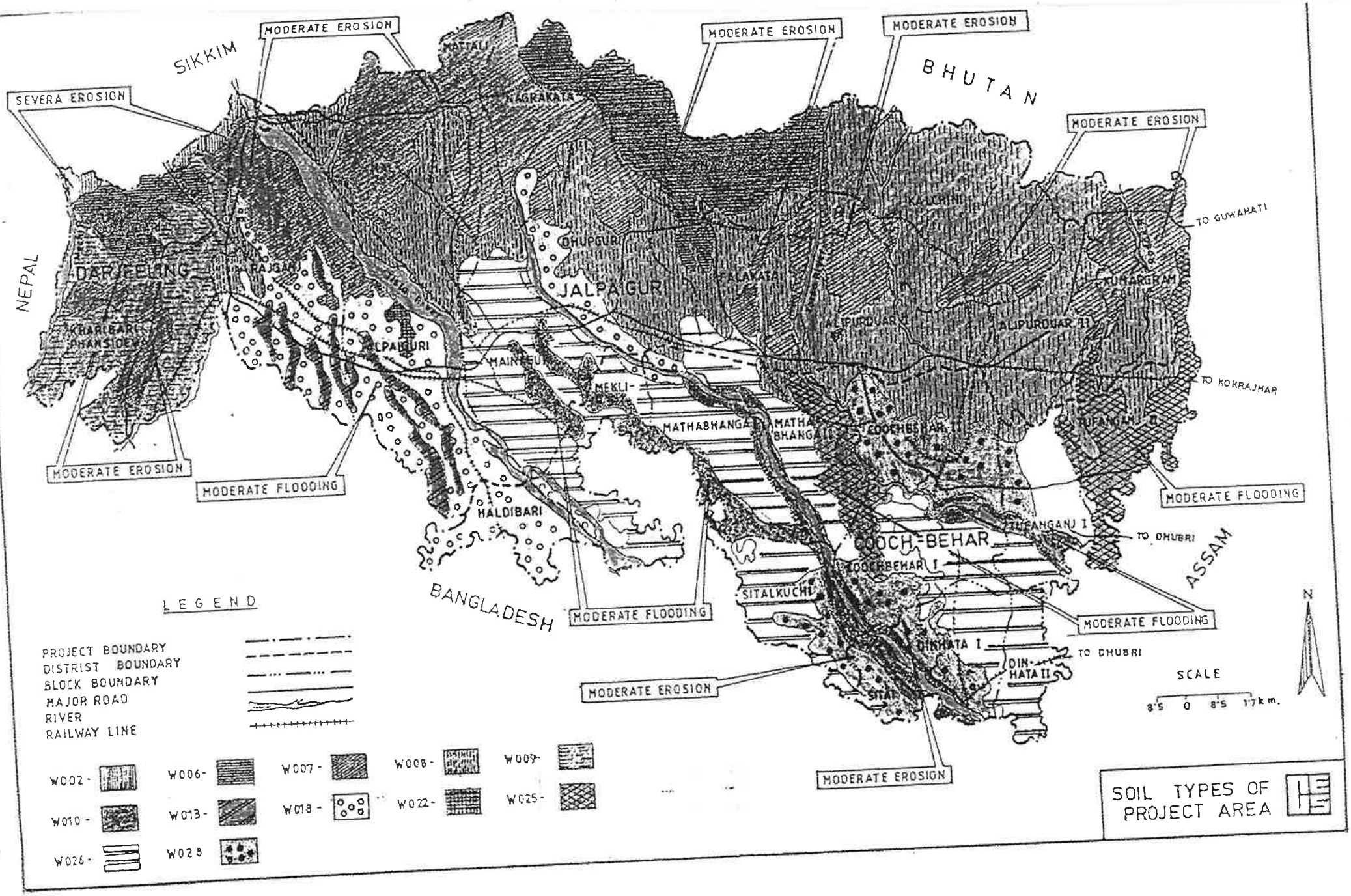
2.5.3 It should be clear from the above discussion that the soils of the project area to be distinguished on the basis of their texture rather than their structure. The National Bureau of Soil Survey (NBSS), Government of India, has classified the soils of West Bengal from this perspective. They have added to it their observations on the governing process of drainage operating over each type of soil. These types have been matched against International Soil Taxonomic Classification System. Area covered by each type of soil has also been mapped. Data relevant for the project area presented in Table - 2.5.3. The spatial distributions of these types is shown in Fig. - 2.5.3.

Table - 2.5.3
Typology of Soils of the Project area

Index in Fig.2.5.3	Description	Taxonomic Identity
W002	Moderately shallow, excessively drained, coarse loamy soils occurring on steep side slopes with gravelly loamy surface, severe erosion and strong rockiness	Typic Udorthents
W006	Very deep, imperfectly drained, coarse loamy soils occurring on very gently sloping upper piedmont plains with loamy surface and moderate erosion	Umbric Dystrochrepts
W007	Very deep, imperfectly drained, fine loamy soils occurring on very gently sloping lower piedmont plain with loamy surface and moderate erosion	Fluventic Eutrochrepts
W008	Very deep, poorly drained, coarse loamy soils occurring on level to nearly level lower piedmont plain with loamy surface	Typic Haplaquents
W009	Very deep, imperfectly drained, coarse loamy soils occurring on nearly level lower piedmont plain with loamy surface	Aquic Udifluvents
W010	Very deep, moderately well drained, coarse loamy soils occurring on level to nearly level active alluvial plain with loamy surface and moderate flooding	Aquic Ustifluvents
W013	Very deep, poorly drained, fine loamy soils occurring on level to nearly level active alluvial plain with loamy surface	Typic Haplaquents
W018	Very deep, poorly drained, coarse loamy soils occurring on level to nearly level recent alluvial plain with loamy surface and moderate flooding	Typic Fluvaquents
W022	Very deep, moderately well drained, coarse loamy soils occurring on level to nearly level recent alluvial plain with loamy surface and moderate flooding	Aquic Ustifluvents
W025	Very deep, imperfectly drained, coarse loamy soils occurring on level to nearly level recent alluvial plain with loamy surface and moderate flooding	Aquic Ustifluvents
W026	Very deep, poorly drained, fine loamy soils on level to nearly level recent alluvial plain with loamy surface	Aquic Haplaquents
W028	Very deep, poorly drained, fine silty soils occurring on level to nearly level recent alluvial plain with loamy surface and moderate erosion	Typic Fluvaquents

2.5.4 Fig. 2.5.3 shows that the differentiated soils in the southern part of the project area occur as linear patches concordant with the alignment of the regional drainage system. These identify the tracts under annual flood alluviation or those under the influence of fresh transportation of materials by the flowing rivers. Similar features are not discernible on regional scales in the northern part. This is possibly because the north is covered mostly under forests and tea plantations over higher terraces. In the south, the forest cover has been largely removed to make room for agriculture.

Based on these taxonomic grouping, areas susceptible to flooding and erosions have also been identified on Fig. 2.5.3


SIKKIM
MODERATE EROSION
MODERATE EROSION
MODERATE EROSION
BHUTAN
SEVERA EROSION
MATTALI
NAGRAKATA
MODERATE EROSION
TO GUWAHATI
NEPAL
DARJEELING
RAJGANJ
DHUPGURI
JALPAIGURI
FALAKATA
KALCHINI
KUMARGRAM
ALIPURDUAR I
ALIPURDUAR II
KHARIBARI
PHANSIDEWA
JALPAIGURI
MAINAGURI
MEKLI-
TO KOKRAJHAR
MATHABHANGA I
MATHA-BHANGA II
COOCHBEHAR II
RUPANGANJ II
MODERATE EROSION
MODERATE FLOODING
MODERATE FLOODING
HALDIBARI
RUPANGANJ I
TO DHUBRI
COOCH-BEHAR
COOCHBEHAR I
ASSAM
BANGLADESH
SITALKUCHI
MODERATE FLOODING
MODERATE FLOODING
DINHATA I
TO DHUBRI
DIN-HATA II
MODERATE EROSION
SITAI
MODERATE EROSION
N
SCALE
8·5 0 8·5 17 Km.
LEGEND
PROJECT BOUNDARY
DISTRIST BOUNDARY
BLOCK BOUNDARY
MAJOR ROAD
RIVER
RAILWAY LINE
W002 -
W006 -
W007 -
W008 -
W009 -
W010 -
W013 -
W018 -
W022 -
W025 -
W026 -
W028
SOIL TYPES OF PROJECT AREA

2.6 FORESTS, GROVES & PASTURES

2.6.1 The forest lands, in the records of the Department of Forest, Government of West Bengal, are classified by ranges and divisions, the boundaries of which are demarcated by the Department itself and do not conform to the administrative territories. Most other departments compute their data either by tehsils (Police Station jurisdiction) or by Blocks (developmental units). Reconciliation of these records, therefore, pose problems. Some order of reconciliation is made for the Districts as areal units; but the process takes time to complete. Recent data are not always available in published forms. Hence, the reality can be deciphered by patient collating of information from various sources.

2.6.2 From an April 30, 1993 run of satellite a set of data on vegetation cover of the project area was prepared which is shown in Table - 2.6.2. Here the data on the District of Darjeeling refers to the whole district not exclusively the part belonging to the project area. To that extent, this table should be seen as an approximate statement.

Table 2.6.2
Rapid Forest Cover Estimate
(in sq km)

Territory	Geographical Area	Forest Cover	Degraded & Scrub Forests(A)	Village Orchard	Total Vege-tation Cover
Darjeeling(B)	3149	1610	169	55	1834
Jalpaiguri	6227	1602	435	178	2215
Cooch Behar	3387	35	159	68	262
Project Area(B)	12763	3247	763	301	4311
West Bengal	88752	12712	4134	4085	20931

Note : Based on Satellite run of April 30, 1993
(A) Based on Satellite run of October, 1988
(B) Refers to the entire district.

2.6.3 To facilitate comparison, the above data have been converted into percentages of the geographical area of the respective territorial units in Table - 2.6.3. This table yields the following judgments :

(a) The project area is decidedly greener than the rest of West Bengal. But this is primarily due to higher vegetative coverage in Darjeeling and Jalpaiguri districts;

(b) The district of Cooch Behar is poor in this regard;

(c) Village orchards are relatively few in the project area in relation to the State of West Bengal; and

(d) The forests under the care of the Department of Forests account for the greenery except in Cooch Behar

Table 2.6.3
Relative Incidence of Vegetation Cover
(in percent)

Territories	Geographical Area	Forest Cover	Degraded & Scrub Forests(A)	Village Orchard	Total Vegetation Cover
Darjeeling(*)	100.00	51.13	5.37	1.75	58.24
Jalpaiguri	100.00	25.73	6.99	2.86	35.24
Cooch Behar	100.00	1.03	4.69	2.01	7.74
Project Area(*)	100.00	25.44	5.98	2.36	31.72
West Bengal	100.00	14.32	4.66	4.60	23.58

Note : * Indicates the whole of Darjeeling District

2.6.4 The data from Satellite run on forests do not, however, tally with the data available in the records of the Forest Department as shown in Table - 2.6.4. This is possible on many counts. The records of the Forest Department do not consider the large blanks within the forests. Similarly, the satellite imageries without adequate ground check may provide inaccurate data.

Table 2.6.4
Comparison of Forest Land as Recorded by Forest Department and as Derived from Satellite Images
(in ratio percent of Total Area)

Territories	Forest Records	Satellite Images
Darjeeling	38.23	51.73
Jalpaiguri	28.75	25.73
Cooch Behar	1.68	1.03
Project Area	23.91	25.44
West Bengal	13.38	14.32

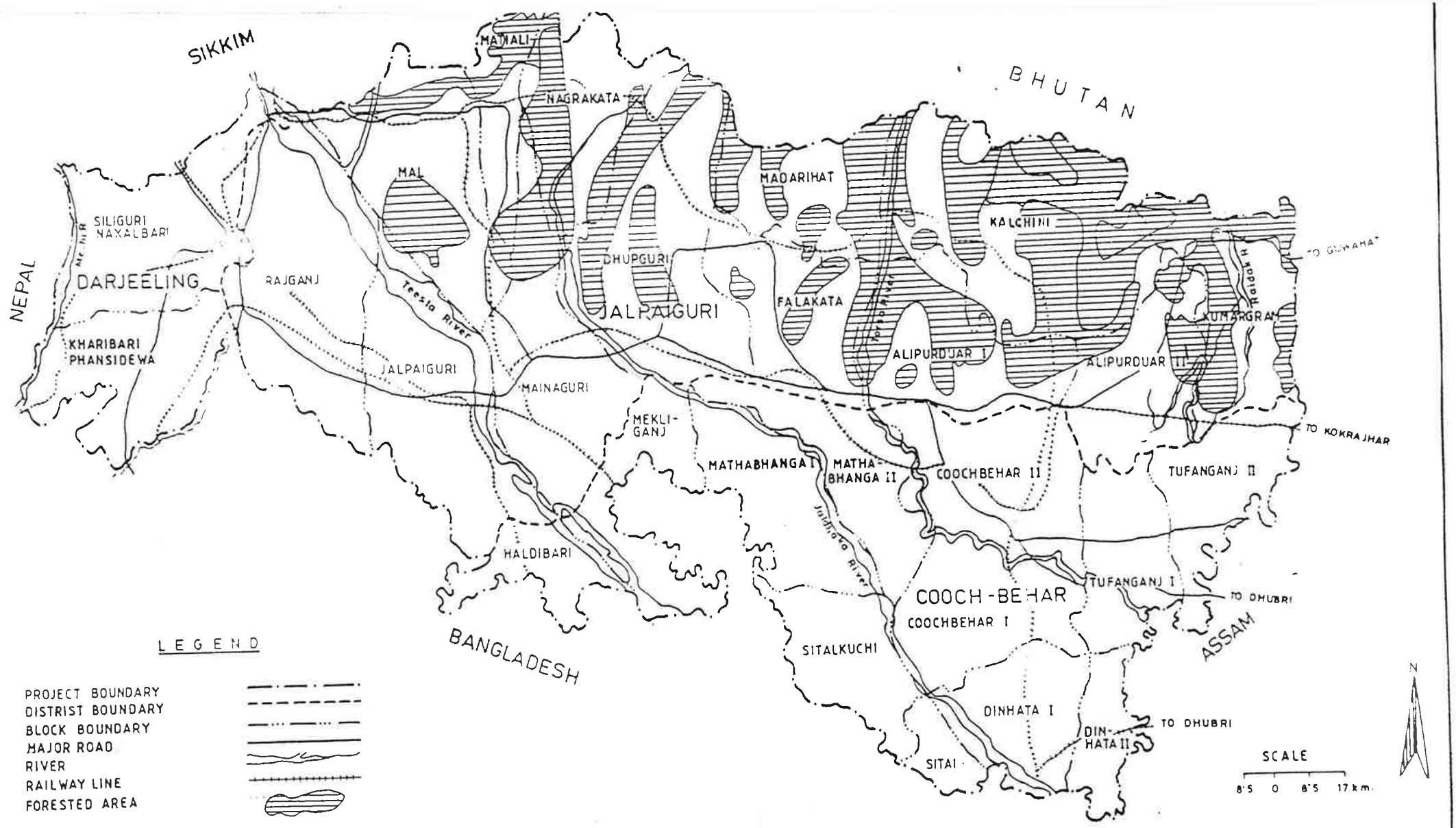
2.6.5 In Figure - 2.6.5, the locations of the major forested tracts of the projected area are shown. These are found mostly on terraces in the northern and eastern quadrants of the region under reference.

2.6.6 The dominant tree species in the forests of the project area are noted in Table - 2.6.6.

Table 2.6.6
Dominant Tree Species in Forests

Location	Species
1. Sub tropical hill forest occur upto an elevation of about 1800m.	*Betula cylindreostachys, Alnus nepalensis, Schima wallichii, Engelhardtia spicata* etc
2. Wet mixed forest restricted to the foothills of North Bengal	*Michelia champaca, Teminalia myriocarpa, Ailanthus grandis, Phoeba* spp
3. Moist deciduous forests occur in northern plains	*Shorea robusta, Chukrassia velutina* interspersed with riverine forest of *Acacia catechu, Dalbergia sissoo* and *Bombax ceiba*

2.6.7 Forests areas have been regularly encroached upon and many existing forests are degraded in the project area. Major encroachments are from extension of the tea estates and agricultural areas, unauthorised settlements of people especially from the neighbouring countries, illegal felling of trees by timber smugglers and unplanned timbering operations by the department in some cases. Major irrigation and hydroelectric projects, roads etc. have also taken their tolls. Degradation of forests have taken place due to forest fires - natural and man-made, grazing of cattle, collection of fuel woods and loping of trees. Combinedly, poor forest management, wrong development policies and local poverty have resulted in depredation of forests both in area and quality.



SOURCE: NORTH BENGAL FLOOD CONTROL COMMISSION : JALPIGURI

MAP SHOWING FOREST COVER OF PROJECT AREA

2.7 Wild Life

The forests in the project were the prime habitats of tiger, cheeta, rhino and elephant in the past. About 100 years back, more than 120 rhinos were counted in these forests. However, by 1967-68, the rhino population came down sharply. Similarly, by 1972, when the Project Tiger began at Buxa in Jalpaiguri there were only 17 tigers. The cheeta was already extinct. With depredation of forests and destruction of wild life habitats along with poaching, the number of many wild life species reduced to an alarming extent. However, during the last 20 years or so a number of Reserve Forests and Sanctuaries have been established in the forest areas of the region, enhancing the preservation of species and population increase. A recent study on faunal diversity of Reserve Forests in North Bengal has identified the following number of species per vertebrate class :

Vertebrate Class	Number of Species
Mammals	67
Reptiles	36
Amphibians	4
Birds	230
Fishes	136

The following mammals and birds are commonly found in the forests of North Bengal :

Mammals	Birds
1. Rhinoceros	1. Wood Cock
2. Indian Bison	2. Pie
3. Gayal	3. Tit
4. Elephant	4. Babbler
5. Sambar	5. Iora
6. Swamp Deer	6. Swallow
7. Spotted Deer	7. Horn Bill
8. Hawk Deer	8. Hoopoe
9. Barking Deer	9. Fishing Eagle
10. Wild Pig	10. Pigeon
11. Tiger	11. Dove
12. Leopard	
13. Monkey	
14. Buffalo	
15. Squirrel	

Census of major wild life in the Buxa Reserve Tiger Project gives the following estimates of major mammals and birds in the area :

Type	Year of Census	Estimated Nos.
Tiger	(1992)	29
Leopard	(1992)	61
Lesser cats	(1994)	200-300
Civet	(1994)	200-300
Elephant	(1992)	84
Gaur (Bison)	(1994)	400-500
Barking Deer	(1994)	1100-1300
Hog Deer	(1994)	310-410
Spotted Deer	(1994)	450-550
Sambar	(1994)	300-400
Pangolin	(1994)	190-290
Mongoose	(1994)	110-210
Porcupine	(1994)	50-70
Wild Boar	(1994)	2800-3200
Monkeys	(1994)	14800-15800
Peacock	(1994)	2300-2500
Jungle Fowl	(1994)	2400-2600

Presence of these animals and birds have also been reported in the other forests of the area. However, the areas outside the forests, where the project interventions are located, are almost totally devoid of any animal or bird except the common ones like dogs, squirrels, pigs, monkeys, mynahs, house crows, sparrows, pigeons and doves.

Though the population of different species are small compared with the total forest area, encroachment in habitats, cultivation within forest area and extension of tea plantation occasionally lead to exodus of animals to the surrounding areas creating hazards. Marauding groups of elephants destroying crops in the vicinity of the forests and leopards attacking the tea garden labourers are reported quite frequently in this region.

2.8 Landuse

The landuse pattern in the project area is basically rural with urban areas i.e. the District Headquarters at Jalpaiguri and Cooch Behar as also the Sub-divisional Headquarters comprising about 1.85% of the total land. Based on data available in the Annual Plans, published by the Department of Agriculture, Govt. of West Bengal areas under different landuses (non-urban) for the years 1986-87 and 1991-92 are given in Table 2.8. The data available for Darjeeling District relate to the whole district. No separate data is available for the blocks coming within the project area and the data available are only for 1986-87.

Forest is the major landuse in Darjeeling District. However, there is almost no forest in the project area, most of which is agricultural land and partly urban. In Jalpaiguri, forests still occupy a substantial portion of the land, though area under forest has reduced from 29.05% to 24.37% between 1986-87 and 1991-92. There has also been a qualitative degradation of forest. The areas under non-agricultural use also show reduction of about 7.5% with a simultaneous decrease in the net area available for cultivation. This anomaly is partly explained by the increase in area under orchards and plantations. There may be also some increase in tea garden areas, data for which for the area 1986-87 is unfortunately not available. In case of Cooch Behar area under non-agricultural use shows an increase over the years with decrease in the net area available for cultivation and increase in the area under orchards and plantation. However, the transfer of landuse between the different items is not quite transparent. Further discussions on use of land is being made in subsequent chapters under different heads of such uses.

Table 2.8
Land Use Pattern in the Project Area

Sl No	Item	District					
		Cooch Behar		Darjeeling		Jalpaiguri	
		Area in Ha (1991 -92)	Area in Ha (1986-87)	Area in Ha (1991-92	Area in Ha (1986-87)	Area in Ha (1991-92)	Area in Ha (1986-87)
1	Geographical Area (including enclaves)	33451 5	3413 50		3255 00	6100 22.4	6161 20.0
2	Area under Non-Agricultural use	69137 (20.6 7%)	5387 0 (15 78%)		4638 0 (14. 25%)	1018 82.0 (16. 7%)	1482 50.0 (24. 06%)
3	Forests	5268 (1.57 %)	5700 (1.6 7%)		1204 00 (36. 99%)	1486 56.8 (24. 37%)	1790 00.0 (29. 05%)
4	Barren and Uncultivable land	14277 (4.27 %)	2770 (0.8 1%)		2590 (0.8 0%)	1250 .0 (0.2 0%)	1163 0.0 (1.8 9%)
5	Permanent pastures & other grazing land	181 (0.05 %)	750 (0.2 2%)		2130 (0.6 5%)	Nil	220. 0 (0.0 4%)
6	Area under orchards, plantation & misc.	10340 (3.09 %)	6560 (1 9 2%)		5660 (1 7 4%)	1318 8.2 (2.1 6%)	4940 .0 (0.8 0%)
7	Cultivable waste land	3332 (1.0%)	2290 (0.6 7%)		2540 (0.7 8%)	2000 .0 (0.3 3%)	3060 .0 (0.5 0%)
8	Fallow and other current fallow	1587 (0.47 %)	1730 (0.5 1%)		8880 (2.7 3%)	Nil	8350 .0 (1.3 6%)
9	Current fallow	-	1980 (0.5 8%)		-	N.A.	1350 .0 (0.2 2%)
10	Net area available for cultivation	23039 1 (68.8 7%)	2657 00 (77. 84%)		1369 20 (42. 06%)	2283 37.8 (37. 43%)	2593 20.0 (42. 09%)
11	Tea Garden					1187 07.6 (19. 46%)	

N.B. : Percentages are of respective geographical area

This shows that the total population has increased by 23% in 10 years time which almost correspond to the national average 2.11% growth per annum. Micro level data shows that amongst the blocks, the lowest growth rate is recorded in Kharibari-Phansidewa (31%), while Rajganj in Jalpaiguri District shows the highest level of growth (59%) closely followed by Nagrakata in the same district (45%). But more alarming than the growth rate is the age distribution. Though formal data for 1991 Census are not yet published, available information revealed that the age pyramid is significantly bulged in the productive range (15-45 years). This is also corroborated by field visits. With such age pyramid, even with the best of family planning, the population growth rate will take a long time to show a reducing trend.

2.10 Health

Major diseases in the project area are malaria, gastro enteritis, tuberculosis and leprosy, the last one being more rampant in the tea garden areas of Darjeeling and Jalpaiguri. Data from *Health on the March*, a GoWB publication, presented district level data for cases of malaria and diarrhoeal diseases which are summarised in Table 2.10 (i) and (ii) respectively.

Table 2.10(i)
Distribution of Positive Cases of Malaria

District	1987	1991	1992
Darjeeling	382	249	131
Jalpaiguri	13261	13523	21403
Cooch Behar	3569	1672	1940
Project Area	17212	15444	23474
West Bengal	46029	24787	N.A.

Table 2.10(ii)
Cases and Deaths Due To Diarrhoeal Diseases
(Gastro-enteritis, Bacillary Dysentery etc)

Year	District	Case
1987	Darjeeling	783(3)
	Jalpaiguri	20793(32)
	Cooch Behar	41204(59)
	Project area	67786(96)
	West Bengal	192247(914)
1991	Darjeeling	486(22)
	Jalpaiguri	27778(228)
	Cooch Behar	8635(39)
	Project Area	36899(289)
	West Bengal	167192(1514)
1992	Darjeeling	N.A.
	Jalpaiguri	3871(N.A.)
	Cooch Behar	4583(N.A.)
	Project area	N.A.
	West Bengal	N.A.

Fig. ( ) indicate cases of death.
N.A. - Not Available

These show that the project area had 37.39% and 62.30% of all malaria cases in West Bengal in 1987 and 1991 respectively and also the only cases death. In June 1995, an epidemic of malignant malaria (Malaria tropica, transmitted through the parasite *Plasmedium falciparum)* made many victims in the Jalpaiguri district and in adjacent areas of Northern Bangladesh. Reported cases of diarrhoeal disease are 35.25% and 23.40% and death rates are 10.5% and 13.49%. Thus compared to the size the project area had more than its share of malaria and diarrhoeal diseases.

Similarly in case of tuberculosis and leprosy the project area's share was 18.24% and 7.2% respectively [Tables 2.10(iii) and (iv)].

Table 2.10 (iii)
Number of Tuberculosis Patients Detected by District and Place of Detection Under, National T.B. Programme, West Bengal, 1991

Districts	District T.B. Centre	Peripheral Health Institution	District T.B. Programme
	All TB Patient	All TB Patient	All TB Patient
Darjeeling	2283	6938	9221
Jalpaiguri	2250	63	2313
Cooch Behar	985	425	1410
All District	32487	38473	70961
Average per District	1911	2263	4174

Source : A.D.H.S (T.B.), West Bengal

Table 2.10(iv)
Cases of Leprosy

District	Cases on record as on 31.3.91	Cases on record as on 31.3.92
Darjeeling	3161	4124
Jalpaiguri	8669	7768
Cooch Behar	3511	3188
West Bengal	204096	181444

Source : National Leprosy Eradication Programme : Objective Performance Report

However, according to knowledgeable sources, the actual cases of all these diseases especially leprosy are much higher and that a majority of the cases remain unreported.

3.0 PROJECT DESCRIPTION AND ENVIRONMENTAL ISSUES

3.1 Project Description

North Bengal Terai Development Project was initiated in 1985. Implementation so far has covered Phase-I from the year 1984-85 to 1987-88 and Phase-II from 1988-89 to 1992-93. The project has concerned itself with the development of land through

- construction of minor irrigation facilities such as Hand Tubewells (HTW), Pump Dug Wells (PDW), Shallow Tubewells (STW), Deep Tubewells (DTW), River Lift Irrigation Systems (RLIs) as well as lining of field channels for 4 ha units in DTW and RLI command areas.
- agricultural extension and training of farmers and Government Officials
- land reclamation and soil conservation

With the exception of the training programme by a local organisation (KVK), which came to a stop in 1991, the activities have been implemented by the existing Government Institutions and no special project structure was created. Operational responsibilities rest with the Department of Agriculture, Government of West Bengal with the Joint Director of Agriculture (JDA), Jalpaiguri Range being the in-charge of the project. Liaison is maintained with the Department of Minor Irrigation (now Department of Water Resources) which takes care of the larger irrigation facilities, i.e. RLIs and DTWs. The objective of the project is to induce better income for and better income distribution among the marginal and small farmers in the Terai Region through increase of production capacities (*2). The principal target groups for the project are thus the marginal and small farmers owning less than 1 ha and between 1 & 2 ha of land respectively. Based on encouraging responses from the first two phases, the Government of India and the Government of Netherlands have embarked on a Phase III programme to cover another 5 years. In addition to the installation of adequate number of facilities and implementation of training activities this Phase III is to improve the output of the facilities already created primarily through action research on management skills, procedures for handing over of the schemes to the water users, training and extension, gender effects and environmental protection.

3.2 Physical Achievements

The quantitative technical targets and achievements for the different activities in Phase I and Phase II as well as the targets of Phase III of NBTDP are presented in Table 3.2 below (*2 & *3).

Table 3.2
NBTDP Targets and Achievements

	Phase-I		Phase-II		Phase-III
	Target	Achievement	Target	Achievement	Target
Hand Tubewell	5000	1950	20000	28025	15000
Shallow Tubewell	150	203	150	150	300
Pumped Dug well	250	66	300	300	100
River Lift Irrigation System	10	10	30	30	25
Deep Tubewell	4	4	16	16	10
4 ha units	200	126	1000	441	500
Land Reclamation	--	--	3000 ha	5641 ha	5000 ha

3.3 Features (*3)

(a) Hand Tubewells

The hand tubewells (HTW) supplied under the project are of the simple classical lever type design with a cylindrical cast iron body, which were commonly in use for water supply in these regions before the advent of the improved quality Mark II pumps. The HTWs comprise 40 mm dia pipes sunk to about 15 m depth with an approximate capacity of 0.3 litre per second (lps). Many HTW have cemented platforms around the pipes with a drain leading the water away towards the fields. The HTWs are meant for marginal farmers (having less than 1 ha of land) and are planned to irrigate 0.16 ha serving areas near the installations mostly at or near the homesteads. HTWs are normally utilised by the farmers for all the lands for at least 2 seasons, i.e. winter and pre-kharif. Crops grown are vegetables, potato, onion, spice, oilseeds, and in some cases, even paddy. Virtually all HTWs are used for drinking water also.

(b) Pumped Dug Wells (PDW)

Dug wells comprise holes, dug into the ground with an average depth of 12 m depending on ground water levels and soil conditions and are lined with 1.5 m dia concrete rings. The rings are raised above ground by about 1 m normally without any platform at the ground level. These are fitted with 3.5 HP or 5 HP centrifugal pumps (depending on the farmer's choice) and supplies water at a rate of about 6.1 lps for a planned command area of 3 ha. PDWs are mainly used for cultivation of jute, vegetable (pre-kharif). The PDWs are with open top. Traditionally, drinking water is taken out with a bucket from the top whereas the portable pump is fitted when irrigation is needed.

(c) Shallow Tubewells (STW)

STWs constructed under NBTDP are of 50 mm suction pipe for an average depth of 40 m and are driven by a 5 HP centrifugal diesel pump with discharge of about 8.3 lps and a planned command area of 4 ha. The wells are mostly allotted to groups of 4 to 5 farmers with landholding between 1 to 2 ha. The STWs are mainly used for cultivation in pre-kharif season and also to a lesser extent in the winter season. The emphasis is on boro paddy. STWs are normally without platforms. In many cases, during non irrigation periods, these STWs are fitted with hand pumps for drawing drinking water.

(d) Deep Tubewells (DTW)

DTWs are 9" (225 mm) tubewells sunk to an average depth of 150 m and powered by a 17 HP submersible electric pump with a delivery of 56 lps irrigating a planned command area of 40 ha. The distribution of irrigation water is by sub-surface piped system serving an average of 12 delivery points (spouts). Each DTW has multiple outlets controlled by raised masonry cistern and a ground level cistern with V-notch weir. In most cases, both types of outlets are concurrently used each leading to a different set of spouts. Delivery to the spouts are controlled by cast iron (CI) valves. The schemes are operated by staff of the Local Government with Department of Minor Irrigation taking care of the maintenance. The data gathered by the Research Unit of NBTDP showed that approximately 75% of the land under command area of the DTW is owned by marginal and small farmers. However, the crops cultivated with DTW is shown to include about 20% of HYV kharif paddy, rest being devoted primarily to jute (18%), pre-kharif vegetable (24%), vegetable rabi (18%) and others.

(e) River Lift Irrigation (RLIs)

RLIs constructed under the NBTDP are equipped with 2 Nos. 34.5 HP diesel pumps plus one spare with discharge of 2 x 56 lps irrigating a planned command area of 80 ha. Distribution of the irrigation water is by sub-surface piped system serving 20 spouts, each controlled by a CI valve. The pumps are installed in a masonry pump house provided with a drainage outlet and an exhaust pipe for the smoke. Diesel storage facility is provided in the pump house. The intake is directly from the adjoining water course with a foot valve using flexible pipe. RLI at Naljuapara, constructed in 1989 has its pumping system located on a pontoon directly on the stream (Panga) with flexible pipe connected to the delivery system on the bank.

In the command areas of RLIs and DTW, crops that depend on rain and supplementary irrigation - such as Amon, HYV kharif paddy and jute are comparatively more common with lesser role being played by vegetables, wheat and other crops.

(f) 4 ha Units

For every DTW and RLI scheme, to facilitate distribution of water after the spouts, 10 nos. of 4 ha units were to be constructed. These consist of about 150 m long masonry channels distributing water within 4 ha command area of each outlet. Water from these channels are subsequently led through earthen distributory channels to the fields for irrigation.

(g) Soil Conservation

Soil conservation programme of NBTDP uses various methods to reclaim land and/or improve its quality. More than 5600 ha of land have been treated under this programme so far. The techniques involved and the number of schemes are given in Table - 3.3.

Table 3.3
Soil Conservation Works Phase II

Reclamation technique	No.of schemes
Graded bunding	31
Reclamation of sand-laden areas	27
Control of gullies	9
Land levelling	9
Excavation of drainage canals	7
Uprooting of grass/reeds	5
Other measures	8

Graded bunding is the creation of 0.75 to 1.00 m high earthen banks for conservation of rain water and recharge of ground water including provision of safe discharge of excess water. Reclamation of sand-laden areas involve restoration of areas which have been affected by floods bringing in large amounts of sand, which cover parts of the land with a sand layer of varying thickness, making the land unproductive. Under this reclamation programme, the top layer of sand upto 150 mm is removed and used for bunding. Soil improvement is effected by retention of water through bunding, by improving drainage and by improving the binding quality and fertility of soil with culture of leguminous crops and mulching. Control of gullies is done by constructing cross bunds (generally a masonry structure) at suitable points with overflow arrangements so as to check the speed of flowing water in the gullies which gradually lead to stoppage of further gully formation upstream and siltation of the gullies with the added benefit of raising the root moisture zone. Land levelling comprise flattening of the land and grading these in terraces as required, so that soil erosion is reduced retaining valuable top soil for cultivation. Excavation of drainage canals are meant to improve the drainage flow resulting in removal of water-logging upstream and availability of irrigation water in the downstream areas. This combined with bunding improve water availability near the root zones. Uprooting of grass/reeds is undertaken to clean the possible agricultural fields of unwanted growths to be followed up by agriculture. Besides, other measures are also taken as appropriate for soil conservation. In most cases more than one technique is jointly used for effective result.

3.5.2 Environmental issues

In the background given above potential environmental issues in the project area are divided into 3 separate though inter related items :

i) Project independent

ii) Related to irrigation in general

iii) Specific to NBTDP

(i) *Project independent*

Even without any irrigation project the following environmental issues will continue to plague the project area

- Sedimentation of rivers
- Flooding, drainage problems and waterlogging
- Degradation of forest cover
- Ground water fluctuations
- Changes in soil textures and structures
- Changes in chemical properties of soil
- Soil erosion
- Changes in biodiversity
- Problems of health and sanitation
- Problems of land use and cropping pattern
- Water-logging

(ii) *Related to irrigation in general*

- Poor design of structures and inadequate water management leading to inequitable water distribution, high seepage losses and erosion and siltation of canals.
- Poor quality of irrigated water resulting in reduction of crop growth, deterioration of soil fertility, adverse changes in structure and texture, salinization, inadequate assessment of sustainable extraction of ground water in case of deepwell irrigation.
- Water logging and raising up of ground water tables due to inadequate drainage system.
- Water logging in the fields leading to vector breeding and health problems.
- Non judicious use of fertilizer and pesticides resulting in degradation of water and eutrophication. Damage to biodiversity.
- Unplanned rotation of crops leading to damage in the crop ecosystem.
- Inadequate extension support in procurement and use of farm chemicals and marketing of crops.

(iii) *Specific to NBTDP*

Environment issues specific to NBTDP projects are few. These issues are also common with other similar minor irrigation projects operating in the area e.g.

- Inadequate study of soil structure and groundwater aquifers leading to poor location of strainers.
- Inadequate design of platforms around structures and absence of proper drainage systems resulting in water logging, vector breeding and percolation of polluted surface water into the water bearing strata.
- Selection of improper type of hand tubewell heads leading to human drudgery.
- Inadequate drainage system for the pump houses
- Improper outlet systems for DTW's.
- Poor operation and maintenance leading to wastage of water and creation of water pools for vector breeding.
- Lack of extension work for fertilizer and pesticide use as also for sowing of seeds and marketing.
- Lack of training to users in sanitation and personal hygiene.
- Erratic power supply in case of DTWs.
- Improper design of distribution system for DTWs
- Absence of a total land development concept in the soil conservation schemes.

4.0 Collection of Primary Data

4.1 Introduction

The document on Outline for Environmental Impact Assessment (*1) mentioned the lack of adequate specific secondary data on many of the items listed in the document. It was also understood that within the short span of time available for the EIA Study it was not possible to go for comprehensive primary data collection. The document, however, identified the following areas where collection of primary data either through field samples and their testing or through questionnaire survey were essential :

i) Quality of water for agriculture use.

ii) Quality of ground water for drinking purpose.

iii) Presence of pesticides in surface water.

iv) Mineral Enrichment in surface water.

v) Physical and chemical studies of soils in problem areas.

Besides, it also suggested interview of 50 beneficiary farmers to assess their experience on problems of soil acidity and changes in fertilizer requirement in the post-irrigation era including 46 farmers, who, after Phase-I & Phase-II interventions are doing triple cropping.

4.2 Actual Sample Sizes

The following limited samples were collected for the above purpose:

- 6 samples from HTW for item (i) and 4 samples from HTW for item (ii)
- 3 samples from PDW for item (i) and 2 samples from PDW for item (ii)
- 6 samples from STW/DTW for item (i)
- 3 samples from surface water/drainage water for item (i)
- 6 soil samples collected in consultation with the Department of Agriculture, GoWB, for item (v)
- 10 samples of surface water from stagnant water bodies for item (iv)
- 3 samples of tail end drainage water from tea estates for item (iii)
- 3 samples of drainage water from agricultural fields for item (iii)
- 6 samples of water from HTW for testing the presence of Arsenic
- 59 randomly selected water samples from PDW, HTW, STW, DTW and RLI for Bacteriological testing
- Interview of 91 contact farmers including 10 farmers who are doing triple cropping.

Clearly such sampling would not be significantly representative of the project horizon but were really meant to find whether they would corroborate with the data available from secondary sources.

4.3 Sampling Frame

To make the sample statistically representative of the situation as far as possible, consultants have stratified the sampling base in the three existing riverine regions in the project area oriented in a north-south fashion namely :

- between Mahananda and Teesta
- between Teesta and Jaldhaka
- between Jaldhaka and Raidak.

For the first three group of samples (6 in each frame), one sample each was collected from the higher grounds (north) and lower grounds (south) of these three regions to make a total of 6 for the specific item. In selecting a particular structure for sampling, the density of structure in the particular region was taken as a parameter for selection. However, in case of selection of soil samples, the problem areas were marked spatially in consultation with the Department of Agriculture, and subsequently at the site local representatives were consulted to identify the specific problem area for sampling. For selection of farmers the block was taken as the basic unit against which the numbers of different structures present were listed.

In the next stage, sample villages containing a group of structures were identified and a sample structure was taken from each of the villages as unit for the representative structure for the block. The sampling densities were taken in proportion to the density of structures in the village. In the process, it was found that the total number of samples of farmers came to 91 in place of the stipulated 50.

In case of collection of water samples, for bacteriological pollution, the same selection of sampling base was adopted. But since DTWs and RLIs are least affected by bacteriological pollution the number of samples for each of these sources was reduced with more emphasis given on HTWs & PDWs and to a lesser extent on STWs which are more in use for drinking purposes. The total number of bacteriological samples thus came to 59.

A list of samples is given under Annex. 4.3.0 with locations shown in Fig. 4.3.

4.4 Collection and analysis of samples

All the samples were collected in terms of the procedural guide-lines of the respective Indian/International (e.g. FAO, WHO) standards. Testing was also done for the parameters specified by these standards for such tests. Only renowned and well recognised Laboratories were used for the tests. Results are given in Chapter 5.0.

4.5 Interview of farmers

For interviewing the farmers, a detailed questionnaire was designed (Annex. 4.3) including introductory items on ethnicity, education, house types, drinking water and sanitation facilities followed up by questions on sources of income and health statistics. Discursive questions on land holding, source of irrigation, types of crops raised and use of manure, fertilizer and pesticides were included next to lead finally to questions on soil conditions, increase in needs of inputs and an overall assessment of the respondent on the effect of project intervention. A 'two way communication' approach was followed in the interview with the aim of establishing rapport with the candidate to obtain his perception of the benefits from the project in addition to quantitative responses.

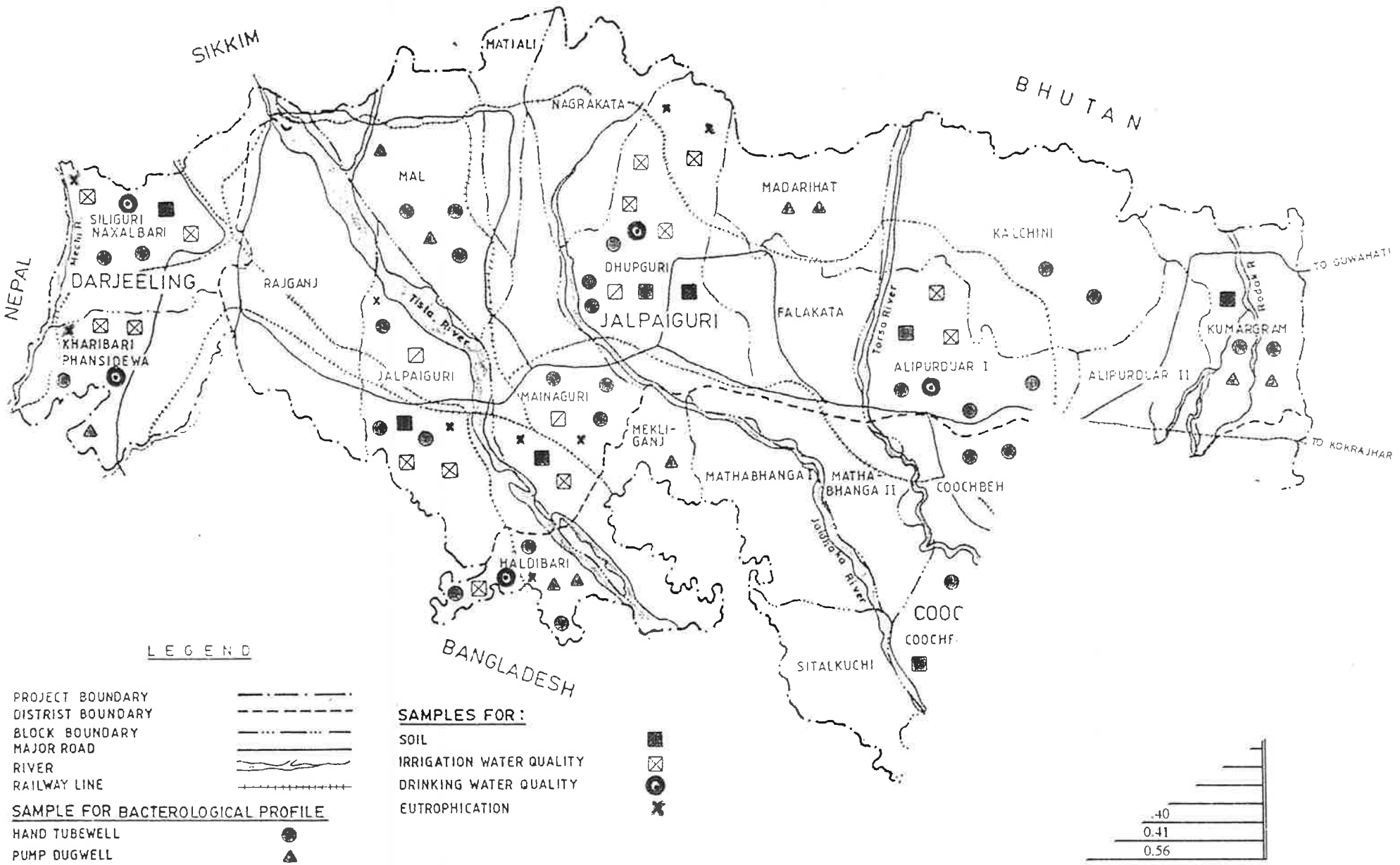


Table 5.2(b) (Contd.)

5.0 FINDINGS FROM PRIMAF DATA AND FIELD STUD'

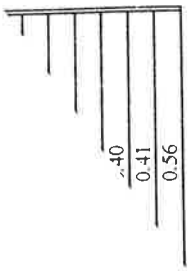


Table 5.2(b) (Contd.)

5.1 Introduction

A major thrust of the EI/
analysis thereof to estir
project area environr
described in the seconda
have been collected to gauge
secondary data and the test results of
various issues are discussed more or less in seria
Reference of the EIA study (*1). The attempt is to pr
based on which environmental impacts, as relevant, will be a
chapters. Since there are certain specific issues related to the pr
which were observed during the field trips and whose solutions are
technological and extension oriented, these have been separately dealt with in cha
6.0.

5.2 Ground Water

Quantity of ground water available in the project area is estimated as below :

(a) Ground Water Regime

CGWB and SWID collected data on location of ground water table in the project area. While the data from the CGWB were limited to a few points, the same for SWID were extensive but related only to the existing ground levels at the site and not to permanent reduced levels (RL). Based on these data a set of maps have been prepared to show the regional disposition of the ground water table within the project area for the pre-monsoon and post-monsoon periods for the years 1989 and 1994. These data have been further analysed to calculate fluctuations in ground water table during these periods. Water table maps both for pre and post monsoon ground water levels and their fluctuations are given in Fig. 5.2 (a), (b), (c), (d), (e) and (f). All these maps clearly show the impact of a transverse fault, known as Neora-Murti Fault. These also show that in the upthrown units of this east-west fault, ground water levels are found at greater depths than the surrounding areas.

The data also suggest the following :

(i) The regional patterns of ground water regime are not similar between the years.

(ii) Fluctuations in ground water table between the pre and post monsoon periods are higher in the west than in the east as also higher in the north than in the south.

(iii) The aquifer tapped for the data is decidedly unconfined in nature implying that water flows horizontally to lower grounds.

b) Ground Water Estimation

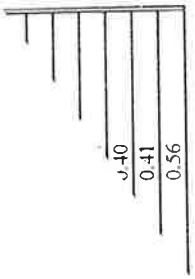


Table 5.2(b) (Contd.)

Estimation of ground water
discharge components from t'
the aquifer the TOR (*1
disadvantages have also b
Committee Report (A
recommended estimat'
Rainfall Aquifer, whicl
water budget. In doing tl
taken as gross recharge, out of whic

According to the CGWB findings, the area close to
main intake of ground water regime for the project area. The
Terai Region tapped by deep tubewells are recharged by downwar
lateral flow of rain water from this region. The ground water body is also susta
recharged by direct infiltration from precipitation and infiltration from the turbulen
stream flow across the belt. Other sources of recharge are seepage from existing canals
and rivers and the return flow of irrigation water. The shallower aquifers are ordinarily
recharged from these sources in addition to rain water percolation.

The major sources of ground water discharge in the project are evaporation and transpiration by phreatophytes and by the overflow of the springs. The present utilisation of ground water in the district is mainly for agricultural use and for use in the tea gardens. A very small percentage is used for domestic purpose. The ground water budget as done by CGWB is given in Table 5.2(b).

From the table, it is clear that the whole of the Terai Region is under developed as far as the ground water extraction is concerned with the average being 6.3% against the limits of 'white area', i.e. permissible range of extraction at 60%. So there is enough scope for further ground water extraction. However, this should be done in a planned manner to prevent localised overdrawals (viz. Cooch Behar II and Dinhata I). In absence of specific studies, changes in the rate of aquifer recharge over the years, if any, in the project area cannot be confirmed but, in view of the forest cover reduction in the foothills, a decrease in the rate of recharge of the aquifer is likely, since the level of percolation is reduced. Available studies and reports did not deal with the role of the Himalayan Mountain Belt north of the project area including Bhutan, in the re-charge of aquifers in the project area. The hydrolithological information point to these areas being the source of still deeper aquifers in the project area and beyond. It is understood that forests are being depleted at an alarming rate in these hilly regions. Though there is no established relation, so far, between the ground water availability at the project area and the recharge from these regions, such depletion naturally are cause for concern also because of increased sediment loads downstream, specially in the Teesta which originates in this region (Ref. Table-2.4.6).

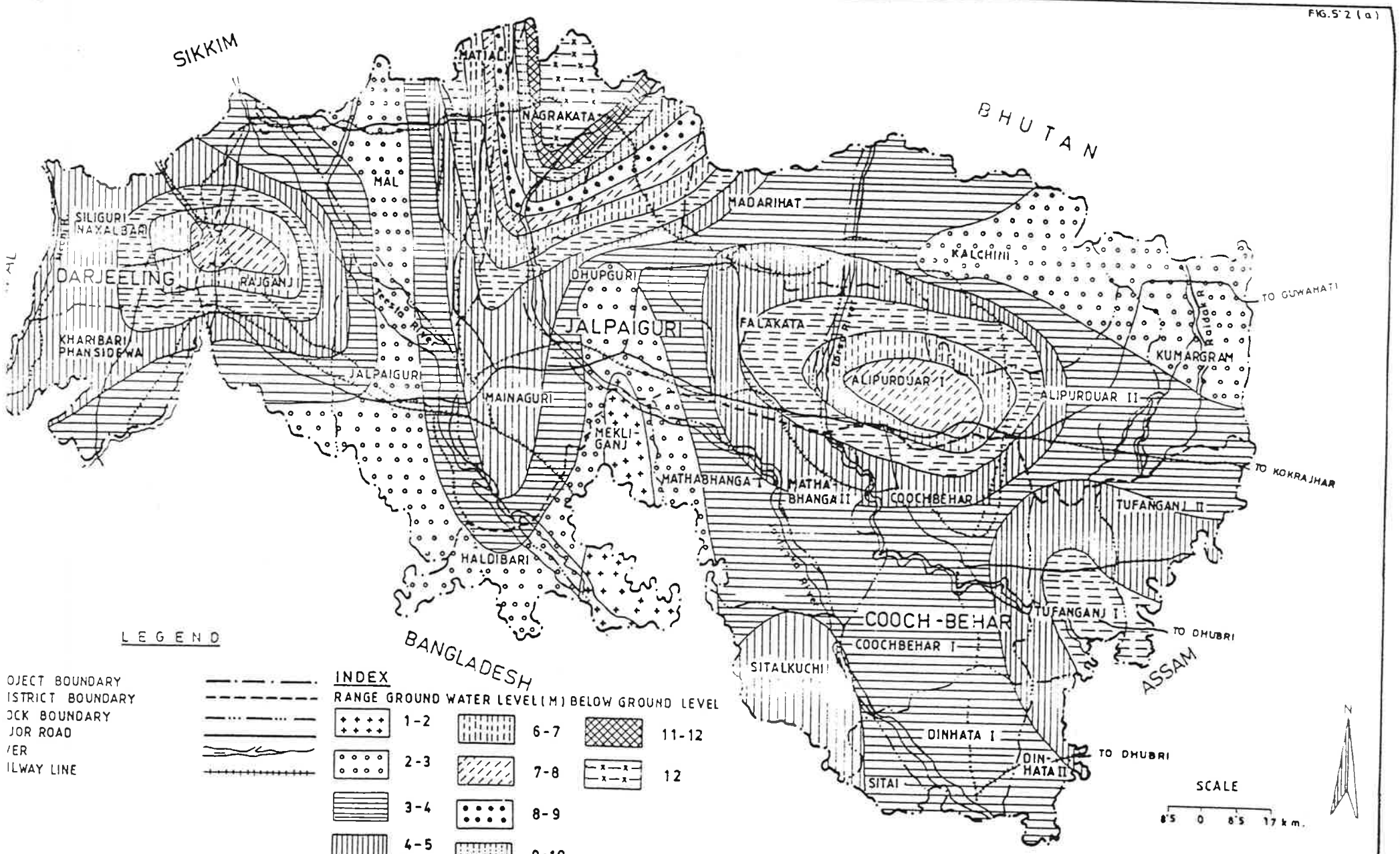
Table 5.2(b)
Ground Water Budgeting And Development Potential

District	Block	Area (Sq.Km.)	Ground Water Potential (MCM)	Net Ground Water Net Potential (MCM) 70% of Col. (4)	Draft (MCM)	Net G.W. Available for future Develop-ment (MCM)	% of Develop-ment	Type of G.W. Development	Net G.W. Available for future Develop-ment per unit area (MCM/ (Sq. Km)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Cooch Behar	Cooch Behar II	371.32	173.12	121.18	21.89	99.29	18.06	White Area	0.27
	Cooch Behar II	372.36	175.20	122.64	38.33	84.31	31.25	White Area	0.23
	Tufanganj	585.70	362.67	253.87	41.91	211.96	16.51	White Area	0.36
	Dinhata I	287.38	244.67	171.27	41.33	129.94	24.13	White Area	0.45
	Dinhata II	267.55	224.56	157.19	11.90	145.29	7.57	White Area	0.54
	Sitai	156.68	128.45	89.92	13.75	76.17	15.29	White Area	0.49
	Mathabhanga I	322.38	166.76	116.73	15.50	101.23	13.28	White Area	0.31
	Mathabhanga II	313.96	162.62	113.83	16.91	96.92	14.85	White Area	0.31
	Sitalkuchi	261.70	190.64	133.45	5.16	128.29	3.87	White Area	0.49
	Mekhliganj	291.89	136.40	95.48	3.31	92.17	3.47	White Area	0.32
	Haldibari	200.70	102.72	71.90	6.60	65.30	9.18	White Area	0.33
	Total	3431.62	2067.81	1447.47	216.5 9	1230.88	14.96	White Area	0.36
Jalpaiguri	Jalpaiguri	502.97	387.35	271.15	16.41	254.74	6.05	White Area	0.51
	Rajgang	636.62	545.95	382.17	6.32	375.85	1.65	White Area	0.59
	Maynaguri	643.92	601.34	420.94	14.16	406.78	3.36	White Area	0.63
	Mal	561.71	502.60	351.82	10.69	341.13	3.04	White Area	0.61
	Matiali	309.12	233.70	163.59	8.02	155.57	4.90	White Area	0.50
	Nagrakata	202.34	205.60	143.92	1.66	142.26	1.15	White Area	0.70
	Dhupguri	178.34	249.57	174.70	2.78	171.92	1.59	White Area	0.96
	Falakata	317.59	181.30	126.91	17.19	109.72	13.55	White Area	0.35
	Madarihat	417.36	457.38	320.17	3.97	316.20	1.24	White Area	0.76
	Kalchini	890.95	768.24	537.77	3.67	534.10	0.68	White Area	0.60
	Alipurduar-I	363.28	198.95	139.27	9.13	130.14	6.56	White Area	0.36
	Alipurduar-II	335.75	201.40	140.98	7.01	133.97	4.97	White Area	0.40
	Kumargram	504.01	304.67	213.27	5.10	208.17	2.39	White Area	0.41
	Total	5863.96	4838.05	3386.64	106.1 1	3280.53	3.13	White Area	0.56

Table 5.2(b) (Contd.)

District	Block	Area (Sq.Km.)	Ground Water Potential (MCM)	Net Ground Water Net Potential (MCM) 70% of Col. (4)	Draft (MCM)	Net G.W. Available for future Develop-ment (MCM)	% of Develop-ment	Type of G.W. Development	Net G.W. Available for future Develop-ment per unit area (MCM/ (Sq. Km)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Darjeeling	Kharibari-Phansidewa	55.90	391.04	273.73	10.98	262.75	4.01	White Area	0.58
	Siliguri-Naxalbari	381.50	303.92	212.74	5.64	207.10	2.65	White Area	0.54
Project Area	Grand Total	10132.98	7600.82	5320.57	339.32	4981.25	6.38	White Area	0.49

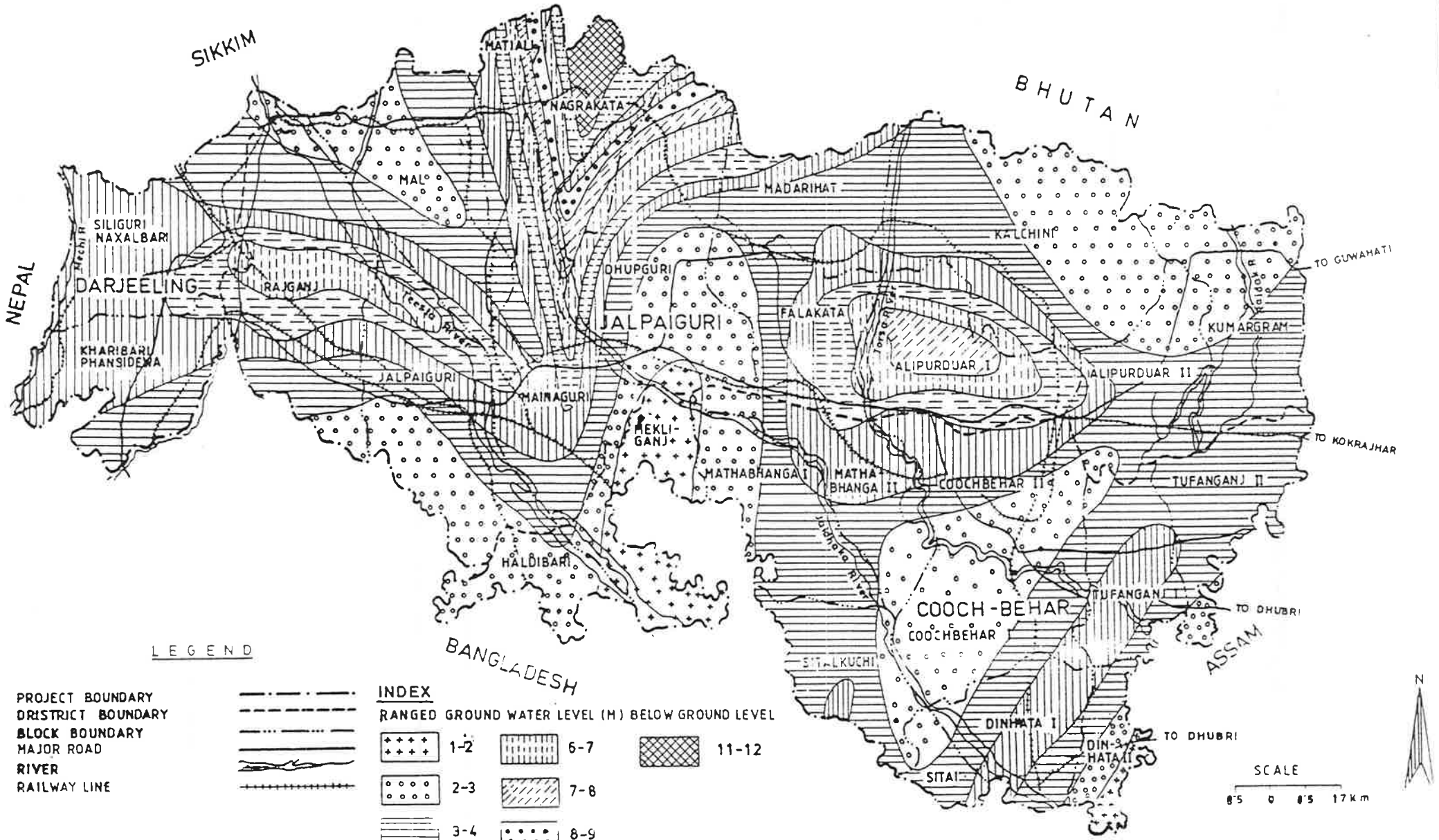
FIG. 5.2 (a)



SOURCE: GROUND WATER LEVEL DATA FROM CGWB/SWID NETWORK HYDROGRAPH STATION

MAP OF GROUND WATER TABLE
(IN M)
PRE MONSOON (MAY 1989)

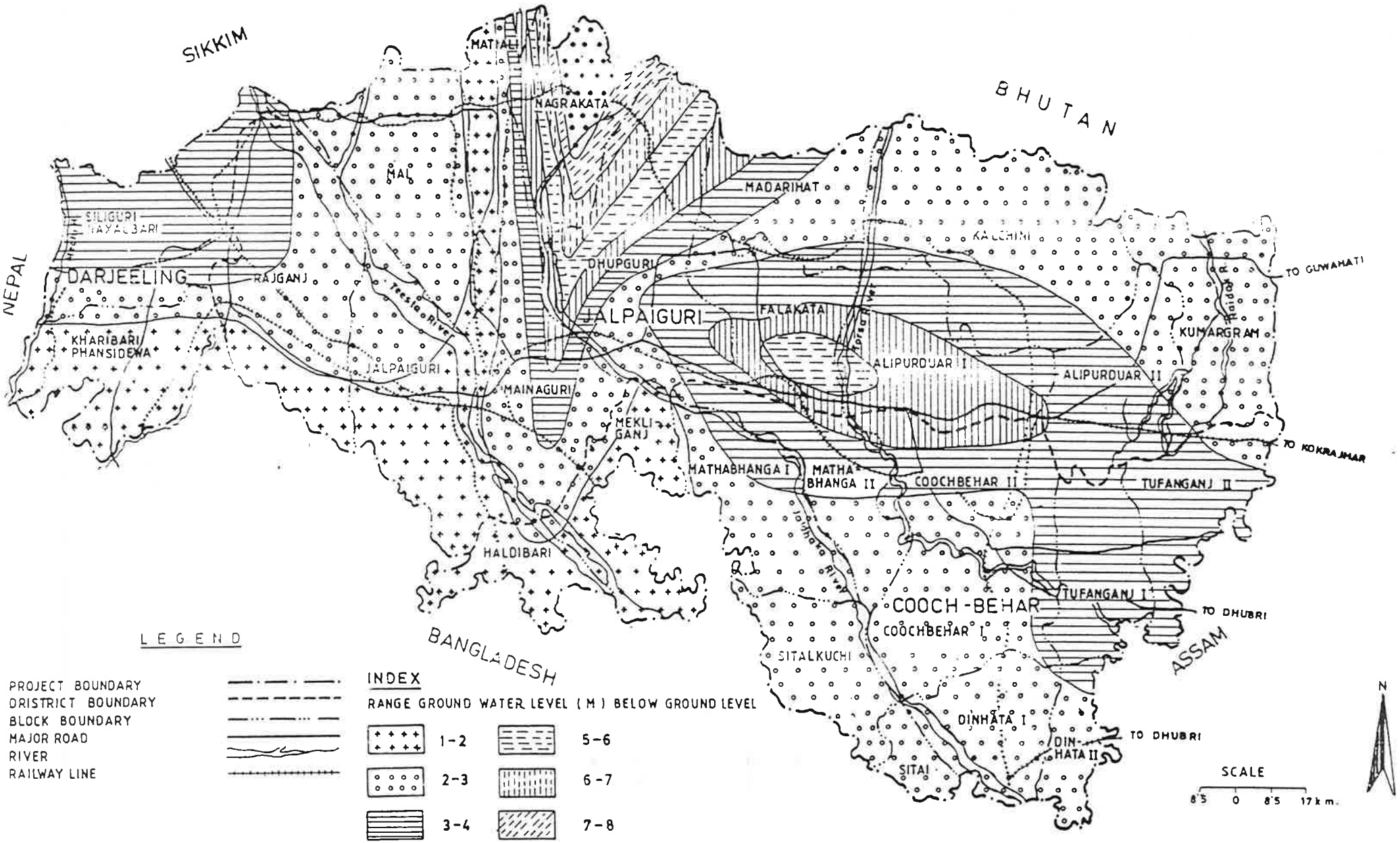
FIG. 5·2 (b)



SOURCE: GROUND WATER LEVEL DATA FROM CGWB/SWID NETWORK HYDROGRAPH STATION

MAP OF GROUND WATER TABLE
(IN M)
PRE MONSOON (MAY 1994)

FIG. 5·2 (c)



LEGEND

PROJECT BOUNDARY
DRISTRICT BOUNDARY
BLOCK BOUNDARY
MAJOR ROAD
RIVER
RAILWAY LINE

INDEX

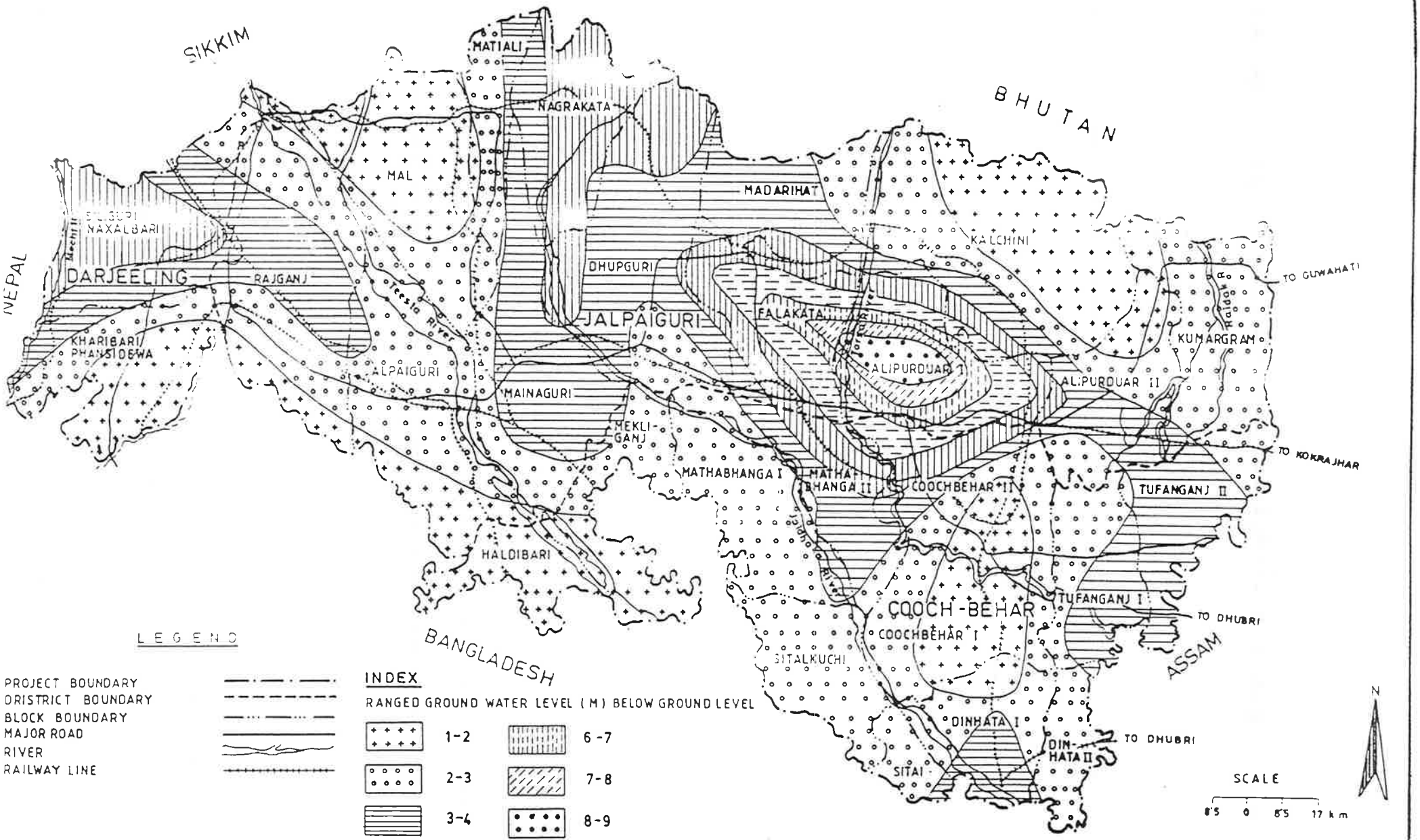
RANGE GROUND WATER LEVEL (M) BELOW GROUND LEVEL

1-2		5-6	
2-3		6-7	
3-4		7-8	
4-5		8-9	

SOURCE: GROUND WATER LEVEL DATA FROM CGWB/SWID NETWORK HYDROGRAPH STATION

MAP OF GROUND WATER TABLE
(IN M)
POST MONSOON (DECEMBER 1989)

FIG. 5.2 (d)



LEGEND

PROJECT BOUNDARY
DRISTRICT BOUNDARY
BLOCK BOUNDARY
MAJOR ROAD
RIVER
RAILWAY LINE

INDEX

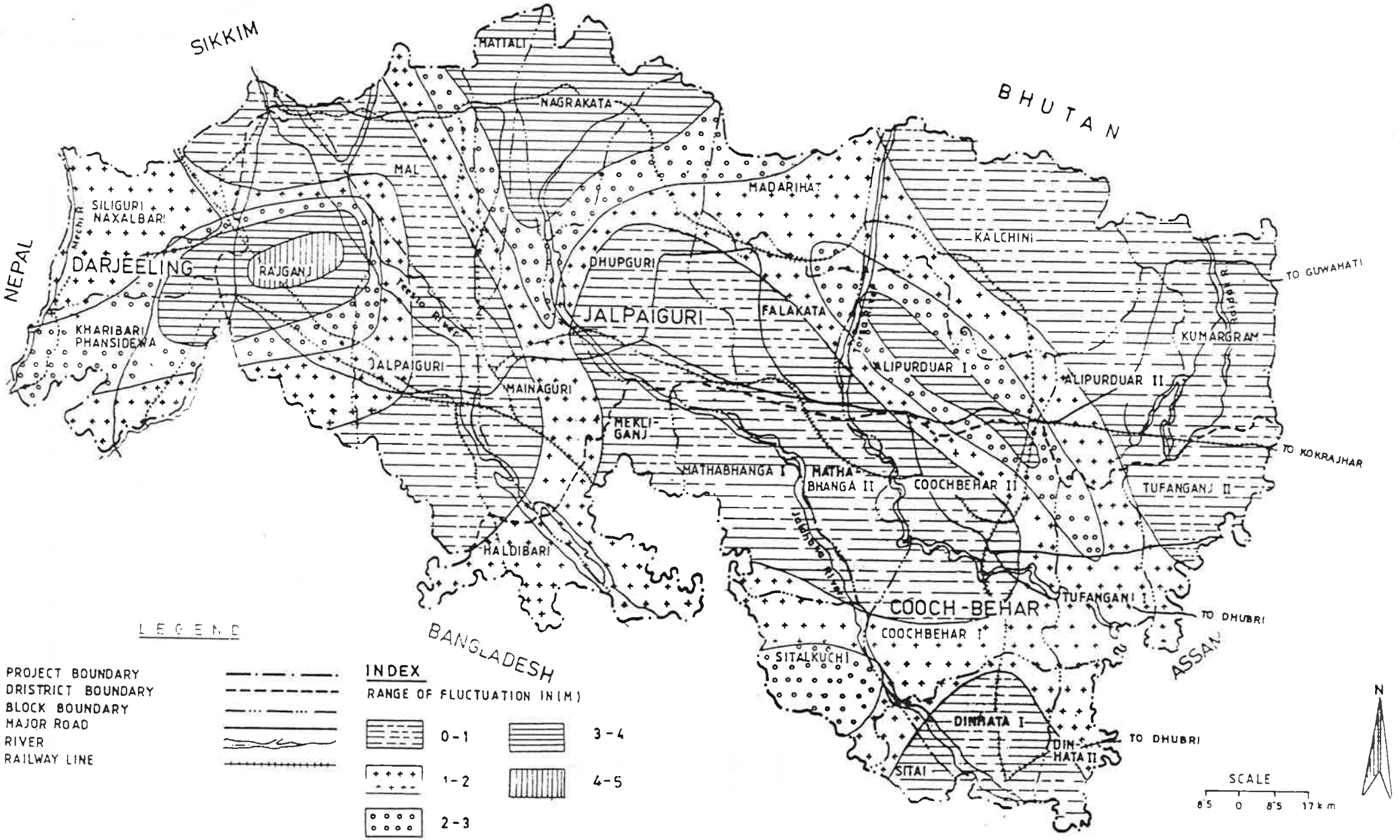
RANGED GROUND WATER LEVEL (M) BELOW GROUND LEVEL

1-2		6-7	
2-3		7-8	
3-4		8-9	
4-5			
5-6			

SOURCE: GROUND WATER LEVEL DATA FROM CGWB/SWID NETWORK HYDROGRAPH STATION

MAP OF GROUND WATER TABLE
(IN M)
POST MONSOON (DECEMBER 1994)

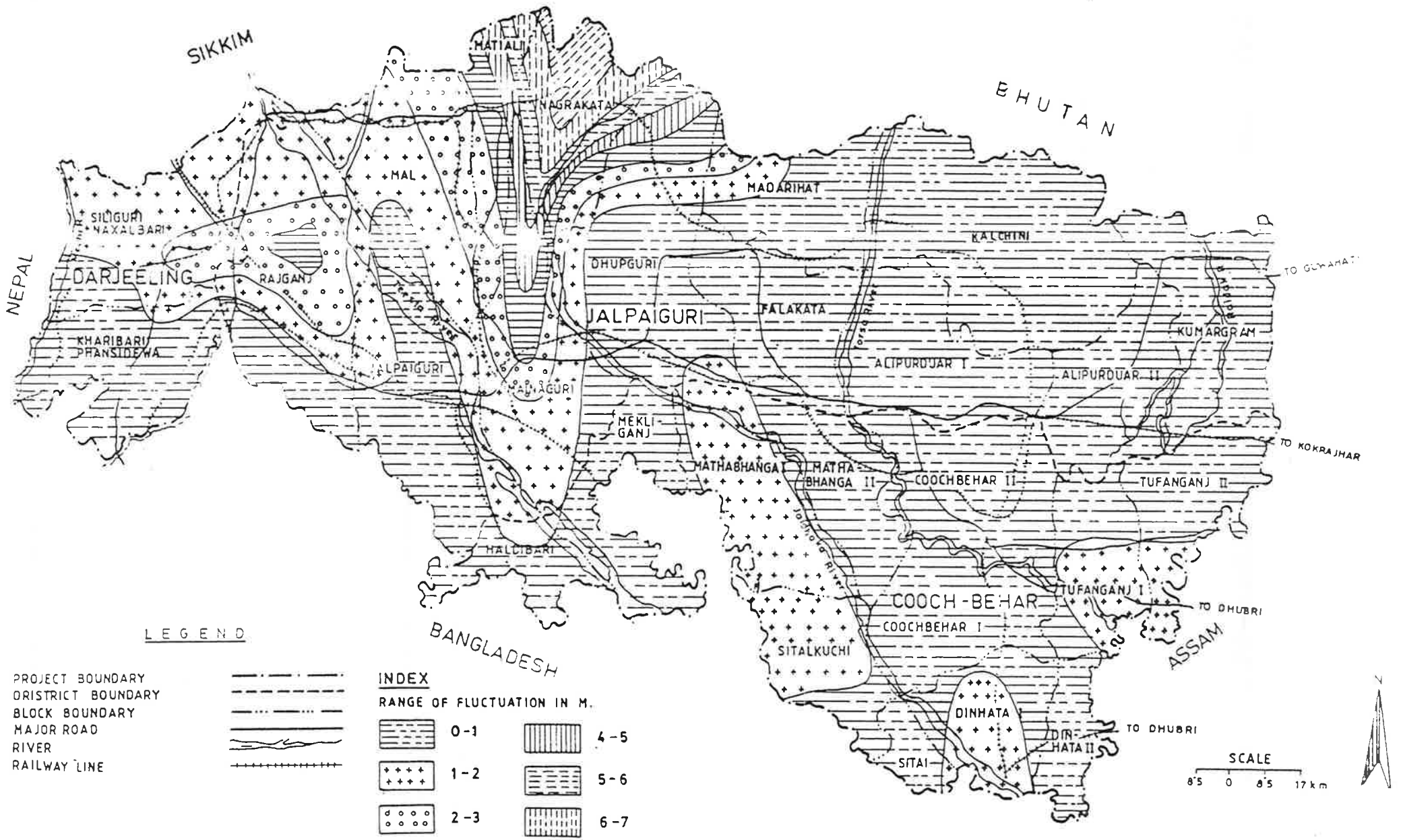
FIG. 5·2 (e)



SOURCE: GROUND WATER LEVEL DATA FROM CGWB/SWID NETWORK HYDROGRAPH STATION)

MAP OF GROUND WATER TABLE FLUCTUATION (IN M)
DIFFERENCE BETWEEN PRE MONSOON (MAY 1989)
AND POST MONSOON (DECEMBER 1989)

FIG. 5.2 (f)



LEGEND

PROJECT BOUNDARY
DISTRICT BOUNDARY
BLOCK BOUNDARY
MAJOR ROAD
RIVER
RAILWAY LINE

INDEX

RANGE OF FLUCTUATION IN M.

0-1		4-5	
1-2		5-6	
2-3		6-7	
3-4		7-8	

SOURCE : GROUND WATER LEVEL DATA FROM CGWB/SWID NETWORK HYDROGRAPH STATION)

MAP OF GROUND WATER TABLE FLUCTUATION (IN M) DIFFERENCE BETWEEN PRE MONSOON (MAY 1994) AND POST MONSOON (DECEMBER 1994)

5.3 Quality of water

In the following paragraphs water quality in the project area is examined - both ground and surface - for their suitability for agricultural and domestic use. Data from secondary and primary agencies are all discussed.

5.3(a) Quality of Ground Water for Agriculture use

In order to find out the quality of water for agricultural use, two sets of studies were carried out.

i) Study and analysis of the data available from SWID for the years 1986, 1989, 1991 and 1993 for all the three districts of the project area, except for 1991 when no data of Jalpaiguri District were available, are presented in 11 Nos. of tables [5.3(a)ii.]

ii) Study and analysis of data generated from primary sources for which 18 water samples (both ground and surface water) were collected within the project area for the season April - May 1995. These data are presented in Table 5.3(a)iii. All these data available from primary and secondary sources were analysed on the basis of IS 11624 : 1986 [presented in Table 5.3(a)i].

Table 5.3(a)i
Classification of Irrigation Water
(based on I.S. 11624 - 1986)

Water Quality Rating Based on the Salt Concentration	
Class	**Range of E.C. (Micromhos/cm)**
Low	Below 1500
Medium	1500 - 3000
High	3000 - 6000
Very high	Above 6000

Water Quality Rating Based on Sodium Absorption Ratio	
Class	**SAR Range (Millimoles/lt)**
Low	Below 10
Medium	10 - 18
High	18 - 26
Very high	Above 26

Water Quality Rating Based on Residual Sodium Carbonate	
Class	**RSC Range (Me/L)**
Low	Below 1.5
Medium	1.5 - 3.0
High	3.0 - 6.0
Very high	Above 6.0

From analysis of the data from SWID [Table 5.3(a)ii] it, may be inferred that the water is free from sodium and salinity hazards. In most of samples, the range of Residual Sodium Carbonate (RSC) value is low. Only one sample in Cooch Behar II in 1993 show high values of RSC, though RSC for this location in 1986 was low. No data is available for this site for 1989 and 1991.

QUALITY OF WATER

District : DARJEELING Year : 1986

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR	RSC	PI in %	TDS in ppm	Quality for Irrigation Water * SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1		Sathvaia	P. Tube	May '86	6.0	110	Nil	50	20	40	-	10	4	2	Nil	8	0.71	0.06	112.33	70	LOW	LOW	LOW
2		Sathyain, Giri Zoth	P. Tube	May '86	7.0	110	Nil	50	10	40	-	10	4	1	0.5	9	0.69	0.03	109.27	70	LOW	LOW	LOW

= : Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1986]

Table No. : 5.3(a) II QUALITY OF WATER District : JALPAIGURI Year : 1986

Sl No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR	RSC	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(18)	(23)	(24)
1	Mainaguri	Mainaguri B.D.O	P.Tube	May'86	6.5	254	Nil	120	10	100	Nil	16	5	3	5 #	22	0.70	0.00	78.93	164	LOW	LOW	LOW
2	Mathabhanga	Mathabhanga H.C.	P.Tube	May'86	7.0	172	Nil	60	10	60	Nil	15	10	3	4 #	13	0.84	0.00	87.81	110	LOW	LOW	LOW
3	Mathabhanga	Mathabhanga Block	Dugwell	May'86	7.5	134	Nil	50	20	30	Nil	2	1*	2	0.5	6	0.16	0.23	145.88	86	LOW	LOW	LOW
4		Holong Forest Bunglow	Dugwell	May'86	7.5	530	Nil	20	10	240	12	1*	2*	8	Nil	58	0.46	0.00	22.17	338	LOW	LOW	LOW
5		Holong Forest Office	Dugwell	May'86	7.5	100	Nil	10	20	70	Nil	3	5	5	Nil	14	0.16	0.00	34.96	64	LOW	LOW	LOW
6		Jaldapara Range Office	Dugwell	May'86	7.5	164	Nil	20	10	50	Nil	6	24	4	Nil	10	0.3*	0.00	64.99	106	LOW	LOW	LOW
7		Jaldapara Range Office	S.T.W	May'86	6.5	270	Nil	10	10	120	Nil	2	23	4	2 #	26	0.08	0.00	20.25	174	LOW	LOW	LOW
8		Falakata H.C.	Dugwell	May'86	7.5	202	Nil	10	10	120	Nil	2	5	5	Nil	26	0.08	0.00	19.85	128	LOW	LOW	LOW
9		Kalabari T.E.	Dugwell	May'86	8.0	298	Nil	10	10	150	Nil	3	6	5	Nil	33	0.11	0.00	17.28	190	LOW	LOW	LOW
10		Kalabari T.E.	S.T.W	May'86	7.5	344	Nil	10	10	190	Nil	2	6	6	Nil	44	0.06	0.00	12.26	220	LOW	LOW	LOW
11		Jalpaiguri-Pandapara	P.Tube	May'86	7.5	320	Nil	100	30	160	Nil	21	9	4	Nil	36	0.73	0.00	53.76	206	LOW	LOW	LOW
12		Gharadara-Berubari	P.Tube	May'86	6.9	130	Nil	30	20	30	Nil	19	6	2	Nil	6	1.52	0.00	107.61	84	LOW	LOW	LOW
13		Talma Colony	P.Tube	May'86	6.8	250	Nil	30	60	30	Nil	43	5	2	Nil	6	3.43	0.00	104.39	160	LOW	LOW	LOW
14		Magabari-Falapukur	P.Tube	May'86	7.0	140	Nil	30	20	60	Nil	10	4	1	0.2	14	0.56	0.00	69.31	90	LOW	LOW	LOW
15		Congpara-I	P.Tube	May'86	6.5	270	Nil	60	40	30	Nil	25	20	3	Nil	5	2.05	0.42	126.22	174	LOW	LOW	LOW
16		Ulabari-Mainaguri	P.Tube	May'86	6.5	480	Nil	90	30	60	Nil	2*	49	1	Nil	14	1.51	0.2*	100.44	308	LOW	LOW	LOW
17		Ramsai-Maina	P.Tube	May'86	6.2	80	Nil	30	10	20	Nil	3	3	1	1 #	4	0.30	0.11	163.22	54	LOW	LOW	LOW
18		Rangdhamali	P.Tube	May'86	7.0	660	Nil	110	60	130	Nil	41	5*	5	Nil	32	1.48	0.00	66.95	422	LOW	LOW	LOW
19		Congpara-II	P.Tube	May'86	6.5	320	Nil	60	30	60	Nil	32	2*	3	Nil	13	1.78	0.00	91.26	206	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1986]

Table No. : 5.3(a) II QUALITY OF WATER District : COOCHBEHAR Year : 1986

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water *		
																				SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	Coochbehar-I	Dhuliabari	Dugwell	May'86	8.5	672	40	270	20	320 #	6	8	*	8	0.5	72	0.20	0.00	36.69	432	LOW	LOW	LOW
2	Coochbehar-II	Pundibari Agri. College	Dugwell	May'86	7.5	270	Nil	120	10	140	Nil	2	8	*	0.5	29	0.07	0.00	52.75	174	LOW	LOW	LOW
3	Alipurduar	Alipurduar H.C.	Dugwell	May'86	8.5	440	60	110	20	210	275 #	5	*	*	1 #	46	0.15	0.00	35.81	284	LOW	LOW	LOW
4	Madarihat	Madarihat Forest Office	Dugwell	May'86	7.0	356	Nil	160	20	180	17	6	6	*	Nil	30	0.22	0.00	61.05	228	LOW	LOW	LOW
5	Madarihat	Madarihat Range Office	Dugwell	May'86	7.0	440	Nil	200	10	250	Nil	3	*	*	Nil	56	0.08	0.00	38.10	284	LOW	LOW	LOW

\# : Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1986]

Table No. : 5.3(a) ii

QUALITY OF WATER

District : DARJEELING

Year : 1989

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR	RSC	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1		Kesodobe	Dugwell	02.03.88	8.0	200	Nil	30	20	30	-	26	32	3	Nil	5	2.14	0.00	108.37	128	LOW	LOW	LOW
2		Bagdogra	Dugwell	02.03.88	7.9	94	Nil	20	10	30	-	10	4	1	Nil	-	0.78	0.00	94.91	60	LOW	LOW	LOW
3		Nimai	Dugwell	02.03.88	8.1	74	Nil	50	10	20	-	9	4	1	Nil	4	0.90	0.44	168.30	46	LOW	LOW	LOW
4		Md. Basaka Jote	Dugwell	02.03.88	7.7	194	Nil	100	20	40	-	30	2	1	Nil	9	2.07	0.85	123.31	124	LOW	LOW	LOW
5		Suknabazar	HTW	02.03.88	7.9	94	Nil	20	10	30	-	12	6	1	Nil	-	0.93	0.00	95.29	60	LOW	LOW	LOW
6		Alal	HTW	02.03.88	7.4	308	Nil	100	30	70	-	42	32	2	Nil	16	2.17	0.22	95.75	196	LOW	LOW	LOW
7		Gopal Goseva Kendra	HTW	02.03.88	7.7	114	Nil	60	20	40	-	9	21	1	Nil	9	0.62	0.19	116.91	74	LOW	LOW	LOW
8		Bidhannagar	HTW	02.03.88	7.7	114	Nil	70	10	40	-	23	3	1	0.1	9	1.59	0.36	115.60	74	LOW	LOW	LOW
9		Naxal Bari	Dugwell	02.03.88	8.0	122	Nil	60	10	30	-	25	3	1	Nil	-	1.94	0.36	121.31	78	LOW	LOW	LOW
10		Atharokhai B.D.O.	Dugwell	02.03.88	7.9	102	Nil	50	10	20	-	16	5	2	Nil	4	1.50	0.39	142.45	64	LOW	LOW	LOW
11		Bhajan Ram	HTW	02.03.88	7.3	268	Nil	80	20	40	-	30	5	1	Nil	9	2.07	0.52	116.87	172	LOW	LOW	LOW
12		Ambari	HTW	02.03.88	7.7	126	Nil	70	20	40	-	25	4	1	0.1	9	1.73	0.36	114.88	82	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal . 1989]

Table No. : 5.3(a) ii

QUALITY OF WATER

District : JALPAIGURI Year : 1989

SL No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR	RSC	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(18)	(23)	(24)
1	Mal	Lataguri P.W.D	Dugwell	March 1987	6.5	420	Nil	20	10	50	-	10	5	1	Nil	13.8	0.56	0.00	62.09	269	LOW	LOW	LOW
2	Mitali	Chapramari Forest	Dugwell	March 1987	6.5	100	Nil	30	5	50	-	4	2	1	Nil	11.4	0.25	0.00	75.21	64	LOW	LOW	LOW
3	Moynaguri	Moynaguri B.D.O	Tubewell	March 1987	6.8	320	Nil	80	25	90	-	21	44	1	Nil	21.0	0.97	0.00	76.38	205	LOW	LOW	LOW
4	Dhupguri	Dhupguri Private Dugwell	Dugwell	March 1987	7.5	790	Nil	100	85	150	-	60	114	2	Nil	34.8	2.14	0.00	69.72	506	LOW	LOW	LOW
5	Coochbehar	Pundibari Agri. Col.	Tubewell	March 1987	7.8	470	Nil	200	10	240	-	5	18	2	Nil	56.4	0.14	0.00	40.81	301	LOW	LOW	LOW
6	Alipurduar	Panchkalguri H.C	Tubewell	March 1987	7.6	410	Nil	150	10	180	-	6	13	2	Nil	42.0	0.20	0.00	47.82	262	LOW	LOW	LOW
-	Mathabhanga	Mathabhanga B.S.F	Tubewell	March 1987	7.8	160	Nil	60	10	80	-	3	17	1	Nil	18.6	0.15	0.00	65.47	102	LOW	LOW	LOW
8	Falakata	Falakata H.C	Tubewell	March 1987	7.8	280	Nil	110	10	50	-	3	5	2	Nil	10.8	0.19	0.81	131.57	179	LOW	LOW	LOW
9	Madarihat	Madarihat Seed Farm	Dugwell	March 1987	7.8	400	Nil	160	5	300	-	1	6	2	Nil	70.8	0.03	0.00	27.79	256	LOW	LOW	LOW
10	Jaldapara	Jaldapara Forest Office	Dugwell	March 1987	6.5	250	Nil	70	15	110	-	6	27	1	Nil	24.6	0.26	0.00	56.94	160	LOW	LOW	LOW
11	Nagrakata	-	STW	March 1987	7.0	220	Nil	90	30	70	-	8	20	3	-	15.0	0.42	0.09	90.17	142	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1989]

Table No. : 5.3(a) ii QUALITY OF WATER District : COOCHBEHAR Year : 1989

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1		Chandrabandha H.C.	STW	14.05.87	7.5	320	Nil	80	30	140	-	21	28	8	-	29	0.77	0.00	55.65	206	LOW	LOW	LOW
2		Sitalkuchi B.S.F.	STW	14.05.87	7.0	640	-	70	40	60	-	9	297	4	-	12	0.51	0.00	92.69	410	LOW	LOW	LOW
3		Sitai	STW	14.05.87	11.0	450	40	110	40	50	-	50	72	3	-	10	3.12	2.16	111.77	288	LOW	MEDIUM	LOW
4		Shaliganj Dinhata - II	STW	14.05.87	11.0	1030	30	100	190	70	-	144	209	9	0.5	11	7.62	1.29	99.09	660	LOW	LOW	LOW
5		Dinhata - I	STW	14.05.87	11.0	548	40	110	70	50	-	66	91	4	-	10	4.02	2.12	108.26	352	LOW	MEDIUM	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1989]

Table No. : 5.3(a) ii

QUALITY OF WATER

District : DARJEELING Year : 1991

SL No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water *		
																				SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	Darjeeling	Siliguri	HTW	05.11.89	6.5	157	Nil	40	20	60		16	2	1	2.5 #	13	0.93	0.00	82.84	100	LOW	LOW	LOW
2	Darjeeling	Phansidewa	DW	05.11.89	6.5	86	Nil	60	20	50		6	2	1	Nil	11	0.38	0.03	102.88	55	LOW	LOW	LOW
3	Darjeeling	Kharibari	DW	05.11.89	6.5	417	Nil	90	70	90		42	15	1	Nil	21	1.93	0.00	84.28	269	LOW	LOW	LOW
4	Darjeeling	Naxalbari	HTW	05.11.89	7.0	212	Nil	120	20	80		20	3	1	0.1	18	0.99	0.43	94.52	136	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1991]

Table No. : 5.3(a) ii QUALITY OF WATER District : COOCHBEHAR Year : 1991

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	Dinhata-II		Bed	08.12.89	7.5	259	Nil	150	20	110		9	5	6	Nil	23	0.37	0.27	75.84	166	LOW	LOW	LOW
2	Dinhata-I		HTW	08.12.89	6.5	259	Nil	90	20	90		38	9	5	Nil	18	1.78	0.00	84.74	166	LOW	LOW	LOW
3	Dinhata-I		HTW	08.12.89	6.5	314	Nil	70	20	90		29	12	4	0.3	19	1.34	0.00	77.09	201	LOW	LOW	LOW
4	Dinhata-II		HTW	08.12.89	6.9	322	Nil	170	10	40		12	10	5	0.4	7	0.81	1.96	162.92	206	LOW	MEDIUM	LOW
5	Dinhata-II		Bed	08.12.89	7.0	322	Nil	170	10	130		16	10	7	0.1	27	0.61	0.22	72.39	206	LOW	LOW	LOW
6	Toofanganj-I		HTW	08.12.89	6.5	118	Nil	90	10	40		16	5	5	0.3	7	1.08	0.65	125.78	76	LOW	LOW	LOW
7	Toofanganj-II		HTW	08.12.89	6.5	141	Nil	50	10	80		14	6	3	2.0 #	17	0.69	0.00	70.14	90	LOW	LOW	LOW
8	Mathabhanga-I		HTW	08.12.89	7.0	511	Nil	80	20	220		13	15	13	0.4	45	0.38	0.00	34.79	327	LOW	LOW	LOW
9	Sitalkuchi		HTW	08.12.89	6.9	511	Nil	300	20	160		20	17	7	0.3	34	0.69	1.77	76.82	327	LOW	MEDIUM	LOW
10	Sitai		HTW	08.12.89	6.4	79	Nil	30	10	30		12	30	5	0.1	4	0.97	0.00	111.45	51	LOW	LOW	LOW
11	Coochbehar-I		HTW	08.12.89	6.5	79	Nil	40	10	30		13	9	3	0.1	5	1.07	0.10	122.21	51	LOW	LOW	LOW
12	Haldibari		HTW	08.12.89	6.4	110	Nil	30	10	30		16	6	2	0.1	6	1.28	0.00	108.38	70	LOW	LOW	LOW
13	Mekhliganj		HTW	08.12.89	7.0	330	Nil	190	10	150		10	9	4	0.1	34	0.35	0.11	64.01	211	LOW	LOW	LOW
14			HTW	08.12.89	6.4	275	Nil	?	20	60		28	10	13	0.1	7	1.56	0.00	50.03	176	LOW	LOW	LOW
15			HTW	08.12.89	6.5	79	Nil	40	10	20		9	3	4	-	6	0.67	0.00	110.92	50	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1991]

Table No. :5.3(a) ii **QUALITY OF WATER** **District : DARJEELING** **Year : 1993**

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1		Siliguri	HDTW	-	6.3	140	Nil	50	20	20	NA	10	4	4	0.1	2.0	1.02	0.46	168.30	90	LOW	LOW	LOW
2		Phansidewa	DW	-	6.3	86	Nil	30	10	20	NA	5	3	2	Nil	4.0	0.47	0.06	142.29	54	LOW	LOW	LOW
3		Nexalbari	HDTW	-	7.0	185	Nil	50	20	50	NA	11	2	3	0.2	10.0	0.69	-0.15	95.38	118	LOW	LOW	LOW
4		Kharibari	DW	-	6.4	460	Nil	40	80	110	NA	50	29	1	Nil	25.0	2.12	-1.46	69.62	294	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1993]

Table No. : 5.3(a) ii

QUALITY OF WATER

District : COOCHBEHAR Year : 1991

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	Dinhata-II		Beel	08.12.89	7.5	259	Nil	150	20	110		9	5	6	Nil	23	0.37	0.27	75.84	166	LOW	LOW	LOW
2	Dinhata-I		HTW	08.12.89	6.5	259	Nil	90	20	90		38	9	5	Nil	18	1.78	0.00	84.74	166	LOW	LOW	LOW
3	Dinhata-I		HTW	08.12.89	6.5	314	Nil	70	20	90		29	12	4	0.3	19	1.34	0.00	77.09	201	LOW	LOW	LOW
4	Dinhata-II		HTW	08.12.89	6.9	322	Nil	170	10	40		12	10	5	0.4	7	0.81	1.96	162.92	206	LOW	MEDIUM	LOW
5	Dinhata-II		Beel	08.12.89	7.0	322	Nil	170	10	130		16	10	7	0.1	27	0.61	0.22	72.39	206	LOW	LOW	LOW
6	Toofanganj-I		HTW	08.12.89	6.5	118	Nil	90	10	40		16	5	5	0.3	7	1.08	0.65	125.78	76	LOW	LOW	LOW
7	Toofanganj-II		HTW	08.12.89	6.5	141	Nil	50	10	80		14	6	3	2.0 #	17	0.69	0.00	70.14	90	LOW	LOW	LOW
8	Mathabhanga-I		HTW	08.12.89	7.0	511	Nil	80	20	220		13	15	13	0.4	45	0.38	0.00	34.79	327	LOW	LOW	LOW
9	Sitalkuchi		HTW	08.12.89	6.9	511	Nil	300	20	160		20	17	7	0.3	34	0.69	1.77	76.82	327	LOW	MEDIUM	LOW
10	Sitai		HTW	08.12.89	6.4	79	Nil	30	10	30		12	30	5	0.1	4	0.97	0.00	111.45	51	LOW	LOW	LOW
11	Coochbehar-I		HTW	08.12.89	6.5	79	Nil	40	10	30		13	9	3	0.1	5	1.07	0.10	122.21	51	LOW	LOW	LOW
12	Haldibari		HTW	08.12.89	6.4	110	Nil	30	10	30		16	6	2	0.1	6	1.28	0.00	108.38	70	LOW	LOW	LOW
13	Mekhliganj		HTW	08.12.89	7.0	330	Nil	190	10	150		10	9	4	0.1	34	0.35	0.11	64.01	211	LOW	LOW	LOW
14			HTW	08.12.89	6.4	275	Nil	?	20	60		28	10	13	0.1	7	1.56	0.00	50.03	176	LOW	LOW	LOW
15			HTW	08.12.89	6.5	79	Nil	40	10	20		9	3	4	-	6	0.67	0.00	110.92	50	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1991]

Table No. :5.3(a) ii **QUALITY OF WATER** **District : DARJEELING** **Year : 1993**

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO3 in ppm	HCO3 in ppm	Cl in ppm	Total H in ppm	SO4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water * SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1		Siliguri	HDTW	-	6.3	140	Nil	50	20	20	NA	10	4	4	0.1	2.0	1.02	0.46	168.30	90	LOW	LOW	LOW
2		Phansidewa	DW	-	6.3	86	Nil	30	10	20	NA	5	3	2	Nil	4.0	0.47	0.06	142.29	54	LOW	LOW	LOW
3		Naxalbari	HDTW	-	7.0	185	Nil	50	20	50	NA	11	2	3	0.2	10.0	0.69	-0.15	95.38	118	LOW	LOW	LOW
4		Kharibari	DW	-	6.4	460	Nil	40	80	110	NA	50	29	1	Nil	25.0	2.12	-1.46	69.62	294	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal , 1993]

Sl. No.	Block	of Sample	of Source	Collection		microhmhos/cm at 25 Deg. C	in ppm	in ppm	in ppm	in ppm	in ppm	in ppm	in ppm	in ppm	in ppm	in ppm	m/l	m/l	in %	in ppm	Limits	Limits	(Ify. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	Rajganj	Rajganj	HTW		6.8	150	-	50	20	30		10	3	2	0.1	6	0.80	0.23	130.36	96	LOW	LOW	LOW
2	Rajganj	Rajganj	HTW	07.11.90	6.7	295	-	80	20	60		13	5	5	0.1	67	0.33	0.00	26.98	189	LOW	LOW	LOW
3	Rajganj	Rajganj	HTW	26.05.90	6.8	228	-	60	10	50		7	4	1	0.3	11	0.44	0.03	102.78	146	LOW	LOW	LOW
4	Haldibari	Haldibari	HTW	10.11.91	7.1	165	-	110	20	70		20	6	4	0.2	14	1.06	0.45	99.61	106	LOW	LOW	LOW
5	Mayanaguri	Mayanaguri	HTW		6.7	200	-	90	10	70		12	3	4	0.1	14	0.63	0.12	92.69	128	LOW	LOW	LOW
6	Mayanaguri	Mayanaguri	HTW	07.11.90	6.5	255	-	110	20	50		10	4	6	0.7	50	0.29	0.00	36.62	163	LOW	LOW	LOW
7	Mayanaguri	Mayanaguri	HTW	17.05.90	6.5	222	-	90	10	40		7	5	1	2.0#	9	0.48	0.68	138.59	85	LOW	LOW	LOW
8	Dhupguri	Dhupguri	HTW		7.2	180	-	110	20	110		8	5	6	0.2	2	0.73	1.34	209.36	93	LOW	LOW	LOW
9	Mal	Mal	DW		7.0	180	-	50	20	60		7	3	4	-	12	0.40	0.00	81.14	114	LOW	LOW	LOW
10	Mal	Mal	DW	14.11.90	6.6	160	-	50	40	40		8	5	7	-	-	0.84	0.48	181.19	102	LOW	LOW	LOW
11	Mal	Mal		?	7.0	125	-	30	10	30		9	3	1	-	7	0.70	0.00	107.33	80	LOW	LOW	LOW
12	Mal	Mal	DW	20.11.91	6.8	38	-	?	20	30		8	2	1	0.1	14	0.45	0.00	22.41	74	LOW	LOW	LOW
13	Nagrakata	Nagrakata	DW		6.9	185	-	50	20	80		7	3	7	0.2	12	0.43	0.00	93.45	114	LOW	LOW	LOW
14	Matiali	Matiali	DW	14.11.90	7.0	235	-	80	20	40		9	7	3	0.5	-	1.44	1.16	285.25	150	LOW	LOW	LOW
15	Nagrakata	Nagrakata	DW	16.05.90	6.0	133	-	40	10	50		7	7	1	-	11	0.44	0.00	88.35	135	LOW	LOW	LOW
16	Jalpaiguri	Nagrakata	DW	20.11.91	7.0	98	-	60	20	60		18	6	1	0.1	14	1.01	0.00	89.31	63	LOW	LOW	LOW
17	Matiali	Matiali	DW	20.11.91	7.1	115	-	100	30	70		9	3	2	0.1	15	0.48	0.30	96.79	74	LOW	LOW	LOW
18	Matiali	Matiali	DW		8.0	133	-	40	10	30		11	4	1	0.1	7	0.85	0.03	116.57	85	LOW	LOW	LOW
19	Matiali	Matiali	DW	14.11.90	7.0	235	-	80	20	70		17	5	2	-	-	3.34	1.21	225.03	150	LOW	LOW	LOW
20	Matiali	Matiali	DW		7.9	175	-	90	20	80		10	3	3	0.1	17	0.49	0.00	83.11	112	LOW	LOW	LOW
21	Dhupguri	Dhupguri	Bed		6.5	155	-	40	20	20		5	4	4	0.1	2	0.51	0.29	177.44	97	LOW	LOW	LOW
22	Dhupguri	Dhupguri	HTW		7.0	280	-	110	20	50		4	3	3	0.1	10	0.25	0.83	132.31	176	LOW	LOW	LOW
23	Dhupguri	Dhupguri	HTW	21.05.90	6.9	322	-	150	10	120		10	5	1	0.2	28	0.40	0.10	71.68	206	LOW	LOW	LOW
24	Dhupguri	Dhupguri	HTW	15.11.90	6.8	285	-	130	30	120		5	7	2	0.5		0.98	2.03	531.40	182	LOW	MEDIUM	LOW
25	Dhupguri	Dhupguri	Bed	19.11.90	6.9	70	-	80	40	70		8	3	2	0.1	15	0.43	0.00	88.68	45	LOW	LOW	LOW
26	Dhupguri	Dhupguri	HTW		7.2	180	-	110	20	50		10	6	10	0.1	6	0.62	0.82	125.10	115	LOW	LOW	LOW
27	Dhupguri	Dhupguri	Bed	17.05.90	7.0	133	-	50	10	30		7	6	1	0.1	7	0.54	0.19	129.93	457	LOW	LOW	LOW
28	Madarihat	Madarihat	HTW		7.8	573	-	300	20	100		8	7	1	-	47	0.25	0.99	60.01	367	LOW	LOW	LOW
29	Madarihat	Madarihat	HTW	21.11.90	7.6	400	-	300	40	210		8	8	12	0.1	-	0.64	4.33	273.73	181	LOW	HIGH	LOW
30	Madarihat	Madarihat	HW		7.5	460	-	220	20	320*		3	3	4	-	74	0.07	0.00	31.55	294	LOW	LOW	LOW
31	Madarihat	Madarihat	HW	21.11.90	7.9	360	-	250	30	290		8	7	14	0.1	61	0.21	0.00	39.09	230	LOW	LOW	LOW
32	Kalchini	Kalchini	HTW	21.11.90	7.0	225	-	90	30	100		8	21	8	0.1	19	0.35	0.00	67.69	144	LOW	LOW	LOW
33	Kalchini	Kalchini	HTW	21.11.90	6.5	377	-	140	10	70		8	5	1	0.4	16	0.42	0.93	108.49	241	LOW	LOW	LOW
34	Kalchini	Kalchini	HW		6.3	370	-	110	40	90		24	22	4	0.1	10	1.46	0.78	115.56	238	LOW	LOW	LOW
35	Kalchini	Kalchini	HW	21.11.90	6.7	270	-	80	20	100		26	20	6	-		2.94	1.02	159.68	250	LOW	LOW	LOW
36	Jalpaiguri	Jalpaiguri	HW	19.05.90	6.6	236	-	110	10	50		9	3	1	1.0#	11	0.57	0.85	128.65	150	LOW	LOW	LOW
37	Jalpaiguri	Jalpaiguri	HW	25.04.91	6.6	130	-	90	10	40		14	4	2	0.1	8	0.99	0.72	133.38	87	LOW	LOW	LOW
38	Jalpaiguri	Jalpaiguri	HW	20.11.90	6.1	270	-	110	30	100		4	7	1	-		1.11	1.75	680.08	173	LOW	MEDIUM	LOW
39	Alipurduar	Udayan Club Premises, Alipurduar	TW	04.06.90	6.9	322				30		130	-	-	-	-	-	0.00	100.00	206		LOW	LOW
40	Alipurduar	Alipurduar, sample No. 2	TW	08.06.90	7.0	770	-	-	-	60		290	-	-	1.0#	-	-	0.00	100.00	493		LOW	LOW
41		Banarhat, Handwork		04.01.91	7.5	786	-	-	-	10		70	-	-		-	-	0.00	100.00	503		LOW	LOW
42		Angrabhasa G.P.I			7.4	283	-	300	-	10		150	-	-	0.1	-	-	4.92	134.00	181		HIGH	LOW
43		Jalpaiguri	TW	03.12.91	6.6	120	-	100	10	60		20	2	3	0.6	13	1.11	0.42	102.89	77	LOW	LOW	LOW

\# Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal, State Water Investigation Directorate, Government of West Bengal, 1993]

Sl. No.	Sampling Block	Location of Sample	Type of Source	Date of Collection	pH	Sp. Con. micromhos/cm at 25 Deg. C	CO_3 in ppm	HCO_3 in ppm	Cl in ppm	Total H in ppm	SO_4 in ppm	Na in ppm	K in ppm	Ca in ppm	Fe in ppm	Mg in ppm	SAR me/l	RSC me/l	PI in %	TDS in ppm	Quality for Irrigation Water *		
																					SAR Limits	RSC Limits	Salt Concentration (Sp. Con. Limits)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	Coochbehar-I		HTW	18.05.90	7.2	495	Nil	220	20	190	10	8	3	39	0.1	25	0.25	1.40	51.94	317	LOW	LOW	LOW
2	Coochbehar-I		HTW	04.12.91	6.2	135	Nil	100	10	60	16	5	6	11	10.0	25	0.19	0.00	53.11	86	LOW	LOW	LOW
3	Coochbehar-II		HTW	18.05.90	7.2	684	Nil	330	90	230	72	14	10	50	0.2	-	0.55	4.92	95.76	437	LOW	HIGH	LOW
4	Coochbehar-II		HTW	24.11.91	7.7	480	Nil	320	20	320 #	30	15	22	64	0.2	30	0.39	1.69	46.92	307	LOW	MEDIUM	LOW
5	Coochbehar-II		HTW	26.06.91	7.1	350	Nil	170	20	160	8	5	2	37	0.1	30	0.15	0.21	41.84	224	LOW	LOW	LOW
6	Coochbehar-II		HTW	21.11.90	7.5	520	Nil	250	20	270	11	14		ND	0.1	30	0.55	1.62	85.38	333	LOW	MEDIUM	LOW
7	Coochbehar-II		HTW	22.11.90	7.4	310	Nil	150	20	110	9	7	2	ND	0.1	25	0.30	0.30	79.11	198	LOW	LOW	LOW
8	Dinhata-I		HTW	18.05.90	6.0	503	Nil	80	20	170	13	9	5	38	0.2	9	0.34	0.32	51.21	222	LOW	LOW	LOW
9	Dinhata-I		HTW	18.05.90	6.5	424	Nil	107	20	110	18	3	2	22	0.7	30	0.10	0.00	39.47	272	LOW	LOW	LOW
10	Dinhata-I		HTW	04.12.91	6.8	410	Nil	190	30	200	40	12	7	44	3.0 #	30	0.34	0.30	44.33	262	LOW	LOW	LOW
11	Dinhata-I		HTW	03.12.91	7.2	215	Nil	130	20	130	19	2	5	28	0.1	9	0.08	1.14	70.16	136	LOW	LOW	LOW
12	Dinhata-I		HTW	26.06.91	6.8	600	Nil	150	40	210	38	9	2	49	0.1	9	0.31	1.62	55.34	384	LOW	MEDIUM	LOW
13	Dinhata-I		HTW	26.06.92	6.5	285	Nil	130	20	50	20	6	3	10	0.1	30	0.21	0.00	53.32	182	LOW	LOW	LOW
14	Dinhata-I		HTW	22.11.90	6.5	285	Nil	70	30	60	28	7	3	ND	0.1	9	0.50	0.26	131.39	182	LOW	LOW	LOW
15	Dinhata-I		HTW	22.11.90	6.8	300	Nil	120	20	110	25	8	3	ND	0.5	30	0.31	0.00	62.00	192	LOW	LOW	LOW
16	Dinhata-II		HTW	18.05.90	7.0	433	Nil	280	20	180	11	8	4	30	0.5	20	0.28	2.74	71.74	276	LOW	MEDIUM	LOW
17	Dinhata-II		Beel	18.05.90	9.0 #	243	40	90	10	120	9	1	4	26	Nil	-	0.05	2.61	95.28	156	LOW	MEDIUM	LOW
18	Dinhata-II		Beel	03.12.91	7.2	180	Nil	120	20	110	10	4	5	23	0.1	-	0.23	1.72	120.94	115	LOW	MEDIUM	LOW
19	Dinhata-II		HTW	03.12.91	7.0	320	Nil	230	10	200	9	6	6	44	3.0 #	20	0.19	1.83	54.09	205	LOW	MEDIUM	LOW
20	Dinhata-II		Beel	03.12.91	7.2	260	Nil	170	20	150	18	8	4	34	0.2	-	0.38	2.59	99.97	166	LOW	MEDIUM	LOW
21	Dinhata-II		HTW	26.06.91	6.9	500	Nil	240	30	260	5	3	2	61	0.1	20	0.09	2.19	44.26	320	LOW	MEDIUM	LOW
22	Dinhata-II		Beel	26.06.91	6.8	135	Nil	70	10	60	3	4	2	13	Nil	-	0.31	1.05	153.26	86	LOW	LOW	LOW
23	Dinhata-II		Beel	26.06.91	6.6	130	Nil	80	10	60	3	3	1	14	Nil	-	0.22	1.26	155.93	82	LOW	LOW	LOW
24	Dinhata-II		Beel	22.11.90	7.5	270	Nil	120	20	80	7	4	2	ND	-	NA	-	1.87	906.48	173		MEDIUM	LOW
25	Dinhata-II		Beel	22.11.90	8.2	275	Nil	150	20	120	10	5	4	ND	0.1	-	-	2.26	821.34	176		MEDIUM	LOW
26	Dinhata-II		HTW	22.11.90	7.2	380	Nil	160	20	160	10	9	4	ND	0.4	20	0.43	0.78	98.50	243	LOW	LOW	LOW
27	Toofangunj		HTW	18.05.90	6.2	212	Nil	100	10	80	12	3	2	18	5.0 #	14	0.13	0.39	65.02	136	LOW	LOW	LOW
28	Toofangunj		HTW	04.12.91	6.7	88	Nil	60	20	80	14	2	5	16	2.0 #	12	0.09	0.00	57.91	56	LOW	LOW	LOW
29	Toofangunj		HTW	04.12.91	7.2	295	Nil	190	20	70	10	7	4	14	0.2	14	0.32	1.76	96.37	189	LOW	MEDIUM	LOW
30	Toofangunj		TW	06.06.90	6.8	227	Nil	-	30	50	-	-	-	-	0.4	-	-	0.00	-	146		LOW	LOW
31	Toofangunj						Nil									14	0.00	0.00	0.00		LOW	LOW	
32	Toofangunj-II		HTW	27.06.91	6.4	100	Nil	50	10	40	6	3	2	8	0.1	12	0.16	0.00	68.44	64	LOW	LOW	LOW
33	Toofangunj-II		HTW	27.06.91	6.5	285	Nil	100	10	140	7	2	2	32	0.1	12	0.08	0.55	51.62	182	LOW	LOW	LOW
34	Toofangunj-I		HTW	22.11.90	7.0	165	Nil	70	20	40	10	5	5	ND	0.2	14	0.29	0.00	93.89	106	LOW	LOW	LOW
35	Toofangunj-II		HTW	22.11.90	6.9	180	Nil	70	20	250	10	5	4	ND	1.0 #	9	0.36	0.21	134.24	115	LOW	LOW	LOW
36	Mathabhanga-II		HT	26.11.90	6.2	94	-	30	20	-	20	4	2	5	0.1	-	0.50	0.39	208.63	66	LOW	LOW	LOW
37	Mathabhanga-II		HT		7.0	350	-	70	30	-	110	39	21	4	0.4	30	1.47	0.00	63.35	224	LOW	LOW	LOW
38	Sitalkuchi		HT		6.5	105	-	30	20	-	20	5	2	5	0.1	30	0.19	0.00	31.27	60	LOW	LOW	LOW
39	Sitalkuchi		HT	26.11.90	6.7	115	-	50	10	-	60	10	4	1	0.4	25	0.42	0.00	52.62	74	LOW	LOW	LOW
40	Sitai		HT		7.0	520	-	190	40	-	50	1	9	5	-	15	0.05	1.44	118.45	78	LOW	LOW	LOW
41	Sitai		HT		6.5	140	-	30	20	-	60	10	8	2	0.1		1.96	0.10	213.14	90	LOW	LOW	LOW

: Above maximum permissible limit for drinking water (as per IS : 10500-1983)

* : Water Quality Classification for Irrigation Purpose (as per IS : 11624-1986)

[Source : Report on Chemical Analysis of Water Samples Collected from Different parts of West Bengal,
State Water Investigation Directorate, Government of West Bengal , 1993]

The primary data which gives an idea about the present day situation also, more or less, corroborates this. [Table 5.3(a)iii]

The water samples are largely neutral to slightly alkaline in reaction. The salt concentrations are low, signifying no salinity hazard. This is equally true with the content of Total Dissolved Solids (T.D.S.) which range from 51.0 - 238.0 mg/litre.

The basic cation contents of the present water samples are generally low, so also the SAR. values. This implies that the present samples are free of sodium hazards.

These RSC values vary widely. The sample from DTW of Alipurduar show very high values of RSC, whereas STW sample of Dinhata II show RSC hazards as medium. All the other samples show low value of RSC. The hardness value of the given samples are also rather low.

The analysed water samples are free of chloride hazard as could be seen from the corresponding low chloride contents. The range of nitrogen is 12.6 to 25.2 mg/litre while phosphorus varies from 0.30 to 1.4 mg/litre. The iron content of the present water samples varies widely, ranging from 1.80 to 3.56 ppm. All of these are within acceptable limits.

5.3(b) Quality of Surface Water for Agricultural Use

No data on surface water were available from any sources. However, the Consultants have generated its own data by collection of the samples from River Lift Irrigation (RLI) and analysis of the results are presented in Table 5.3(a)iii items 1, 11 & 17. The surface water qualities of the given samples are good as far as agricultural use is concerned. There is no SAR, RSC or Salt Concentration hazards from these sources.

5.3(c) Pesticides in Water

In the Terai region, chemical pesticides were primarily used in the tea gardens. In the past, the tendency was to use excessive pesticides washing them down with water subsequently. However, in recent times, with restrictions coming from European Communities and other receivers of exported tea on the presence of pesticide residues on tea leaves, the tea estates have gone for more and more pragmatic use of organic pesticides like Neem Gold and Godrej Achhoo. The use of pesticide by farmers in this area is limited mostly to the HYV crops and the quantities, in most cases, are small. However, in an attempt to detect whether pesticide residues have entered the surface water, three samples were taken from the drains outside three major tea estates and another three from surface water sources near the agricultural fields. The samples were tested for predominant varieties of pesticides in use in the region - especially ones on which there are international restrictions on residual toxicity limits. The results are given in Table 5.3(c) which indicate that no appreciable pesticide residues were found.[1]

[1] N.B. The samples were, however, taken within a narrow time-frame which may not have coincided with the time of use of high pesticide doses.

Table 5.3(c)
Pesticide Residues in Water

Block Name	Location	Nature of Location	Pesticide Residues				
			Dicofol ppm	Endos-ulfan ppm	Dieldrin ppm	Chloro-pyriphos ppm	Ethion ppm
Dhupguri	Purba Altagram	Surface Water	ND	3.70	ND	ND	0.019
Mainaguri	Pashanerdanga	Surface Water	ND	0.78	ND	ND	0.013
Jalpaiguri	Barakamath	Surface Water	ND	2.89	ND	ND	0.002
Mal	Rannichera	Tea Estate	ND	0.66	ND	ND	0.087
Dhupguri	Gayarkata	Tea Estate	ND	0.094	ND	ND	0.034
Nagrakata	Bhagotpore	Tea Estate	ND	0.00	ND	ND	0.031

ND : Not Detected

5.3(d) Nutrient Enrichment

The project area has a large number of small water bodies which retain water almost perennially. Many of these ponds are used for bathing, washing of utensils and for ablution. Some are also used for rating of jute. Mineralisation through sub-surface contamination from human night soils, cow dung and similar materials are also a possibility. Many of these ponds show high levels of weed growth and water hyacinth pointing to the presence of nutrients in these waters. Fishes and other minor aquatic lives are, however, observed in these waters indicating presence of dissolved oxygen. To examine the extent of nutrient enrichment in these confined water bodies and the possibility of eutrophication, 10 samples were collected and analysed. The results given in Table 5.3(d) indicate that the samples are almost in the neutral range in terms of pH with substantial levels of dissolved oxygen. Levels of nitrogen and potassium are generally low with phosphorous being almost absent. These results indicate low level of nutrients with absence of possibilities of eutrophication in near future.

Table 5.3(d)
Analysis of Samples for Nutrient Enrichment

District	Block	Sample Location	Indicators for Eutrophication				
			pH	Dissolved Oxygen (mg/l)	Nitrogen (mg/l)	Phosphorus (mg/l)	Potassium (mg/l)
Darjeeling	Kharibari	Adhikari	6.38	2.00	5.10	BDL	4.50
	Naxalbari	Bengajote	6.60	3.20	4.30	BDL	1.40
Jalpaiguri	Mainaguri	Mainaguri	7.13	1.00	10.20	BDL	4.10
	Mainaguri	Mainaguri-Domohoni	6.69	1.00	9.30	BDL	4.30
	Dhupguri	Charchurabhander	6.35	1.20	6.40	BDL	1.20
	Dhupguri	Dharaiguri	6.75	3.00	4.20	BDL	1.30
	Jalpaiguri	Vivekananda Palli	7.50	3.00	4.50	BDL	1.50
	Jalpaiguri	Domohoni Crossing	7.40	3.00	4.70	0.01	1.50
Cooch Behar	Haldibari	Kasiabari	6.30	5.00	2.70	0.19	6.50
	Dinhata II	Dakshin Boronachina	6.65	4.00	2.90	0.16	7.20

BDL : Below Detection Limit

Quality of Water for Domestic Use

Water quality for use of drinking and other domestic purposes are guided in India by IS:10500 - 1983. Accordingly, all available data on water quality were tested against these standards, the results of which are given below. Such data comprise :

(i) secondary data from SWID which were primarily tested for their suitability of agricultural use. Chemical analyses of these data show that except for excess iron in some cases [indicated in the tables 5.3.(a)ii] the water qualities are within the given standard.

(ii) Analysis of 18 samples [Table 5.3(a)iii] which were also examined for suitability of irrigation. These results also show that the waters are fit for drinking except regarding Fe.

(iii) 6 samples were also taken specifically for testing of drinking water and the results are given in Table 5.3(e)iii. Here also the water samples are found to be fit for drinking from the chemical point of view except for Fluoride. In one case, iron and manganese are also in excess (Alipurduar I). On the point of Fe, it is pertinent to note that in most areas of West Bengal the ground water samples are rich in iron. Another notable point is that all the samples show Arsenic to be below detection level (i.e. below 0.003 mg/l).

(iv) Altogether 59 water samples were taken from different project structures for testing of bacteriological quality. The results are given in Table 5.3(e)iv below :

Table 5.3(e)iv
Bacteriological Quality of Water from Project Structures

Quality	Type of Structures				
	HTW	PDW	STW	DTW	RLI
Safe	34	1	0	3	0
Unsafe	6	9	2	1	3
Total	40	10	2	4	3

Table 5.3(e) iii

Analysis of Drinking Water Samples for Chemical Parameters

PARAMETER	MAXIMUM PERMISSIBLE LIMITS AS PER DRINKING WATER STANDARD IS 10,500 1983	SAMPLE LOCATIONS					
		JHURIPARA (BLOCK DINHATA) HTW	PURBA BHOLARDABRI (BLOCK ALIPURDUAR - I) HTW	UTTAR DANGAPARA (BLOCK DHUPGURI) HTW	LACHKA (BLOCK MATIGARA) HTW	KHARIBARI (BLOCK KHARIBARI) PDW	KASIBARI (BLOCK HALDIBARI) PDW
pH	6.5 - 9.2	6.70	6.60	6.90	6.50	6.70	6.80
Temparature (Deg. C)		26.00	26.00	27.00	26.00	26.00	24.00
Turbidity (NTU)	25	19.00	16.00	3.00	9.00	3.00	0.00
Alkalinity P (mg/l)		Nil	NIL	NIL	NIL	NIL	NIL
M		50.00	55.00	75.00	45.00	22.50	92.50
Total Suspended Solids (mg/l)		14.00	10.00	9.00	12.00	7.00	6.00
Total Dissolved Solids (mg/l)	1500	262.00	300.00	333.00	252.00	239.00	364.00
Nitrate (mg/l)	45	0.047	0.013	0.022	0.033	0.009	0.022
Phosphate (mg/l)		0.02	0.002	NIL	NIL	NIL	NIL
Sulphate (mg/l)	150	1.80	1.30	6.00	4.30	3.60	4.60
Chloride (mg/l)	250	19.90	22.70	14.20	14.20	11.40	15.60
Fluoride (mg/l)	0.6 - 1.2	1.90 *	1.30	1.60 *	1.30 *	1.50 *	1.50 *
Calcium (mg/l)	200	14.40	15.60	24.00	8.00	8.00	32.00
Magnesium (mg/l)	100	7.70	6.70	9.60	5.80	3.80	4.80
Sodium (mg/l)		5.72	5.84	5.72	5.60	5.96	5.72
Potasium (mg/l)		9.70	9.50	9.60	9.50	9.40	9.60
Total Iron (mg/l)	1.0	0.96	1.10 *	0.38	0.56	0.15	0.99
Copper (mg/l)	1.5	0.004	0.002	0.00	0.002	0.004	0.005
Manganese (mg/l)	0.5	0.26	0.64 *	0.03	0.02	0.02	0.41
Zinc (mg/l)	15	0.06	0.05	0.02	0.06	0.04	0.09
Arsenic (mg/l)	0.05	BDL	BDL	BDL	BDL	BDL	BDL
Mercury (mg/l)	0.001	BDL	BDL	BDL	BDL	BDL	BDL
Selenium (mg/l)	0.01	BDL	BDL	BDL	BDL	BDL	BDL
Aluminium (mg/l)		NOT DETECTED	NOT DETECTED	NOT DETECTED	NOT DETECTED	NOT DETECTED	NOT DETECTED
Lead (mg/l)	0.1	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium (mg/l)	0.01	BDL	BDL	BDL	BDL	BDL	BDL
Chromium (mg/l)	0.05	BDL	BDL	BDL	BDL	BDL	BDL
Phenolic Compound (mg/l)	0.002	BDL	BDL	BDL	BDL	BDL	BDL
Oil and Grease (mg/l)		0.118	0.460	0.920	1.200	0.136	0.118
Dissolved Oxygen (mg/l)		1.00	1.00	1.20	3.00	2.00	5.00
Chemical Oxygen Demand (mg/l)		12.00	17.60	19.30	18.30	20.10	21.10
Salinity (mg/l)		NIL	NIL	NIL	NIL	NIL	NIL
Ammoniacal Nitrogen (mg/l)		NIL	NIL	NIL	NIL	NIL	NIL
Kjeldahl Nitrogen (mg/l)		0.10	0.20	0.25	0.30	0.40	0.20

* Above Permissible Limit

BDL : Below Detection Limit

BDL of various parameters : Zinc 0.001 Cadmium 0.002 Arsenic 0.003 Mercury 0.0005 Chromium 0.008

Water-logging

Study of water-logging covers two aspects, viz. fluctuations in the ground water table and water-logging due to impeded drainage.

(a) Ground Water Fluctuation Studies

Figures 5.2 (a) and 5.2 (c) give the locations of the pre monsoon and post monsoon ground water condition for the years 1989. Similar location maps have also been prepared for 1994 and given in 5.2 (b) and 5.2 (d). Based on these maps, ground water table fluctuations between the pre and post monsoon periods for the two years have been prepared [Figures 5.2 (e) and 5.2(f)]. These show that in certain areas of Haldibari, Mekhliganj and Dinhata, the ground water table stay close to the surface throughout the year, which may lead to ground water congestion and root zone flooding for crops [Fig. 5.4 (a)]. However, detailed studies are required to establish the extent of such problem.

(b) Impeded Drainage

Incidence of prolonged water-logging and impeded drainage was observed in the area centred around Dinahata, located to the south of Coochbehar District. Information gathered from the Agriculture Department followed by field checks reveal that the following areas of Dinhata I & II Blocks are prone to water-logging and submergence :

I) Dinhata Block I :

(a) Balakura Village near Nalbaridola in Putimari I GP

(b) Kharkharia Village near Burhamaridola in Putimari I GP

(c) Poalidoho in Putimari I GP

(d) Dewalirdola in Dinhata Village II GP

(e) Chota Atiabari and Nagar Bhagni in Dinhata Village II GP

(f) Peolaguri Village near Paglarpet in Boro Atiabari I GP

(g) Bhostoli near Brahmanir Chowki in Bhataguri II GP

(h) Baladanga Village

(i) Alokejhari near Mashanpet in Petla GP

(j) Daribas in Gitaldah II GP

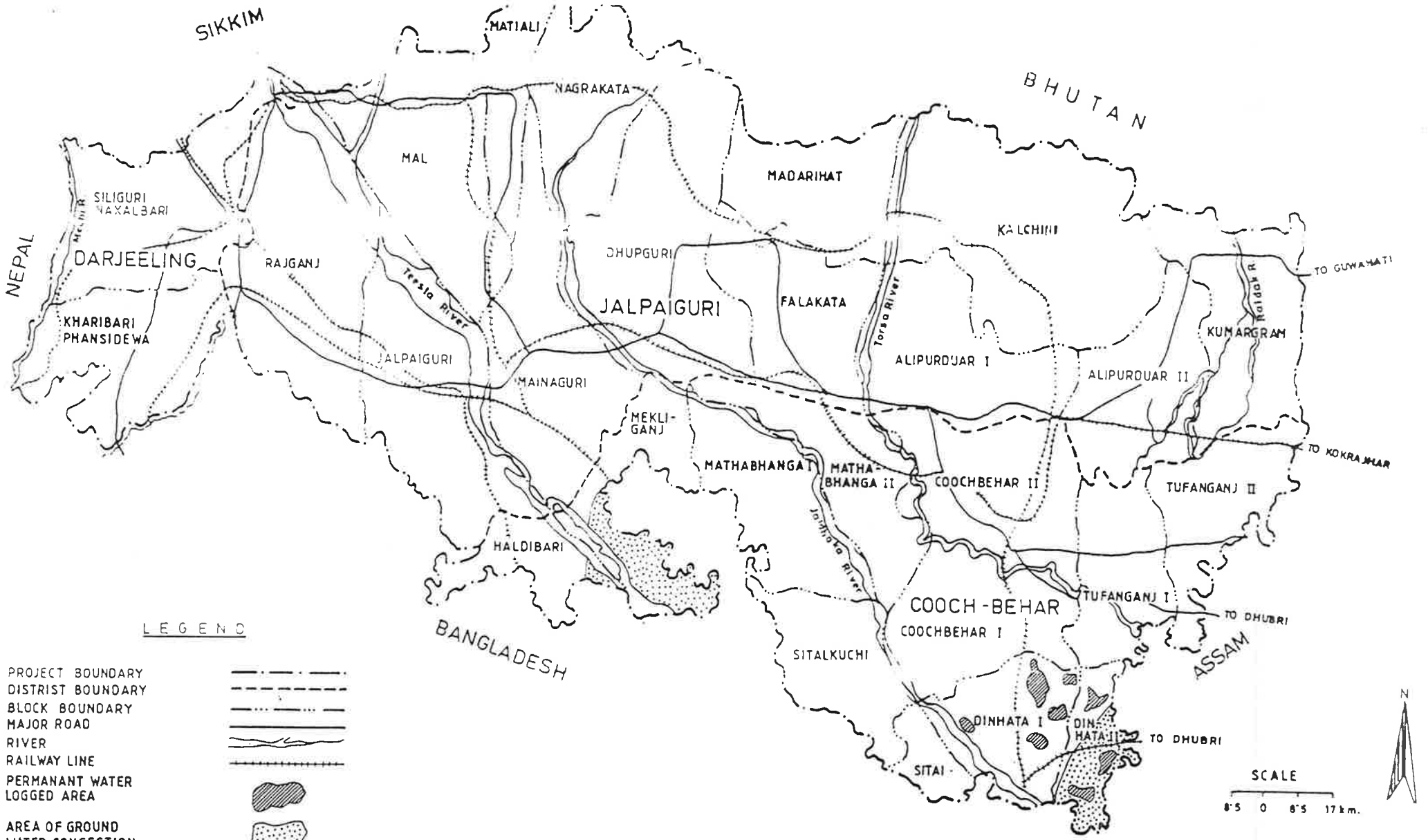
(k) Bhangni Part II near Ambari

(II) Dinhata Block II :

(a) Kalamati & Atialdanga

(b) Khotamara in Burhirhat I GP

(c) Lalaganj in Choudhurihat GP



MAP OF PERMANANT WATER LOGGED AREA AND GROUND WATER CONGESTION ZONE

(d) Nagarabari & Khallimar Villages

(e) Sulmara, Garoljhora, Seoraguri, Haribhangha, Khutamara

(f) Durganagar

(g) Picknidhara & Khamarbakshi

(h) Meghnarayaner Kuthi

The locations of these areas are also shown in Fig. 5.4(a).

The areas prone to water-logging are located at the tail end of the courses of Torsa and Jaldhaka rivers within the project area. Where the rivers have reached the stage of valley widening were through lateral seepage, the channels are widening shoal formation and changing of courses. The areas listed in the flood zone between the two rivers thus get the spill over from these two courses. The areas being low, the spilled water cannot be evacuated through available drainage channels. Since these areas border Bangladesh, any comprehensive drainage plan for such evacuation will need participation of Bangladesh in the project and with the flood water being evacuated into this territory with possibilities of water-logging therein as a result of water-logging could not be properly handled under the existing situation.

5.5 Soil

The process of soil formation in the project area and the taxonomic classifications have been discussed in para 2.5. Below here are described the various soil related issues in the project area based on secondary data, field visits, discussions with academics, Government officials as also from analyses of soil samples.

(a) Soil Texture

Soil texture, which is evaluated by the mechanical analysis of soil, is directly related to soil productivity. Most of the soils of the Terai zone are dominated by the sand fractions followed by clay [Table 5.5(a)]. A tentative chart has been prepared in collaboration with BCKV, North Bengal Campus showing the distribution pattern of soil texture in different blocks of the project area. In Siliguri sub-division which has two blocks, most of the areas have sandy loam to loam as textural composition. Mechanical composition of surface soils ranges as 10-12% clay, 20-25% silt and 60-70% sand in general. However, appreciable lands of sandy texture and clay loam texture have been recognised covering 35 to 40% of the total area available for cultivation. In sandy patches, the sand percent exceeds 89-93% and in clay loamy soil, fractions are as follows 32-38%, silt 10-15% and sand 58-62%.

In Jalpaiguri district, more than 92 percent of the total area in blocks like Jalpaiguri Sadar, Rajganj, Maynaguri, Dhupguri, Alipurduar I and II are sandy loam in texture. However, in areas under blocks like Mal, Metelli, Nagrakata, Madarihat and Kalchini, soils are mostly sandy or sandy loams. Range values of particle size distribution in soils of Jalpaiguri district are sand 55-92%, silt 8-26% and clay 9-19%. In general, major textural combinations are sandy loam followed by sand or sandy loam followed by silty loam, or sand as a major class of soils followed by sandy loam as a minor group of soils.

However, the picture is little different in Cooch Behar district. Loam dominants define the major textural class covering the area in the range of 50 to 60 percent of the total alluvial areas in blocks like Tufanganj, Dinhata II, Mathabhanga I & II and Haldibari. Next to loam, other textural classes like sandy loam with patches of sandy clay loam and sandy clay are detectable. Range values are as follows : sand 66-77%, silt 11-27% and clay 13-23%.

Table 5.5(a)

Distribution Pattern of Soil Texture Composition in Different Blocks Under North Bengal Terai Development Project

DISTRICT	BLOCK	AREA AVAILABLE FOR CULTIVATION (ha)	PREDOMINANT SOIL TEXTURE	TOTAL AREA (%)	OTHER TYPES OF SOIL TEXTURE	TOTAL AREA (%)
Darjeeling	Siliguri & Naxalbari	11316.00	Sandy Loam & Loam	60	Sandy & Clay Loam	40
	Kharibari & Phansidewa	18454.00	Sandy Loam & Loam	65	Sandy & Clay Loam	35
Jalpaiguri	Jalpaiguri	27036.40	Sandy Loam	96	Sandy	4
	Rajganj	28784.00	Sandy Loam	97	Sandy	3
	Maynaguri	33836.00	Sandy Loam	96	Sandy	4
	Dhupguri	20640.80	Sandy Loam	92	Sandy and Silty Loam	8
	Mal	18340.00	Sandy Loam	68	Sandy	32
	Matelli	3852.80	Sandy	60	Sandy Loam	40
	Nagrakata	3478.00	Sandy	58	Sandy Loam	42
	Falakata	19232.80	Sandy Loam	88	Sandy and Silty Loam	12
	Madarihat	6796.00	Sandy	62	Sandy Loam	38
	Kalchini	6349.20	Sandy	63	Sandy Loam	37
	Alipurduar-I	16434.00	Sandy Loam	97	Sandy	3
	Alipurduar-II	25437.60	Sandy Loam	97	Sandy	3
	Kumargram	15459.20	Sandy Loam	70	Sandy and Silty Loam	30
Cooch Behar	Cooch Behar-I	23680.00	Sandy Loam	50	Loam	50
	Cooch Behar-II	18780.00	Sandy Loam	60	Loam	40
	Tufanganj	40620.00	Loam	50	Sandy Loam and Sandy Clay Loam	50
	Dinhata-I	23490.00	Sandy Loam	70	Loam	30
	Dinhata-II	18620.00	Loam	60	Sandy Loam and Sandy Clay Loam	40
	Sitai	8190.00	Sandy Loam	70	Loam	30
	Mathabhanga-I	22960.00	Loam	55	Sandy Loam	45
	Mathabhanga-II	18250.00	Loam	55	Sandy Loam	45
	Sitalkuchi	22570.00	Sandy Loam	58	Loam	42
	Mekhliganj	23310.00	Sandy Loam	60	Loam	40
	Haldibari	10270.00	Loam	60	Sandy Loam	40

Source : Status Report (1993) Volume 1, Terai Zone, West Bengal. NARP, BCKV, North Bengal Campus.

Thus soils in the project area are sand dominated and they are characterised by an absence of plasticity, stickiness, swelling and low water holding capacity. The surface infiltration rate is rapid and status of available water (- 0.3 bar to -15.0 bar) is low. In practice, it is observed that in many areas drainage is impeded and surface flood occurs at the time of heavy rain depending on topography and hydrology of area. For these reasons, many areas having soils with good to very good depth have been classified and named as water logged or submerged lands with imperfect drainage under marshy conditions.

(b) Soil Structure

Very few experimental results are available on evaluation of structural stability indices of soils in the project area. Based on few samples of data, it has been found that water stable aggregates > than 0.25mm (WSA %) ranges between 16.70 and 30.00 percent. Mean Weight Diameter (MWD - mm) varies from 0.29 to 0.82mm. Both the sets of results indicate low to medium soil aggregation, particularly in terms of soil water stability.

Soil management practices, crops and cropping sequences, application of manures & fertilizers, uses of soil amendments - all have profound effects on improvement of soil aggregation and stability of soil structure. Suggestions are discussed in detail in a later section (8.1.5).

(c) Soil Acidity & TDS

The solid phase of soils is an admixture of predominantly silicates and soil humus. The chemical composites of surface soils from different locations in the Terai show the following ranges :

SiO_2	:	58.80 - 74.24 %
Al_2O_3	:	9.04 - 15.97 %
Fe_2O_3	:	5.14 - 12.78 %
TiO_2	:	0.25 - 1.27 %
CaO	:	0.44 - 8.96 %
MgO	:	0.64 - 3.85 %
K_2O	:	0.51 - 5.42 %
P_2O_5	:	0.05 - 0.56 %
MnO	:	0.06 - 0.44 %

The Cation Exchange Capacity (CEC) ranges from 5.72 to 20.15 Cmols (p^+) Kg^{-1}. Base saturation percentage varies from 58.06 to 82.80. Illites are the dominant clay minerals along with traces of smectite, vermiculite and kaolinite.

Soil Acidity

Soluble and exchangeable H^+ ions along with exchangeable Al ions, play a vital role in soil fertility. The former is expressed in pH values. The distribution of soil pH in different blocks of Siliguri sub-division, Jalpaiguri and Cooch Behar districts is given in Table 5.5.(c). In general, the surface soils are acidic - some are strongly (pH<5.5) and some are moderate (5.5-6.5). Dominant pH of surface soils varies between 4.5 to 6.5. However, patches having nearly neutral soil pH or > than 7.5 have also been reported in Dhupguri, Cooch Behar I & II, Mathabhanga II, Dinhata, Maynaguri, Kumargram etc.

Surface soils differ widely from the sub-surface soils in terms of soil reactions. In most cases, where surface soils have shown distinctly acidic reactions, the sub-surface soils have higher pH values than surface horizons indicating accumulation of basic cations

down the depth. The reasons for surface soil actidity in the Terai zone might be due to intense leaching losses of basic cations (Ca^{+2}, Mg^{+2}, K^{+1}, Na^{+1} etc.)by heavy rainfall and indiscriminate use of irrigation water, wherever available, particularly in summer months. Presence or accumulation of exchangeable Al in the surface zones may contribute to H ions in the soil solution. Acidity has also increased in places where there is absence of cover crops and many fields lie barren during monsoon months when rains of high intensity and kinetic energy hit the soil. In areas under forest litters, humification is slow and incomplete, adding to soil acidity.

TDS

Irrigation water containing a high concentration of soluble salts (chlorides and sulphates of Ca, Mg, K, Na) lead to soil salinity if proper drainage is not provided to leach the salts beyond the root zone. Seepage from canals or irrigation channels may cause salinity problems. The areas under this project show no salinity effects so far. In most of the places, EC_e values remain in the range of 0.21 dsm^{-1} to 0.92 dsm^{-1} indicating negligible salinity effect (EC_e stands for electrical conductivity of saturation extract of soil at 25°C).

Table 5.5(c)

Distribution Pattern of pH in Different Blocks of Project Area

District	BLOCK	VERY STRONGLY ACIDIC (<4.5)	STRONGLY ACIDIC (4.5-5.5)	MODE-RATELY ACIDIC (5.5-6.5)	NEARLY NEUTRAL (6.5-7.5)	ALKALINE (>7.5)
Darjeeling	Siliguri & Naxalbari	1	33	5241	8	6
	Kharibari & Phansidewa	2	44		5	8
Jalpaiguri	Falakata	-	33	58	6	3
	Maynaguri	1	36	52	7	4
	Dhupguri	1	30	40	11	18
	Jalpaiguri	1	36	58	4	1
	Matelli	2	77	21	-	-
	Kumargram	1	34	54	10	1
	Alipurduar-I	-	51	40	5	4
	Alipurduar-II	-	53	42	3	2
	Malbazar	2	72	26	-	-
Cooch Behar	Cooch Behar-I	0	40	38	10	12
	Cooch Behar-II	1	28	47	16	8
	Tufangang	1	53	42	4	-
	Mathabhanga-I	0	78	22	0	0
	Mathabhanga-II	0	38	49	12	1
	Mekhliganj	0	40	56	4	0
	Dinhhata-I	5	44	41	10	0
	Dinhata-II	0	28	48	18	6
	Sital	2	81	15	2	0
	Sitalkuchi	4	81	13	2	0
	Haldibari	0	58	39	3	0

(d) Soil Erosion from Agricultural Fields

Traversing the various blocks of Siliguri Subdivision, Jalpaiguri and Cooch Behar Districts and feeling the farmers' perception and technologists' views at various locations, reveal few signs of serious soil losses due to erosion from agricultural fields. In most of the areas soil loss in tonnes/ha/year ranges between 1.32 and 4.54. Bunded fields, in particular, provide protection against soil erosion through run-off. Splash erosion and sheet washes are not prevalent in this area due to its general flat topography.

Gully erosion can not be blamed on cropping but is mainly concerned to riverine forest destruction and intensive grazing of scarce protective vegetation.

In the flood-prone areas centered around north of Cooch Behar and central parts of Alipurduar, patches of soil losses by splash erosion are noticeable. Few research observations are available for quantifications and hence no conclusive statement could be made.

(e) Soil Fertility

Soil fertility status is usually assessed by soil test values viz. pH, electrical conductivity, organic carbon, available N, P & K, available micronutrients (DTPA extractable), and soil amendment quantification. The North Bengal Terai region has been evaluated by various organisations (Government, Agencies or Institutes) who have examined fertility levels of soils for proper utilisation of fertilizers application. Since pH and salinity effects have already been discussed, special attention is given on Organic Carbon, available N, P & K together with micronutrients like Fe, Mn, Cu, Zn, B, Mo.

Three sets of tabular presentations are given below and these have been prepared mostly from Status Report - Volume 1 : Terai Zone, West Bengal NARP : BCKV, North Bengal Campus (1993). These are shown in Tables 5.5 (e) i , 5.5 (e) ii and 5.5. (e) iii

Organic Carbon

This not only indicates the status of organic matter content of soils but also is an indirect measure for assessing total and available N in soils. In Siliguri-Subdivision, more than 70 percent area of both the blocks have less than 0.75% organic carbon. In Jalpaiguri District, Organic C remains at a level of low (< 0.5 - 0.75%) in large areas of blocks like Falakata, Dhupguri, Metelli, Alipurduar, Mal etc. However, areas of Jalpaiguri Sadar, Kumargram, Maynaguri show medium to high levels of organic carbon ranging from 0.5 to 1.02 percent. More or less, similar values are found in Cooch Behar District. Blocks like Cooch Behar I & II, Tufanganj, Mathabhanga II, Dinhata I & II, Sitai & Haldibari show low to medium levels of organic carbon varying between 0.45 and 0.75 percent. The rest of the blocks have of medium to high level of Organic C varying from 0.50 to 1.16 percent.

Data on total and available N in different blocks of the project area are scanty. Reportedly, total N content in Teesta and Terai alluvium is in the range of 0.05 to 0.08 percent, and available nitrogen (in the form of NO_3-N & NH_4-N) amounts to 15 -25 ppm. All these figures called for application of nitrogenous fertilizers in the range of 60 to 160 Kg/ha depending upon the rating classes - viz. Low, Medium and High.

Status of available P in different blocks of the project area indicates medium to high level (except in few cases) showing available P concentrations at the level of 40 to 96 ppm. This is particularly true in most of the blocks of Cooch Behar and Jalpaiguri. Application of P fertilizers shows significant positive correlation between the input of P and crop yield. Application of P_2O_5 at the rate of 30 to 80 kg per hectare has given good response.

The application of high doses of P-fertilizers and ploughing bringing the sub-soil close to the top soil, may be one of the causes of Zn deficiency in the area. Available K status in most of the blocks under Jalpaiguri and Cooch Behar Districts varies between low and medium rating classes. The same is true in cases of Naxalbari and Kharibari blocks of

Siliguri-Subdivision. The range values of available K lies between 150 kg/ha and 300 kg/ha in the majority of the areas, and the Terai area has been classed as a low potash containing soil zone. Application of K_2O at a rate of 30 kg to 60 kg per ha. has shown good crop response.

Table 5.5(e) i

Blockwise Percent Distribution of Organic Carbon in the Soils of Project Area

DISTRICT	BLOCK	LOW (<0.50%)	MEDIUM (0.50-0.75%)	HIGH (>0.75%)
Darjeeling	Siliguri & Naxalbari	33	40	27
	Kharibari & Phansidewa	31	40	29
Jalpaiguri	Falakata	32	52	16
	Maynaguri	24	39	37
	Dhupguri	24	41	35
	Jalpaiguri	12	11	77
	Matelli	33	35	32
	Kumargram	17	34	49
	Alipurduar-I	43	44	13
	Alipurduar-II	25	47	18
	Malbazar	36	35	29
Cooch Behar	Cooch Behar-I	33	55	12
	Cooch Behar-II	54	39	7
	Tufanganj	53	38	9
	Mathabhanga-I	17	58	25
	Mathabhanga-II	46	41	13
	Mekhliganj	15	41	44
	Dinhata-I	39	49	12
	Dinhata-II	29	47	24
	Sitai	26	53	21
	Sitalkuchi	19	49	32
	Haldibari	38	48	14

Table 5.5 (e) ii

Blockwise Percent Distribution of Available P in the Soils of Project Area

DISTRICT	BLOCK	LOW (<0.50%) Kg/ha	MEDIUM (20-50) Kg/ha	HIGH (>50) Kg/ha
Darjeeling	Siliguri & Naxalbari	16	27	57
	Kharibari & Phansidewa	13	24	63
Jalpaiguri	Falakata	15	15	70
	Maynaguri	17	35	48
	Dhupguri	15	24	61
	Jalpaiguri	23	38	39
	Matelli	25	31	44
	Kumargram	24	20	56
	Alipurduar-I	18	28	54
	Alipurduar-II	8	29	63
	Mal	16	25	59
Cooch Behar	Cooch Behar-I	22	40	38
	Cooch Behar-II	21	19	60
	Tufanganj	11	26	64
	Mathabhanga-I	3	10	87
	Mathabhanga-II	9	8	83
	Mekhliganj	3	16	81
	Dinhata-I	4	8	88
	Dinhata-II	21	28	51
	Sitai	2	2	96
	Sitalkuchi	10	15	75
	Haldibari	20	72	8

Table 5.5 (e) iii
Blockwise Percent Distribution of Available K in the Soils of Project Area

DISTRICT	BLOCK	LOW (<150) Kg/ha^{-1}	MEDIUM (150-300) Kg/ha^{-1}	HIGH (>300) Kg/ha^{-1}
Darjeeling	Siliguri & Naxalbari	21	69	10
	Kharibari & Phansidewa	29	57	14
Jalpaiguri	Falakata	51	43	6
	Maynaguri	23	60	17
	Dhupguri	16	62	22
	Jalpaiguri	65	30	5
	Matelli	61	32	7
	Kumargram	28	62	10
	Alipurduar-I	58	35	7
	Alipurduar-II	41	52	7
	Mal	22	58	20
Cooch Behar	Cooch Behar-I	49	40	11
	Cooch Behar-II	42	45	13
	Tufanganj	54	35	11
	Mathabhanga-I	14	46	40
	Mathabhanga-II	35	55	10
	Mekhliganj	15	65	20
	Dinhata-I	36	44	20
	Dinhata-II	44	44	12
	Sitai	38	51	11
	Sitalkuchi	37	53	10
	Haldibari	20	72	8

(f) Micronutrients

The importance of micronutrients for crop growth, and their role in increasing agricultural production in North Bengal Terai Region, have been convincingly established. The uses of high quantity of fertilizers for high yield varieties, less recycling of organic wastes, unfriendly climatic factors and unscientific soil management practices are the main factors to depletion of available micronutrients in this zone. Several Institutions/Universities have conducted investigations on micronutrient status of North Bengal soils from time to time. Indo-British Fertilizer Education Project (IBFEP) of HFC recorded useful information concerning levels of available Fe, Cu, Mn & Zn in Teesta and Terai alluvium soils of West Bengal. Table 5.5(f) is enclosed to show Micronutrient status of Jalpaiguri and Cooch Behar Districts : Courtesy : IBFEP - HFC. Widespread deficiencies of Zn have been observed ranging from 16-68% of the total cultivable areas in soils of both Jalpaiguri and Cooch Behar Districts. In spite of the fact that most surface soils are distinctly acidic, available Fe might have caused Zn deficiency by displacement reactions from the cation exchange complex as well as from organic complexes. Zn-Phosphate interaction may also cause negative impacts on the availability of Zn.

The study further reveals that there is no deficiency of Fe and Cu, the average content of Fe in soils of Jalpaiguri and Cooch Behar districts are 37.4 ppm and 106.5 ppm respectively ranging from 4.8 to 336.8 ppm which seems to be high. No deficiency of Cu was observed, the main values ranged from 2.15 to 2.73 ppm - the critical limit being 0.1 ppm.

Mn deficiency was not observed in Cooch Behar except in Dinhata-II where 7% deficiency was recorded. In Jalpaiguri district, Mn deficiency ranges from 1 to 14%. However such deficiencies are not alarming.

Hot water soluble Boron (B) varies from 0.08 to 2.30, 0.02 to 3.36 and 0.05 to 1.46 ppm in Siliguri-Subdivision, Jalpaiguri District and Cooch Behar District. Overall soil samples are deficient in available B if the critical level for hot water soluble B is taken as 0.36 ppm. District-wise magnitude of deficiency has been reported to be 57, 53 and 60 percent in Siliguri Sub-division, Jalpaiguri and Cooch Behar Districts respectively. Low soil pH, high availability of Fe and Al might have caused low availability of B.

Acidic Ammonium Oxalate Extractable Mo (Molybdenum) (pH 3.3)

Very little information is available in the Terai belt of North Bengal on the contexts of these soil components except tea growing soils and for some patches of alluvial soils. Records show that the status of available Mo varies from 0.08 - 0.48 ppm the critical limit being considered at 0.05 ppm. Delineation of Mo deficiency or otherwise is yet to be established particularly in terms of agricultural production and status in soils.

Table 5.5 (f)
Micronutrient Status of Soils of Jalpaiguri and Cooch Behar District
(Teesta and Terai Alluvial Soils)

BLOCK	SAMPLE S ANA-LYSED (NO.)	AVERAGE Zn (ppm)			AVERAGE Fe (ppm)			AVERAGE Cu (ppm)			AVERAGE Mn (ppm)		
		RANGE	MEAN	DEFI-CIENT (%)	RANGE	MEAN	DEFI-CIENT (%)	RANGE	MEAN	DEFI-CIENT (%)	RANGE	MEAN	DEFI-CIENT (%)
Jalpaiguri Dist													
Jal-Sadar	132	0.2-4.1	0.74	58.3	4.8-51.2	53.8	-	0.4-4.9	1.90	-	0.2-46.2	8.6	12.1
Maynaguri	101	0.1-7.0	0.90	62.2	5.9-240.5	52.7	-	0.2-5.5	2.40	-	0.4-26.7	6.7	9.9
Dhupguri	133	0.2-3.7	1.10	16.5	38.2-190.0	105.6	-	1.8-6.4	4.30	-	3.1-43.7	6.5	-
Falakata	230	0.2-7.4	0.70	46.9	5.4-413.6	62.7	-	0.6-6.2	1.40	-	0.9-56.5	14.2	0.8
Rajganj	743	0.1-7.0	0.64	54.8	16.6-197.5	37.4	-	0.3-7.16	1.10	-	0.2-51.5	3.2	13.7
Mal	336	0.1-10	1.30	40.8	16.6-210.1	74.8	-	0.4-6.0	2.80	-	0.5-93.3	9.2	3.2
Madarihat	144	0.2-6.1	1.30	49.3	25.6-336.8	79.0	-	0.7-8.4	3.50	-	1.0-72.0	12.8	1.0
Alipurduar-I	264	0.1-12.5	0.90	55.7	14.3-127.5	57.8	-	0.2-9.9	3.20	-	0.5-56.5	7.3	6.1
Total	2092		0.88	49%		57.8			2.15			7.3	8
Cooch Behar Dist.													
Toofanganj-II	155	0.10-13.5	0.90	47.14	6.0-236.2	102.3	-	0.40-6.2	2.80	-	0.90-80.8	23.6	0.6
Cooch Behar-II	163	0.10-18.5	2.10	41.7	10.1-248.5	106.9	-	0.50-24.4	3.10	-	0.40-98.0	29.0	-
Dinhata-II	191	0.10-40.1	0.80	68.6	32.2-196.4	77.0	-		2.40	-	0.20-47.8	15.9	7.4
Mekhliganj	131	0.10-2.8	2.50	44.3	45.4-134.4	74.9	-	0.50-6.4 0.70-3.8	2.70	-	1.30-64.0	19.6	-
Total	640		1.53	51%		90.3			2.73			21.9	4

5.5(g) Analysis of Soil Samples

Six composite soil samples have been collected from the surface horizons (0-20 cm) from different locations of the Project area and analysed for physico-chemical, and fertility status. Description of the soil samples are as follows :

Sample No.1 : Surface soil from Kumargram Block (Jalpaiguri District)

Sample No.2 : Surface soil from Dinhata II Block fed by STW (Cooch Behar District)

Sample No.3 : Surface soil from Jalpaiguri Sadar fed by RLI (Jalpaiguri District)

Sample No.4 : Surface soil from Moinaguri Block fed by RLI (Jalpaiguri District)

Sample No.5 : Surface soil from Dhupguri Block fed by DTW (Jalpaiguri District)

Sample No.6 : Surface soil from Siliguri Naxalbari Block fed by HTW

Standard procedures were followed for analyses (*5) and for special procedures necessary references have been mentioned below the respective tables 7 and 8.

The results based on six samples presented in Tables 5.5g (i to ix) should not be recognised as the true representatives of the project area and no conclusive remark could be drawn from these tables. It is hoped that it will provide primary information about soil characteristics and the discussion is therefore made on general terms.

1. Physical parameters of the tested soil samples [Table 5.5(g) i] indicate that surface soils are mostly loam to sandy loam in texture, with heavy texture soil in a few patches (Sample 2 where silt and clay constitute more than 90 percent). Soil structure is basically disturbed in the surface horizons and is in general weak, fine granular or crumb. As regards to structural stability, the samples are low to medium in status having water stable aggregates varying from 0.56 to 1.38 when expressed in terms of mean weight diameters (MWD) in mm. Relationship between water holding capacity and available water is wide. The status of available water has been calculated by the difference between the moisture per cent held at (-)0.33 bar and (-)15 bars. The results clearly indicate that the percentage of available water is low because of light soil texture and also due to low organic matter content. Sample No.2 shows the highest value for available water (18.2 percent) which is explained by the high silt and clay percent.

2. Results on chemical composition of soils [Table 5.5(g) ii] have been obtained after removal of the humus (organic) part of the soil, the remaining inorganic part being subjected to alkali fusion and thereafter analysed for $Si0_2$, Al_20_3, Fe_2O_3,

MnO, CaO, MgO, P_2O_5, K_2O etc. These data give an idea of the total quantities present in the soil samples but are not suitable for detecting at any stoichiometric relationships of the soils.

3. Soil acidity and TDS have been evaluated and results are given in [Table 5.5(g) iii]. In general, soils are acidic to slightly acidic in nature. No salinity hazard has been noticed because EC_e values (at 25 degree Centigrade) are within safe limits. Exchangable Al^{+3} appears to play no direct role in controlling soil acidity. However, heavy rainfall and indiscriminate use of irrigation water might have leached out basic cations from the colloidal complexes.

4. Ion-exchange properties and base saturation per cent [Table 5.5(g) iv] indicate that soils have on average low to medium cation exchange capacities and concentrations of exchangeable basic cations (Ca, Mg, Na, K etc.) are low in comparison to other Gangetic alluvial soils of West Bengal. Because of the low status of basic cations in the exchange complex, the percentage base saturation has been rated as low to medium ranging between 51.22 to 73.33 except sample No.2.

5. The nature and characteristics of humus substances, viz. humic acid, fulric acid and humin, contribute to the organic matter status of soils. For an overall picture, the organic carbon per cent is estimated and organic matter status is calculated by multiplying organic carbon percent by a factor 1.724. Table 5.5(g) v, shows the status of organic matter and total N of different soil samples. The results indicate low to medium organic C content with the values ranging from 0.41 to 0.82 per cent. In terms of organic matter, it ranges between 0.7 to 1.42 percent. It is further observed that total N is also low. It varies from 0.04 to 0.09 per cent. The C : N ratios lie in the range 8.88 : 1 to 12.5 : 1. In general, the results indicate low status of organic matter and total nitrogen. Since all the samples have been collected from the agricultural fields, such results are not unusual. These findings imply that little recycling of organic wastes have taken place. Application or organic manures along with N-fertilizers could improve both Organic C and total N status of soils.

6. The state of available macronutrients (N, P & K) has been presented in [Table 5.5(g) vi]. Available N includes summation of NO_3-N and NH_4-N (soluble & exchangeable) and varies from 16 to 22 Kg/ha. Available P level is medium, the values ranging from 21 to 29 kg ha-1. The same is true for available K, which ranges between 109 and 198 Kg ha-1. Comparative data collected from other sources (Soil Testing Laboratory, Department of Agriculture, Government of West Bengal) in respect of available N, P & K from the years 1983-84 to 1991-92 indicate some anomalies between our figures and those data. Figures from H.F.C. and other organisations showed trends similar to the findings of the consultants (*29). Truely speaking, soil fertility has definitely improved due to increased uses of fertilizers, particularly N, P & K fertilizers.

7. Results of DTP extractable micronutrients (Zn, Cu, Fe & Mn) and hot-water soluble B along with acid ammonium oxalates soluble Mo have been presented in Table Nos. 5.5 (g) vii and 5.5 (g) viii respectively. There is no deficiency of Fe (which ranges from 24.3 62.8 ppm) and Cu (which ranges from 1.6 to 5.7 ppm). Mn deficiency is negligible and varies from 3.6 to 19.8 ppm. However, Zn deficiency is widespread ranging between 2.3 and 3.0 ppm. It is sometimes believed that available P and available Fe have a negative impact on Zn availability in soils.

   Available B ranges between 0.12 to 0.98 ppm and available Mo from 0.08 to 0.32 ppm. There are reports that B-application has responded very well particularly in vegetable cultivation and also in cases of pulses and cereals. However, role of Mo has yet to be established since its critical limit for terai alluvium is yet to be found out.

8. Liming is an excellent practice for the maintenance of soil fertility and nutral soil pH. Lime requirement values at different soil pH levels have been given in Table 5.5 (g) ix. It is an essential practice and the exact quantity of effective lime materials must be correctly determined.

   It is worthwhile to note that the results of this study show similar trends with very few exceptions as compared to the findings by the past research in different aspects of soils.

Table - 5.5 (g) i
Physical Parameters

Soil No.	Soil Colour		Texture				Structure		Bulk Density Mgm^{-3}	Water Holding Capacity	Available Moisture (%)
	Dry	Moist	Sand (%)	Silt (%)	Clay (%)	Textural Class	Type	MWD-mm mm			
1	10YR5/3 (Brown)	10YR2/2 (Very Dark Brown)	56.69	24.75	19.56	Sandy Loam	Granular	0.56	1.50	43.6	8.9
2	10YR6/1 (Gray)	10YR4/1 (Dark Grey)	9.15	50.19	40.66	Silty Clay	Sub-Angular Blocky	1.30	1.38	55.7	18.2
3	10YR5/2 (LIght Gray)	10YR5/2 (Greyish Brown)	35.55	47.41	17.04	Loam	Granular	0.69	1.65	42.2	11.6
4	10YR5/2 (Greyish Brown)	10YR5/3 (Brown)	47.41	28.66	23.93	Loam	Granular	0.72	1.70	41.1	11.9
5	10YR6/2 (Light Brownish Gray)	10YR5/3 (Brown	51.91	27.21	20.88	Loam	Crumb	0.71	1.59	39.4	11.3
6	7.5YR5/2 (Brown)	7.5YR3/2 (Dark Brown)	64.52	18.48	17.00	Sandy Loam	Granular	0.58	1.48	42.2	7.8

Table -5.5 (g) ii

Chemical Composition of Soils as % (on oven dry basis)

Soil No.	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	MnO	CaO	MgO	K_2O	P_2O_5
1	47.5	8.29	10.92	0.32	0.16	3.15	3.27	1.69	0.63
2	48.5	6.36	8.48	0.42	0.14	2.24	3.85	2.41	0.57
3	58.8	9.44	11.83	0.28	0.26	3.35	3.03	1.48	0.49
4	50.02	8.90	10.87	0.36	0.31	1.78	2.25	1.60	0.58
5	53.48	8.10	10.10	0.23	0.17	1.85	1.26	0.96	0.62
6	49.31	10.78	17.04	0.32	0.22	3.10	3.85	1.31	0.70

Table 5.5 (g) iii

pH, Exchangeable H^+, Exch· Al^{3+} & ECe

Soil No.	pH	Exch. H^+ Cmol (P^+) Kg^{-1}	Exch. Al^{3+} Cmol (P^+) Kg^{-1}	ECe (dSm^{-1})
1	5.9	0.11	-	0.47
2	6.2	0.27	-	0.38
3	5.8	0.33	-	0.47
4	5.2	0.69	0.29	0.42
5	5.3	0.85	0.35	0.52
6	4.8	0.71	0.38	0.67

Table 5.5 (g) iv

Ion-exchange Properties

Soil No.	CEC [Cmol (P^+) Kg^{-1}]	Exchangeable Cations [Cmol (P^+) Kg^{-1}]				Base Saturation Percentage (%)
		Ca^{2+}	Mg^{2+}	Na^+	K^+	
1	7.05	3.90	0.98	0.12	0.17	73.33
2	16.22	11.41	2.03	0.09	0.12	84.16
3	13.97	6.94	1.49	0.11	0.07	61.63
4	11.66	4.72	1.43	0.08	0.16	54.80
5	12.78	4.96	1.49	0.14	0.11	52.43
6	6.56	1.85	0.98	0.28	0.25	51.22

Table 5.5 (g) v

Organic Carbon & Nitrogen

Soil No.	Organic C (%)	Organic Matter (%)	Total N (%)	C:N Ratio
1	0.50	0.87	0.04	12.50 : 1
2	0.71	1.23	0.08	8.88 : 1
3	0.41	0.71	0.04	10.25 : 1
4	0.65	1.13	0.06	10.83 : 1
5	0.53	0.92	0.05	10.60 : 1
6	0.82	1.42	0.09	9.11 : 1

Table 5.5 (g) vi

Available N,P,K (Kg ha^{-1})

Soil No.	Available N (NH_4 - N + NO_3 - N)	Available P	Available K
1	16	25	109
2	21	21	172
3	15	28	189
4	18	22	198
5	14	24	127
6	22	29	198

Available P x 2.29 = Available P_2O_5

Available K x 1.205 = Available K_2O

Table 5.5 (g) vii

Status of DTPA (ppm) Extractable Cu, Fe, Mn, Zn *

Soil No.	Cu	Fe	Mn	Zn
1	3.8	62.8	19.8	3.0
2	4.5	60.3	12.7	2.3
3	5.7	57.6	11.1	2.6
4	1.9	25.4	3.6	2.8
5	1.6	24.3	4.8	2.0
6	3.5	61.9	6.7	3.0

* --- Lindsay, W.L & Norvell, W.A. (1978) Soil Science Soc. Am. J. 42 : 421

Table 5.5 (g) viii

Hot water Soluble & Available Mo

Soil No.	Hot water Soluble B [1] (ppm)	Available Mo [2] (Acid Ammonium Oxalate : pH 3.3)
1	0.32	0.14
2	0.98	0.08
3	0.72	0.30
4	0.98	0.48
5	0.12	0.32
6	0.61	0.28

1 - Bingham FT (1984) : Methods of Soil Analysis(A.L. Page Ed.), A.S.A, Madison
2 - K.L.Lu & Y.M. Chen (1984) Proc. Nat. Sci. Council ROC (A) 8/2 : 85-92

Table 5.5 (g) ix

Lime Requirements (tonnes/ha)

Soil No.	Lime Required to bring the soil to indicated pH (in tonnes/ha of pure Calcium Carbonate)		
	pH 6.0	pH 6.4	pH 6.8
1	0.45	0.55	0.75
2	-	0.25	0.60
3	0.52	0.64	0.84
4	4.52	5.52	6.28
5	3.51	4.27	4.77
6	5.78	6.78	7.78

5.5 (h) Sedimentation

North of the project area, steep slopes at places with heavy and intense rainfall, highly degraded and deforested lands, earthquakes and landslides combined with unwise terraced cultivation given rise to accelerated soil erosion in the piedmont zone of the Himalayas and the foothills. The rainfall causes sharp increase in the discharge rates in the rivers in the foothills and the plains. The heavy sediment load is brought down by these rivers from the mountain ranges and is deposited in the river bed once they debouch on to the plains causing serious cubature decrease of the river beds. Decreased capacity of the rivers lead to bank overflow and extensive flooding over wide areas in the Terai. River migration is also common during high discharge periods resulting in heavy deposit of sediments. Besides, the yearly floods in the project area cause stream bank erosion, transport of large quantities of sediments spilling over the banks and deposition in the spill zone. In the upper reaches, where the rate of flow in the river is intensive, sands and heavy particles are suspended and are in turn deposited in the surrounding areas. Lower down the deposition is mainly in the form of silt and is largely confined to the widened river bed and the low lying areas forming the spill beds. In Table 5.5(h)i an attempt has been made to provide an estimate of suspended sediment loads in some rivers in the project area as computed by CWC. It is clear that with changing discharge occuring progressively during the monsoon months, the sediment load varies correspondingly.

Table 5.5 (h) i
Estimate of Average Suspended Sediment Load in selected Rivers of the Project area (in thousand tonnes average day)

Rivers	Months				
	June	July	August	September	October
Balasore	23.10	57.93	107.06	17.03	9.72
Mahananda	45.56	90.56	90.56	45.40	10.23
Teesta	2351.27	37982.45	45672.89	3456.89	345.76
Torsa	456.22	6781.11	8934.00	1156.54	301.56
Sankosh	134.57	167.89	569.68	98.76	56.11

The information given in the preceding paragraph indicates that sediment load is a function of the size and bed profile of the given river and of the proportion of the basin under forests or other protective vegetations. For example, the Sankosh is as mighty a river as the Teesta, but it has a higher proportion of its catchment under forests, it carries lesser silt loads.

Table 5.6.1(i)
Locales with Extensive/Intensive Cultivation of Specific Crops

Locale	Crop having extensive coverage and intensive cultivation
Mahananda - Teesta (Jalpaiguri Basin and part of Siliguri Sub-division of Darjeeling district)	Cucurbitaceous vegetables
Ambari Kholta (Cooch Behar district)	Potato
Dewanhat (Cooch Behar district)	Radish and Cucurbitaceous vegetables including Pointed Gourd
Batashi village (Siliguri Naxalbari block of Darjeeling district)	Banana
Dinhata, Dewanhat and Cooch Behar I	Motra (Clinogyne dichotoma), a new and non-conventional crop gaining in commercial importance as raw material for mat making and furniture. The crop is fast gaining popularity as an employment generating avenue for women of Cooch Behar district
Jalpaiguri district (Blocks, Kalchini, Falakata, Nagrakata, Mainaguri, Madarihat and Jalpaiguri)	Ginger (this crop has gained extensive coverage in Jalpaiguri district)

With increasing area of irrigation input [Table 5.6.1(ii) below], emphasis has been continuously shifting in favour of high yielding varieties replacing traditional varieties of almost of all types of crop grown in Terai region.

Table 5.6.1(ii)
Percentage of Gross Cropped Area Irrigated in Terai Districts

District	Percentage of gross cropped area irrigated		
	1971-72	1987-88	1991-92
Jalpaiguri	6.30	9.34	24.0
Cooch Behar	2.30	4.07	17.4

(a) Paddy Rice

The most important crop, rice, was confined to only Aus and Aman cultures. Boro rice is only recently catching up following irrigation development.

Nearly 75% of area covered by Aus rice in the Terai districts was confined to local varieties. Aus culture was predominantly based on direct seeding technique and depended on rainfall and residual soil moisture. The crop used to suffer almost every year from moisture stress due to uneven rainfall distribution pattern. These effects were most serious when dry spells occurred during the post-emergence sending phase

(March end - Mid April) and heading phase (mid-May). The most common local Aus varieties in the Terai districts and the recently transplanted varieties that are gradually replacing the old varieties are given below.

Tale 5.6.1 (a) i
Biodiversity in Aus Rice

District	Names of Local (old) Aus Varieties (mostly direct seeded pre-kherif)	Names of transplanted high yielding Aus varieties catching up as replacement for old varieties		Extent of HYV Aus coverage in percentage (1992-93)
		Pre-kharif*	Kharif or Autumn*	
Darjeeling (Siliguri Sub-division)	Harinkajali Jamira Aruna Nepali Kalam	Kshitish (IET 4094) IET 1444 IET 2233 CR-126-42-1	Mahsuri Swarnadhan (IET 5656) IET 4092 IET 42 IET 2233 IET 1444 CNM 25 Panke, MW 10 (Good HYVs infiltrated from Bangladesh : BR 11, BR 42, Malajadu)	46.9
Jalpaiguri	Harinkajali Chapalo	-do-	-do-	73.3
Cooch Behar	Dumra Bannya Kainan	-do-	-do-	62.4

* These varieties are common to all three districts.

Kharif HYV Aus varities are grown mostly with supplementary irrigation. Mahsuri may be cited as an exception to this since it can withstand occasional dry spells.

While the area under Aus cultivation has successively decreased in two of the three districts, Aus yield rates show an upward trend in all three districts.

Table 5.6.1(a) ii
Area of Cultivation ('000 ha.) and Yield Rate (kg/ha) of Aus Rice in Three Terai Districts

District	Area ('000 ha)			Yield Rate (kg/ha)		
	1975-76	1986-87	1991-92	1975-76	1986-87	1991-92
Cooch Behar	104.49	92.32	82.83	601	711	1219
Jalpaiguri	82.59	61.45	61.41	684	718	1258
Darjeeling (Siliguri Sub-division)	8.10	8.42	11.97	667	825	1213

Despite positive changes in area under Aman rice and gradual introduction of short duration improved varieties, Aman yield has not registered any spectacular improvement in the Terai districts. The reasons are light textured soil with low water retention capacity, high rate of leaching, low rate of photosynthate accumulation as well as succeptibility to disease and pest in periods of interupted rainfall, together with high relative humidity, and occasional dry spells during heading time.

Table 5.6.1(a) iii
Biodiversity in Aman (Winter) Rice

District	Names of local Aman Varieties	Names of HYVs in replacement of local Aman varieties	Extent of HYV Aman coverage in percentage (1992-93)
Darjeeling (Siliguri Sub-division)	Kalam Dangibama Jhingasal Indrasal Raghusal	Common improved Kharif varieties rice Mahsuri, Swarnadhan	49.2
Jalpaiguri	Kalma, Kukurjah Dudhkalam Jadhepa Kalonunma (Scented Rice) Kataribhog (Scented Rice) Sadabhag (Scented Rice) Jhagru, Katar, Kharma (Early Aman)	Common improved Kharif varieties rice Mahsuri Swarnadhan	41.7
Cooch Behar	Jashowa Jaldhepa Dudhkalam Haldijam Phulpakri (Scented Rice) Tulsibhog (Scented Rice) Kataribhog (Scented Rice) Sadabhog (Scented Rice) Jhagru, Katar, Kharma (Early Aman)	Common improved Kharif varieties rice Mahsuri, Swarnadhan	37.6

The Terai districts have made little, contribution to the rice bowel of the state (Boro or Summer rice). It is only now that the area under summer rice is increasing in this non-traditional Terai area. All Boro varieties of this region are HYVs ; IET 2233, China-boro and one or two IR varieties (but not IR-30). The productivity (grain yield per hectare) in the two districts - Cooch Behar and Jalpaiguri, where Boro rice

cultivation is making rapid strides, is nearly twice that of Aus or Aman rice [Table 5.6.1(a) iv].

Table 5.6.1(a) iv
Area of Cultivation and Production Per Hectare of Rice in North Bengal Teari Region

District	Area ('000 ha)			Yield Rate (kg/ha)		
	1975-76	1986-87	1991-92	1975-76	1986-87	1991-92
CROP : AUS (Autumn)						
Cooch Behar	104.49	92.32	82.83	601	711	1219
Jalpaiguri	82.59	61.45	61.41	684	718	1258
Darjeeling*	8.10	8.42	11.97	667	825	1213
CROP : AMON (WINTER)						
Cooch Behar	184.16	206.93	221.92	1026	1089	1242
Jalpaiguri	195.01	201.28	199.31	1082	1040	1340
Darjeeling*	36.16	36.27	26.20	1314	1314	1297
CROP : BORO (SUMMER)						
Cooch Behar	0.77	0.91	9.69	1688	2517	2392
Jalpaiguri	0.23	0.27	1.63	1000	3087	2472
Darjeeling*	-	-	-	-	-	-

* Siliguri Sub-division only

(b) Wheat

The two other crops of economic importance in the agricultural scenario of the Terai region, wheat and jute, have yet to register appreciable biodiversity value, as the areas under both crops are occupied by HYVs only. As to wheat, Sonalika (a HYV) is being cultivated everywhere in the North Bengal Terai area. Other varieties may be more suitable, i.e. overcoming the problems of micronutrient (mostly boron) deficiency. Continued late monsoon and pre-monsoon rains during grain maturity are other factors restricting wheat cultivation in Terai region.

(c) Jute

The picture in jute is somewhat different in the sense that the traditional capsularis belt has seen a rapid change to olitorius jute, because of higher productivity of the latter species and a comparatively better market price. Increasing use of irrigation facilities and fertilizers have favoured olitorius jute so much, that the ratio of olitorius : capsularis jute is now nearly 70:30 in the Terai area. Local capsularis varieties which responded well in low lying, early flooded or water logged areas, and which had a good adaptability to early sowing, have been virtually replaced by two improved capsularis varieties namely JRC 321 and JRC 212. The improved olitorius varieties that

are becoming more popular in the Terai region since their introduction over the last decade , are JRO 524 (NAVIN) and JRO 7835 (BASUDEB).

Thus, the overall picture in jute agriculture in the North Bengal Terai region is that earlier only Corchorus capsularis was recognised as the jute crop of North Bengal. The old capsularis varieties were rapidly maturing local varieties, amongst which there was one fully pigmented variety. This important capsularis belt of West Bengal now presents an altered picture. The reports available with Central Research Institute for Jute and Allied Fibres (CRIJ&AF) indicate that 80% of the capsularis crop of North Bengal Terai region are improved varieties, whereas old capsularis varieties account for only 20% of the jute area. All olitorius varieties that are replacing capsularis are improved varieties. The CRIJ&AF and All India Jute Coordinated Project (ICAR) strongly recommended growing of additional fibre crops like Ramie, Mesta and Sunhemp in this area.

(d) Potato

Potato cultivation in the Terai region has increased in terms of area and yield rate per hectare, mainly as a sequel to irrigation development [Table 5.6.1(d)]. The agro-climatic conditions (light soil, prolonged winter and acidic reaction) and good market facilities have helped the use of irrigation and the total replacement of old potato varieties like Nainital and Darjeeling Red Round by modern HYVs, such as Kufri Jyoti, Kufri Chandramukhi, Kufri Badshah, Kufri Sindhuri and Holland (a pigmented high yielding variety), and also two categories of small sized varieties called Badami and Dieshi. The latter two varieties are cultivated in limited areas for use in culinary preparations like boiled, mashed and curry potato.

Table 5.6.1(d) i
Area of Cultivation and Production per Hectare of Potato in Three Terai Districts

District	Area ('000 ha)			Yield Rate (kg/ha)		
	1975-76	1986-87	1991-92	1975-76	1986-87	1991-92
Cooch Behar	2.33	5.22	6.38	5442	6851	12429
Jalpaiguri	2.10	2.69	5.16	5603	6690	14014
Darjeeling (Siliguri Sub-division)	3.32	3.91	1.13	5180	8629	5426

(e) Vegetables

With the development of irrigation facilities, vegetable cultivation (especially winter vegetables) has made tremendous progress in the project area. Increase in fertilizer use and pesticide application, combined with irrigation, has led to a rapid expansion of HYVs in winter vegetables. Cabbage and cauliflower have become tremendously popular as vegetable crops in the project area ; both HYVs and hybrid varieties (mainly in case of cabbage) are fast replacing the few local varieties. As to brinjal (Solanum melongana), local varieties are still predominant in the Terai region. HYVs and hybrids like Pusa Purple Long, Pusa Kranti, Suphal Long-13 are gradually gaining acceptance. However, a good many of them suffer from susceptibility to wilt disease. The project area is witnessing over the years an increasing replacement of local tomato varieties by HYVs, in particular, by hybrid tomatoes.

In Haldibari block of Cooch Behar district and Mainaguri block of Jalpaiguri district, hybrid tomato cultivation has almost completely replaced the cultivation of local tomato varieties.

Rupali and Sadabahar are two very popular hybrid tomatoes of the Terai region.

The comparative picture in regard to vegetable cultivation during '70s and at present is given in Table 5.6.19e)i.

Table 5.6.1(e) i
Progress in Vegetable Cultivationin Terai Districts
As Reflected by Cultivation of HYVs and Hybrids and
Old Varieties

Old crops and varieties (Pre-'70s)	New Crops and varieties (1986-87 onwards)	Remarks
1. Cabbage	1. Cabbage HYVs : Pride of India, Golden Acre Hybrid : Green Express, Hari Rani, Ganesh Gol, Ganga, Jumana, Caveri	1. Cabbage No old or local variety is being cultivated now
2. Cauliflower	2. Cauliflower HYVs : Early Patna, Kartika, Agrahayani, Maghi, Dania, Snow ball	2. Cauliflower No old or local variety is being cultivated now
3. Brinjal **Mahishshinga, Bottle, Panjapara, Islampur, Krishnapur, Shoulmari, Baromashi**	3. Brinjal Pusa Purple Long, Pusa Purple Cluster, Pusa Kranti, Muktakeshi, Hybrid Brinjal Suphal Long - 13	3. Brinjal Old local varieties are still being cultivated, but the area under local and old vars. is gradually decreasing
4. Chillies **All local varieties for Rabi broadcast crop**	4. Chillies Besides local varieties and improved local varieties (Alipore, Haldibari, Akasi, Suryamukhi), certain HYVs are also being grown Jwala, NP-46 A/B, G-1, G-3	4. Chillies In broadcast crop, progress of replacement of old varieties is nil. In transplanted Autumn and Rabi Chillies, HYVs are being increasingly prefered
5. Tomato	5. Tomato Pusa Rubi, Marglobe, Panjab Chuhara, Roma Hybrid Tomato Rupali Sadabahar	5. Tomato Local varieties have been nearly totally replaced by HYVs and Hybrid tomatoes. The hybrid tomatoes have totally replaced even HYVs in Haldibari (Cooch Behar District) and Mainaguri (Jalpaiguri District) blocks

In the Mahananda - Teesta basin vegetable cultivation (area-cum-yield) and introduction of HYVs, particularly cucurbitaceous crops, has taken off. Intensive cultivation of pointed gourd in Dewanhat of Cooch Behar district trend is a trend in recent times.

Okra or Lady's finger is another vegetable which is becoming immensely popular in the project area. The region is free of pest and disease pathogens affecting this crop. Old and local varieties have been replaced by modern high yielding Okra varieties.

Table 5.6.1(f) i
Changes in Varieties of Pulse

Traditional Crops and Varieties	Crops and Varieties in 90s (with irrigation facilities)
Rainfed local varieties of : Lentil - Winter crop Kalai or Urid - Winter & Pre-(Black gram) kharif crop Mung or Green - Winter crop Gram Kulthi or - Winter crop Horse Gram Khesari (Lathyrus) - Winter Pyra crop	Lentil : Improved winter varieties that have replaced local and old varieties - B 77 (Asha) L - 9.2 Black Gram : T-9 and B-76 have completely replaced old local varieties Green Gram : Only pre-kharif HYVs are now being cultivated. They are : B-1, T-44, Sonali, Panna and K-851 Khesari : B 1 in replacement of local types of Arahar or Pigeonpea is a recent incorporation as pre-kharif crop

(g) Tobacco

Tobacco cultivation is practised in Cooch Behar and Jalpaiguri districts. 90% of tobacco production in West Bengal comes from the Terai region. The area under Nicotiana tabacum or Jati tobacco is declining and that under N. rustica or Motihari tobacco is increasing. The improved varieties that have replaced the old varieties are Chama (S-36-3) and Podali (S-36-14) (N tabacum), whereas three varities of N. rustica i.e. Bitri (early maturing), Soguni (medium) and Hemti (late maturing) are being raised using improved varieties.

As regards other traditional crops, ginger cultivation has made good progress in the project area. However, turmeric, arecanut and coconut cultivation have not made much progress as can be expected in an area where the focus is on irrigation development.

Data on area and production rate of various crops in different years have been presented in Table 5.6.1.

The above account outlines the trends in agricultural production in the project area. It is true that provisions of irrigation, HYVs and fertilizer use have created potential for increased crop production. However, there has been no significant change in cropping patterns. Farmers' preference for crops continues to be guided by compulsions of hunger and environmental factors. This explains the fact that rice still occupies the predominant position. Nevertheless, with increasing irrigation development, remarkable change in land use pattern is being witnessed. Vegetables (winter and summer types) are making good progress. In places away from major urban centres, emphasis is being put in farming of oil seeds and pulses. Thus, in the Terai region, two apparently contradictory trends are visible. On the one hand in the major crops e.g. paddy it is clear that good deal of biodiversity is getting lost due to obliteration of traditional varieties as a consequence of their replacement by HYVs, and, on the other hand, in the event of a number of cropping systems, new crops species (not cultivated earlier in that area) have been accommodated alongside the traditional crops. This explains the increase in the number of cultivated species of pulses, oilseeds and winter and summer vegetables. Some of these crop species were absent from the agricultural scene of the Terai region prior to irrigation development.

Table 5.6.1
Area and Yield of Major Crops in Terai district

Sl No	Crop	Year 1983-84		Year 1988-89		Year 1993-94	
		Area (Ha)	Yield (Kg/Ha)	Area (Ha)	Yield (Kg/Ha)	Area (Ha)	Yield (Kg/Ha)
District : Darjeeling							
1	TOTAL PADDY	44317	2026	52784	1572	N.A.	N/A.
2	BORO			68	3153	377	4760
3	WHEAT	3342	1850	1466	1845	2693	1986
4	BARLEY	59	2200			13	875
5	MAIZE	26735	1488	22139	2490	22400	5580
6	RAGI	9548	700	11325	984	11280	1000
7	TUR(ARHAR)			44	935	9	854
8	MUNG	57	439	15	533	209	759
9	MASKOLAI	631	469	312	481	402	691
10	MUSUR	4	637	3	579		
11	MOTOR	-	-	476	1182	848	493
12	KHESARI	12	754	63	624		
13	KULTHI	40	500			15	350
14	TOTAL TIL	310	526	252	298	14	485
15	RAPE & MUS-TARD CROP	569	508	1024	814	781	632
16	LINSEED	35	597	808	115	848	318
17	NIGER	8	652				
18	JUTE *	3205	5.9	2564	7.95	2519	6.85
19	MESTA*	65	5.48				
20	SOYABEAN	191	450	278	500	508	650
21	POTATO	4047	9476	7088	8638	6882	11118
22	GINGER (FRESH)	1182	2280	1294	2630	1704	1400
23	CHILLI	99	404	90	500	N.A.	N.A.
24	COCONUT CROP#					50	3000
District : Jalpaiguri							
1	TOTAL PADDY	272088	1531	270857	1552	N.A.	N.A.
2	BORO	70	4392	610	3153	1926	3448
3	WHEAT	10179	1929	21206	1294	15001	1548
4	BARLEY	204	1024	9	808	18	875
5	MAIZE	6707	1003	3106	1792	2189	1219
6	RAGI	1952	750	855	472	340	385
7	TUR(ARHAR)	550	999	13	935	54	854
8	MUNG	550	525	31	323		
9	MASKOLAI	2881	397	1412	617	1442	520
10	MUSUR	1116	270	416	649	356	361
11	MOTOR	45	216			132	493
12	KHESARI	2091	754	783	624	1072	862
13	KULTHI	127	575	156	621	75	540
14	TOTAL TIL	1218	458	543	212	30	475
15	RAPE & MUS-TARD CROP	8351	504	9456	514	7273	470
16	LINSEED	957	265	873	226	1340	313
17	NIGER	1118	580	1330	560	1198	560
18	JUTE *	42667	5.9	46105	8.76	37637	413
19	MESTA	1897	540	0.145	6.49	1438	914
20	SUGAR CANE	89	30551	9	68605	68	51154
21	POTATO	4077	12080	5163	15086	7466	10015
22	GINGER (FRESH)	766	1520	970	2100	1160	2400
23	CHILLI	2649	1241	2980	638	N.A.	N.A.
24	COCONUT CROP#	830	5600	925	5625	1040	11000
25	TOBACCO	2899	1051	3572	1027	1915	1110
26	TURMERIC			925	3000	870	3000

Table 5.6.1 (Contd.)

Sl No	Crop	Year 1983-84		Year 1988-89		Year 1993-94	
		Area (Ha)	Yield (Kg/Ha)	Area (Ha)	Yield (Kg/Ha)	Area (Ha)	Yield (Kg/Ha)
District : Cooch Behar							
1	TOTAL PADDY	286558	1626	338562	1787	N.A.	N.A.
2	BORO			8746	3619	10826	2423
3	WHEAT	15252	2169	21652	1738	19459	1522
4	BARLEY	15	1024	6	808		
5	MAIZE	11	1064	43	1387	28	1219
6	RAGI			50	200	11	300
7	TUR(ARHAR)			22	935	6	854
8	MUNG	279	409	234	342	2212	371
9	MASKOLAI	15	667	5532	571	7572	637
10	MUSUR	2098	601	489	622	729	371
11	MOTOR	25	216	16	1182	2	493
12	KHESARI	3733	754	2855	711	1299	862
13	KULTHI	65	700	40	650		
14	TOTAL TIL	304	431	630	425	35	428
15	RAPE & MUSTARD CROP	7596	291	7665	689	5450	655
16	LINSEED	2405	737	2575	646	3204	247
17	NIGER	1178	912	407	750	2600	291
18	JUTE *	61391	6.58	55257	7.91	62336	6.81
19	MESTA*	4924	5.41	1239	6.46	969	9.14
20	SUGAR CANE	62	30551	1	68605	2	51154
21	POTATO	2781	9032	3933	9745	8693	13848
22	GINGER (FRESH)	220	2300	290	2200	371	10000
23	CHILLI	892	572	1040	451	N.A.	N.A.
24	COCONUT CROP#	171	800	390	8100	475	11200
25	TOBACCO	10950	1046	13270	1173	210	1500

COCONUT: YIELD RATE IN NUTS/HA. * Yield Rate in Bales/ha.

5.6.2 **Diversity in Cropping Sequence & Cropping Intensity**

One definite result of enrichment in crop diversity is discernible in development of several alternatives in cropping schedules or sequences. It has also increased cropping intensity to about 170% on average. It has been reported (*7) that in certain blocks of Cooch Behar and Jalpaiguri districts provision of assured irrigation has raised the prospects of achieving 200 to 300% cropping intensity following schedules like :

i) Pre-Kharif short duration rice or capsularis jute followed by Kharif HYV rice followed by tobacco in Rabi season (300% cropping intensity)

ii) Kharif rice e.g., Mahsuri or olitorius jute followed by Rabi tobacco (200% cropping intensity)

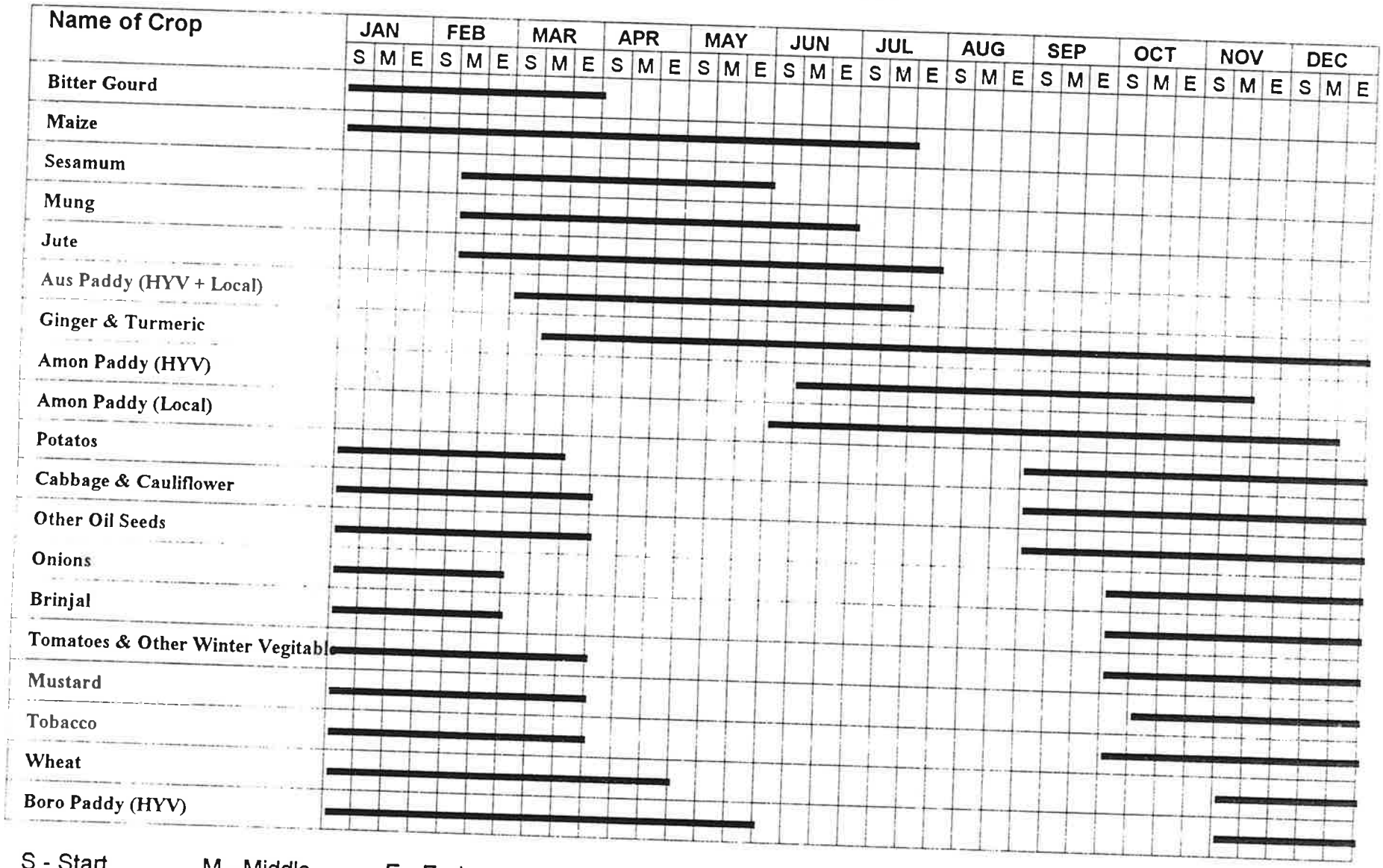
iii) Pre-Kharif short duration HYV rice or jute followed by Kharif HYV rice followed by Potato (300% cropping intensity)

iv) In Cooch Behar I Block, it is possible to take two crops of potato from the same plot of land in a single season (i.e. 200% potato crop intensity) besides growing Kharif HYV rice (300% cropping intensity).

Increase in the cropping intensity in this region, as indicated above, does not necessarily imply equal intensity of increase in application of fertilizers and pesticides, since mostly residual effects of these inputs serve the purpose. At times, supplementation of small

Fig. 5.6.2 (i)

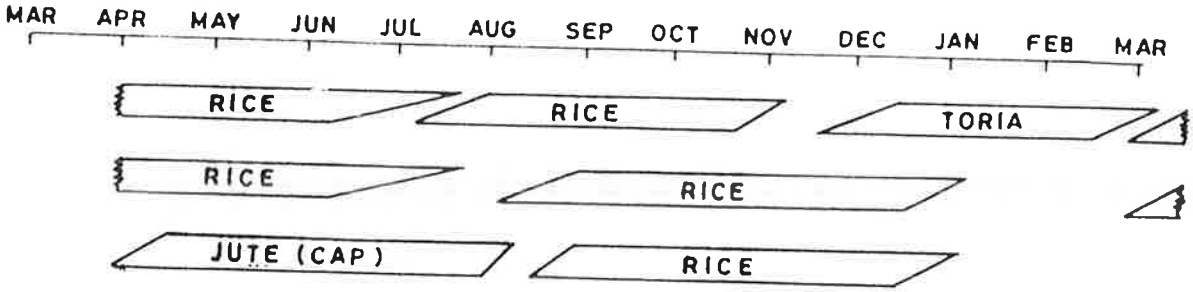
AGRICULTURAL CALENDAR



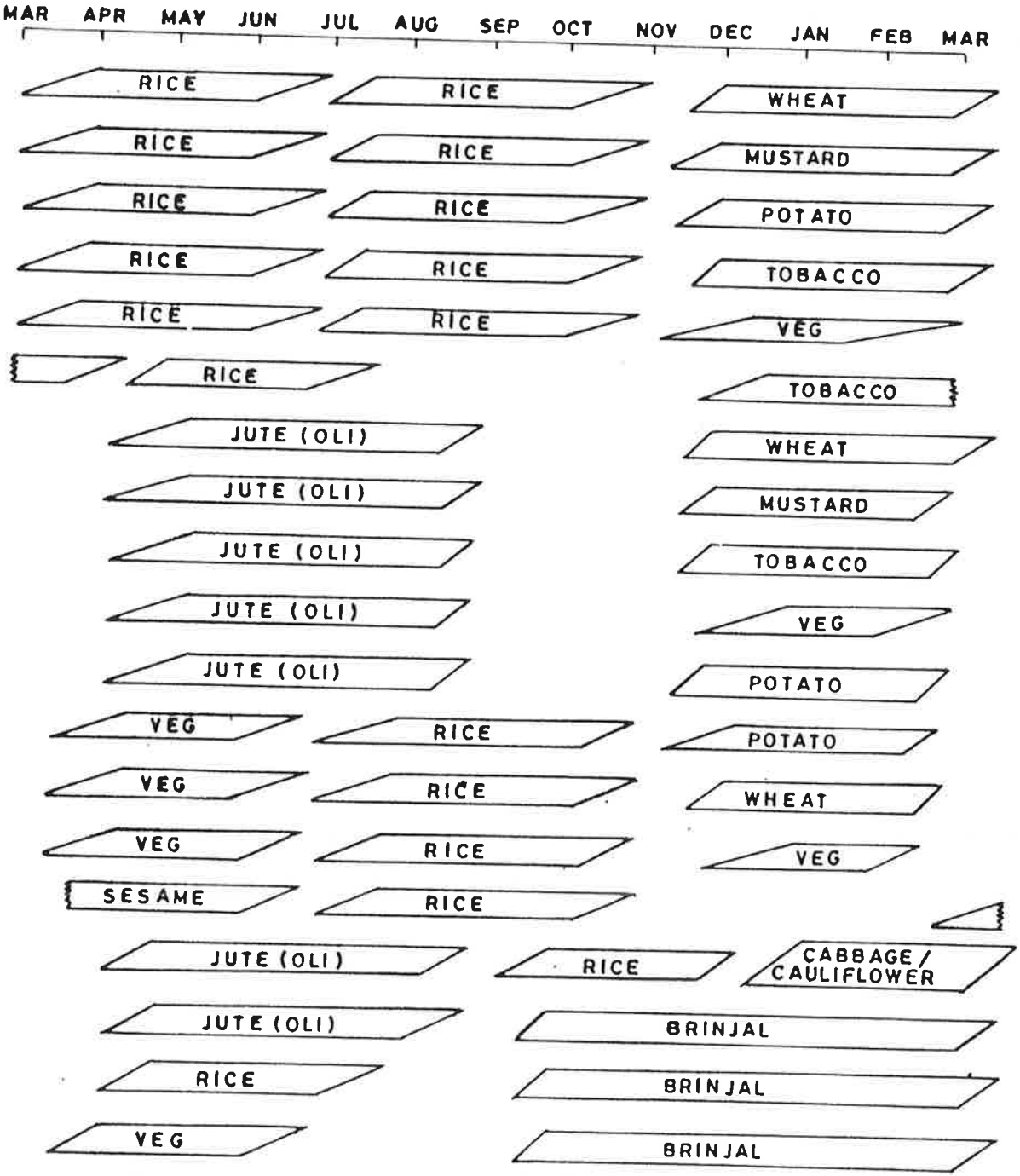
S - Start M - Middle E - End

FIG. 5'6'2 ii

IRRIGATED LOW LAND



IRRIGATED HIGH AND MEDIUM LAND



SOWING TRANSPLANTING

HARVESTING OF CROPS

FIGURE SHOWING ALTERNATIVE CROP SEQUENCES WITH SEASON (FOR TERAI ZONE)

quantity of N fertilizers and pesticides is done for the subsequent crops. The agricultural calendar [Fig. 5.6.2 (i)] bears strong evidence of expanding crop diversity in Terai region. In irrigated high and medium lands some of the various cropping sequences that have emerged are given in the Fig.5.6.2 (ii).

5.6.3 Incidence of Fertilizer Use

There has been a striking increase in the use of fertilizers over the years. Data available show that in Jalpaiguri and Darjeeling districts there has been more than 100% increase in total fertilizer use [Table 5.6.3 (i)].

Table 5.6.3 (i)
Consumption of Fertilizers (M/T)

Year	N	P	K	Total
District : Cooch Behar				
1987-88	12755	5519	3893	22167
1988-89	14335	7718	5535	27584
1992-93	19365	9572	3400	32337
District : Jalpaiguri				
1987-88	5542	2566	2694	10802
1988-89	9565	5798	4425	19788
1989-90	9567	6142	4330	20039
1992-93	14222	7560	2527	24309
District : Darjeeling				
1987-88	3689	1829	1348	6866
1988-89	4437	3310	2451	10198
1992-93	8062	4886	2295	15243

5.6.4 Incidence of Insects, Pests & Diseases and Use of Pesticides and fungicides

There are some noticeable changes in the incidence of diseases and insect pests subsequent upon increasing adoption of HYV technology attuned to irrigated culture. Only a few observations have been reported in this regards. Swarming Caterpillar (Spodoptera mauritia) in rice, pink borer (Chilo auricilius), 4-stripe borer (C.polychrysus) and 5-stripe borer (Schizaphis graminum) in which, aphids (Aphis Craccivora), Bihar hairy caterpillar (Spilosoma obliqua) and stem fly (Melanagromyza phaseoli) in pulses, and aphids (Lipaphis erysimi) and saw fly (Atholia lugens) in oil seeds are some of the important insect pests whose incidence has increased in the Terai region agriculture during the last few years. These are mostly linked to irrigation development and widespread introduction of HYV replacing 'ecologically' resistant traditional varieties. Amongst the diseases, the incidence of soil-borne diseases (e.g., Sclerotium, Pythium and Phytophthora species) causing rots and blights in a number of crops, and diseases due to micronutrient deficiency (particularly Boron and Zinc deficiency) are on the increase. Increasing Nematode infestations on autumn paddy, jute and most of the vegetables, and wilting of Solanaceous crops (potatos, brinjal etc.) also give reasons for concern. Pesticide use has increased considerably, but no data is available on pesticides supply and use. Products are purchased from the dealers'. However, as the table below shows, in recent years, liquid pesticides have become more popular in Terai agriculture than other forms.

Table 5.6.4(i)
Use of Pesticides - Jalpaiguri

	1988-89	1990-91
Dust	109389 kg	34342 kg
Liquid	3137 kg	31120 lit
Granule	1012 kg	512 kg
WP	1960 kg	1550 kg
No of Sale Points	135	228

5.7 Livestock, Fish Population, Economic Yield from Animal Resources

5.7.1 Livestock

(a) Cattle and Buffaloes

The census data presented in Table 5.7.1 reveal that populations of cattle, goat and poultry have increased during the period 1977-87 in two Terai districts namely, Cooch Behar and Jalpaiguri. (Separate census figures for Siliguri Sub-division of Darjeeling district were not available.) In regard to sheep, the figures show that the population declined in Jalpaiguri district but is increasing in Cooch Behar district. The population of buffaloes and horses have declined in both the districts.

Considering agewise, breedwise and sexwise distribution of the livestock population, the Consultants have found that, in both the Terai districts, mature age-group cattle constitutes over 60% of the population, whereas amongst buffaloes, over 80% belong to the mature age group. As regards the female population in the mature age group, the figures are nearly 50% for cattle and 25% for buffaloes, taking both the Terai districts together. For both species, the number of female population decreases with advancing age. In buffaloes the reduction is rather drastic when compared to the cattle population. The reason is to be found in preferential use of buffaloes as draught animals and for soil tillage. Improvement in buffalo population through breeding is yet to take off. Nevertheless, some improvement is already becoming discernible among the cattle population in Cooch Behar and Jalpaiguri districts. The total population of cross-bred cattle in the two Terai districts is 35,165 which is 1.97% of the total cattle population, a percentage of cross-bred cattle is unlikely is increase when data of 1993 onwards are taken into consideration, because of earlier cross-breeding programme in lower age groups (1987-88).

(b) Sheep and Goats

Sheep rearing, as the data show (Table 5.7.1) is still to catch up in these two Terai districts. Improved breed of sheep constitute 10% of total sheep population of the region. The indigenous breed of goat called "Bengal Breed" is the only genotype reared in the two districts. Although these goats are small-sized and short-statured animals, they are well appreciated for their very high "multiple birth" rate (84%), excellent quality meat and for producing one of the finest quality of skin-leathers as per world standard.

(c) **Pigs**

Cooch Behar district is considerably lagging behind in pig rearing as compared to Jalpaiguri district. The local pigs produce about 5 - 6 piglets per litter and are small in size. The improved breeds (cross-bred and exotic bred), which produce 12 - 16 piglets per litter, are gradually making in-roads in the Terai region (16.5% of total pig population). The Jalpaiguri district is considerably ahead of Cooch Behar district with respect to pig rearing (Table 5.7.1).

(d) **Poultry Birds and Ducks**

Chickens and ducks, the farming of which is increasing in West Bengal, are still of low economic importance. However, districtwise data show that the poultry population of Cooch Behar district is much less than that of Jalpaiguri district. The population of improved breeds of poultry in Jalpaiguri district is nearly twice that in Cooch Behar. Only 11% of Poultry population of Terai region belong to improve breeds. Cooch Behar district, however, is ahead of Jalpaiguri district in terms of duck population, whether belonging to improved or indigenous breeds.

Table 5.7.1
Data From Livestock Census

	Cooch Behar			Darjeeling			Jalpaiguri		
	1977	1982	1987	1977	1982	1987	1977	1982	1987
Cattle	680123	812306	899339	166198	202821	137384	646384	845317	885688
Buffalo	12807	10404	10213	7081	8193	906	38445	26760	23522
Sheep	9701	8587	10516	2568	4448	1386	7685	3674	4566
Goat	295601	449201	520804	82375	167678	131350	300999	528660	544270
Pig	10309	4764	-	17234	45852	-	30921	62803	-
Total Poultry	488132	783720	-	209162	559270	-	713123	1598015	-

5.7.2 Fish

It is not possible to make any quantitative deductions on fish populations and productivity in the project area, mainly because quantitative data are lacking. A few general comments can be made based on views of technical officers and scientists in the area. The fish population of the Terai districts is on the lower side of the economic scale of the State of West Bengal as a whole. The names of species collected are given below. Little is known on the survival status of the species. In terms of suitable habitat, Cooch Behar district has considerably more areas under tanks, canals and beels/baor than Jalpaiguri district or Siliguri sub-division of Darjeeling district. To the contrary, Jalpaiguri district, has more river, water area than Cooch Behar [Table 5.7.3b(i)].

As to the Darjeeling district data given in the Table, it is not possible to make any comment on the same, as these figures do not strictly pertain to Siliguri Sub-Division only [Table 5.7.3 (b) ii].

Fish Species Found in North Bengal Terai Region

Common Carp (Cyprinus Carpio L.)

Silver Carp (Hypophthal michthys molitrix (Valenciennes)

Grass Carp (Ctenopharyngodon idella V.)

Tilapia (Tilapia mossambica Peters)

Gourami (Osphronenus Goramy Lacepede)

Catla (Catla catla)

Labeo rohita, Cirrhinus mrigala

Labeo bata, Cyprinus Carpio

Channa marulius
L. Calbasu

5.7.3 Economic Yield from Animal Resources

(a) Milk & Egg Production

As the data given in Table 5.7.3(a) i indicate, cow milk is the major component of total milk production in the project area. Buffalo milk constitutes less than 5% of the total milk production in any year. There has been a decrease in total milk production over the years between 1988-89 and 1993-94 in Jalpaiguri and Cooch Behar districts. In the Darjeeling district (Terai area) however, an increasing trend in cow milk yield during this period is noticeable. This low volume of milk production, in general, may be partly attributed to a lack of productive cross-breeds and improved bred cattle and buffaloes, which is due to a lack of genetic improvement programmes, financial constraints of most of the owners (small and marginal farmers), acute shortage of fodder and poor nutrition. Noteworthy is the striking lack of fodder-crop production during winter (rabi) fallow.

Egg production of Cooch Behar and Jalpaiguri districts has decreased in 1993-94 as compared to production figures in 1988-89 [Table-5.7.3 (a) i], with Jalpaiguri district witnessing a drastic reduction in egg production. Darjeeling district registered an increase in egg production during this period. Duck egg production, on the other hand, shows increasing trends in all three districts. One remarkable aspect of trends in egg production over the years between 1988-89 and 1993-94 is, that, although duck egg production has continued to lag behind the poultry egg production in Jalpaiguri and Darjeeling, it has reached almost levels in the five years in Cooch Behar district. This is possibly due to availability of more water area in the Cooch Behar district [Table 5.7.3 (a) i]. Total egg production, in Jalpaiguri district registered a drastic reduction in 1993-94 as compared to 1988-89 figures. The production figures for Cooch Behar district remained almost unchanged, but Darjeeling district figures showed a considerable increase in production between 1988-89 and 1993-94.

Table 5.7.3 (a) i
Milk & Egg Production

District	Milk Production in '000 Mts			
	Year	Cow	Buffalo	Total
Cooch Behar	1988-89	107.7	1.7	109.4
	1993-94	104.0	0.7	104.7
Darjeeling	1988-89	100.2	3.1	103.3
	1993-94	106.7	2.1	118.9
Jalpaiguri	1988-89	108.7	6.7	115.4
	1993-94	109.8	3.5	113.3

District	Egg Production in Million Nos			
	Year	Fowl	Duck	Total
Cooch Behar	1988-89	33.89	16.36	50.25
	1993-94	27.19	23.42	50.62
Darjeeling	1988-89	31.22	0.75	31.97
	1993-94	53.81	2.13	55.94
Jalpaiguri	1988-89	106.44	12.11	118.56
	1993-94	54.32	15.68	113.3

(b) Fish Production

The indigenous supply demand gap for fish in North Bengal Terai area is already large. Like in other parts of West Bengal, fish production of this area is low. The table [Table - 5.7.3 (b) ii] reveals that annual fish production of Cooch Behar district alone has been considerably higher (about 3.2 to 3.4 times) than the combined fish production of Jalpaiguri and Darjeeling (Siliguri Sub-division) districts combined. Again, while the annual fish production figures for the latter two districts have remained constant between 1991-92 and 1993-94, the figures of Cooch Behar district show a continuing increase over the period. Increased water area [Table - 5.7.3 (b) i] is evidently one reason for this increase in fish production of the Cooch Behar District. Another important reason is the effect of installation and use of HTWs in fish culture.

Table 5.7.3 (b) i
Area of Water Bodies

DISTRICT	TANK (HA)	BEEL/BAOR (HA)	RIVER (HA)	CANAL/KHAL (HA)
Cooch Behar	4319.31	1168.11	13095.82	1664.58
Jalpaiguri	955.77	504.38	16006.44	562.29
Darjeeling	-	683.94	3395.63	683.94

Table 5.7.3 (b) ii
Fish Production
(in 100,000 Tons)

DISTRICT	1991-92	1992-93	1993-94
Cooch Behar	0.31	0.32	0.34
Jalpaiguri	0.08	0.08	0.08
Darjeeling	0.02	0.02	0.02

5.8 Agroforestry

Agroforestry activities are still of little importance in the North Bengal Terai area. Sporadic agroforestry - type activities are being pursued by some villagers in a number of Blocks. The State has launched initiatives in this direction by promoting Central and State Government activities like setting up of a Regional Centre (Central Plantation Crops Research Institute) at Mohitnagar, and research on agroforestry in North Bengal under the West Bengal Forestry Project. Arecanut-based multiple cropping experiments at Mohitnagar are promising in terms of (a) productivity increase per unit area and maximising economic returns (b) organic matter recycling and improvement of soil fertility through increased microbial activities. Agroforestry research of North Bengal has led to the realization that some economic crops (yielding food, fibre, medicine and essential oils), which could be grown in conjunction with forest crops. Agroforestry trials by the State Forest Department of West Bengal (as reported in the "Workshop on Cattle Development and Fodder Cultivation in Wild Life Area", held at Raja Bhatkhawa on March 26, 1995) under "Comprehensive Fodder Development Programme" in Jalpaiguri district indicated good prospects for getting non-conventional fodder from certain leguminous trees like Acacia albida, Albizia spp., Gliricidia, spp., etc. and also from perennial fodder crops like Stylo, etc.

Intercropping using agroforestry technics could be further developed. Turmeric (Curcuma longa), ginger, citronella, black pepper, etc. are suitable species for intercropping. Plantation crop culture experiments at Mohitnagar point to similar possibilities for remunerative inter-and mixed cropping of Arecanut plantations with betewine, banana, acid lime, pulses and vegetables. Agroforestry for fuel wood production is also a crying necessity in the Terai area. Besides, Acacia albida and other Acacia spp., a number of other species like Albizia, Betula, Butea, Derris, Emblica, Gliricidia, etc. may be grown for fuel wood as well as for organic matter build-up in neighbouring agricultural lands. The vast areas of cultivable waste land in the Terai zone should be able to sustain agroforestry and plantation crop farming. Putting some of their own farm land or homestead land under such crops as arecanut and bamboo, and farming of motra (Clinogyne), is already practised at some places in the Terai districts.

Thus, agroforestry and plantation crop farming have good economic prospects : these activities would relieve the serious shortage of fuelwood and wood provide grazing and fodder production for livestock.

Both agro and social forestry including plantation programme for stabilisation of embankment will help augment economic returns from minor forest products also. A list of some minor forest products being exploited at present and with good potentials for expansion in the Terai region is given below :

Minor forest products that can be further developed in North Bengal Terai Region

1. Honey
2. Wax
3. Citronella oil
4. Sal Seeds (Shorea robusta)
5. Kendu leaves (Diospyros melanoxylon)
6. Bamboo (Bambusa spp.)
7. Cane (Calamus spp./Clinogyne)
8. Grasses
9. Harra (Terminalia chebula , Chebulia myrobalan or Myrobalan [Family : Combretaceae]
10. Bahera (Terminalia bellirica or Belliric myrobalan [Family : Combretaceae]
11. Amla (Emblica officinalis) [Family : Euphorbiaceae]
12. Tamarind (Tamarindus indica) [Family : Caesalpiniaceae]
13. Mahua (Madhuca indica) [Sapotaceae]
14. Achar or Chironji (Buchanania lanzan) [Family : Anacardiaceae]
15. Mango (Mangifera indica) [Family : Anacardiaceae]
16. Jack Fruit (Artocarpus heterophyllus) [Family : Moraceae]

As a consequence of a number of research studies and trials between 1967 and 1989, the following companion crops came to be recognised for intercultivation with forest crops in the Terai region of West Bengal at various stages of growth of forest crops : turmeric (Curcuma longa) [Family : Zingiberaceae], ginger (Zingiber officinale) [Family : Zingiberaceae], citronella and black pepper.

Due to lack of proper marketing and absence of good storage facilities, cultivation and production of pineapples is facing a severe jolt in the Terai region for the past few decades. However, the prevalent climatic and soil conditions of North Bengal are truly favourable for pineapple cultivation, as an export commodity. In order to fetch quick returns, there has been a rising tendency to convert pineapple orchards into tea gardens, thus paving the way for increased soil, water and land pollution. To stop undue increase in monoculture practices of tea in this region, the age-old pineapple cultivation has to be restored along with development of proper storage and marketing facilities, which will favour optimal utilisation of land and enhance the positive impacts on the environment.

5.9 Embankment Stabilisation through Planting of suitable tree species for soil protection

The issue of stabilisation of the constructed embankments in Terai region is a complicated one. The embankments constructed in North Bengal Terai region are mostly

found to have been planted with the tree species like Sissoo (Dalbergia sissoo) and Babul (Acacia nilotica). These trees have not been suitable for the purpose of soil production and embankment stabilisation. The reason is that the light texture and the preponderance of coarse sand of the soil belonging to the area have caused threats like scouring and bank collapse. Hill deforestation and Dolomite mining etc. in the Northern hill areas have aggravated these risks.

5.10 Fodder Production

Organised local production of green fodder in the project area is negligible from the point of view of actual fodder requirements of livestock. The quality of agricultural residue (mostly stubbles) is rather poor and insufficient. The bulk of concentrate-feed is procured from outside the state of West Bengal. Whatever little quantity of fodder is cultivated in the three project districts is restricted to rainfed cropping. Hardly any fodder crop is raised with irrigation support. The main crops grown are maize Zea mays), jower (Sorghum vulgare), cowpea (Vigna sinensis), Rice bean (Vigna rembellasa) and oats (Avena sativa). The common perennials that are making their appearance slowly in the Terai region are Hybrid Napier, Para grass, Guinea grass, Dinanath (Pennisetum padyselatum), Signal grass (Brachyaria rosanensis), Panicum maxium, Stylosanthes, Centrosema, Paspalum etc. They are mostly grown in degraded forests for the purpose of inter-cropping.

5.11 Analysis of Data from Farmers' Survey

Data from the farmers` survey (para 4.5.0) were analysed under the following 4 major heads.

5.11(a) Drinking Water Supply & Sanitation

The status of drinking water supply among the farmers, classified by types of irrigation structures is given in Table 5.11(a)i. More than 90% of the families have an in-house source of drinking water, of which the majority (63.74%) have hand tubewells, while the rest use open dug wells (ODW). As an outside source both deep and shallow tubewells are used to some extent while the ordinary dug well is the major source. For washing and bathing facilities [Table 5.11(a)ii] hand tubewells are again the major source followed by open dug wells, but ponds are also used by a sizable number of households (13.91%). As found earlier [para 5.3(e)ii] about 90% of the dug wells and 15% of the hand tubewells produce bacteriologically bad quality of water. Some of the hand tubewells also produce water with excess of iron which stain clothes and give uneasiness in the stomach.

Table 5.11 (a) i
Drinking Water facilities Against Irrigation Structure Used
(As percent of Row Total)

	IN HOUSE		OUTSIDE			TOTAL
	ODW	HTW	ODW	DTW	STW	
PDW	90.00	10.00	0	0	0	100.00
HTW	7.50	90.00	0	2.50	0	100.00
STW	0	83.33	0	0	16.67	100.00
DTW	25.00	75.00	0	0	0	100.00
RLI	46.67	6.67	40.00	0	6.67	100.00
TOTAL	26.37	63.74	6.59	1.09	2.20	100.00

Table 5.11 (a) ii
Washing and Bathing Water facilities Against Irrigation Structure Used
(As percent of Row Total)

	IN HOUSE				OUT SIDE				TOTAL
	ODW	HTW	PDW	POND	POND	ODW	PDW	RIVE R	
PDW	80.00	0	10.00	0	0	0	10.00	0	100
HTW	12.20	73.17	0	0	2.44	4.88	0	7.32	100
STW	0	40.00	0	40	20	0	0	0	100
DTW	23.81	66.67	0	0	0	0	9.52	0	100
RLI	35.71	0	0	0	57.14	7.14	0	0	100
TOTAL	25.27	50.55	1.10	2.20	10.99	3.30	3.30	3.30	100

As regards sanitation, Table 5.11(a) iii gives the existing situation which show that open defecation in the field is practised by most (71.43%) of the sample tract while pit latrines are used by 24.18%. Use of open field and pit latrine are likely to contribute pathogenic bacteria to the soil which often end up in the drinking water sources like dug well and different types of tubewells. Incidentally, even if the users of the open field could be induced to use pit latrines, the situation is unlikely to improve. Properly designed low cost sanitation units sited away from the direction of aquifer flow, can reduce the risk of bacteriological contamination.

Table-5.11(a)iii
Sanitary Facilities Against Irrigation Structure Used
(As percent of Column Total)

	OPEN FIELD	COMMUNITY LATRINE	PIT LATRINE	SANITARY LATRINE	GRAND TOTAL
PDW	50.00	0	40.00	10.00	100
HTW	80.00	2.50	17.50	0	100
STW	66.67	0	33.33	0	100
DTW	55.00	0	35.00	10.00	100
RLI	86.63	0	13.33	0	100
TOTAL	71.43	1.09	24.18	3.30	100.00

5.11(b) Health

The farmers' survey also collected data on disease, both water-borne diseases and vectors depending on water for part of their life cycle. The data are presented in Table 5.11(b) as percentage of sanitation facilities. It is found that gastro-enteritis is the major ailment in the area and is prevalent in the houses with and without latrine. Since these diseases are mostly from water contaminated with bacterial pathogens, it may be concluded that water sources are in general polluted with pathogens from fecal sources. Worm infection, which is a major ailment in the project area is due again to fecal contaminations of soil. Both infestations indicate that fecal pollution of soils is a major source of ailment in the project area. Malaria, the next common disease, is due to specific mosquitoes, which are reported to have increased in the project area. While major sites of mosquito breeding are the ponds and small pools of water surrounding the project area, the additional irrigation water generated by this project also favours Malaria growth through pools of water created at the inlet points of RLI and at V-notchs point and the leaking spouts and pipes and valves of the deep tubewells.

Table 5.11 (b)
Ailment of Different Types Against Latrine Facilities
(As percent of Sanitation Facilities)

Deceases	Latrine In-House	No Latrine
Malaria	20	22
Gastro-enteritis	76	62
Pulmonary Problem	8	15
Worms	28	40
Food Poisoning	12	19
Not Affected by any ailment	8	12

5.11(c) Changes in Farm Characteristics

The farmers were interviewed regarding their views on specific items related to their farms and farming practices. The results are given in [Table 5.11(c) i and ii] for farmers having three crops a year and less than three crops, classified by project structures respectively. Similar data for the farmers as a whole are given in [Table 5.11(c)iii and iv] grouped under irrigation structures and sizes of land holdings respectively. From these tables it is found that, in general, the requirement for fertilizer and availability of irrigation water showed an increase along with yield of crop but simultaneously invasion of weeds and plant diseases have also increased. Very few farmers complained about increase in water-logging. It is found, in general, that use of lime is not common. In fact most of the users of HTW (84.62%) and DTW (65.00%) and all of the users of STW interviewed do not use lime. Out of the remaining families, 16.67% indicated increase in lime use. Most lime users (i.e. 42.61%) are found in the 1 - 2 ha land holding category. In this category majority reported increase of lime use.

Farmers growing three or more crops per annum, fertilizer use has increased for all types of project structures, with a maximum (100%) for STW and RLI users. However,

only in case of RLI users stiffness of soil is reported to have increased in a large number of cases (90%). Simultaneously, this group reported increase in crop yield. Substantial increase of insects and weeds, and also in plant diseases is being reported. Clearly, this group is the major user of insecticide as reported. Most members of these groups, i.e. 90%, use lime with 60% of the users reporting an increase in lime demand. A majority of PDW users (71.43%) also use lime and 42.86% of them reported an increase. Most of the HTW and STW users do not use lime. In comparison, among the farmers growing less than three crops, lime is not used by almost 80%, though in the RLI group lime use is quite substantial (80%) with 60% showing no change in lime requirements over the years. All of the PDW and STW and most of the HTW users in this group do not use lime.

5.11(d) Perception of the Project Benefits by the users

Tables 5.11(d)i, ii and iii show the users' perception of changes in certain items as well as the perceived advantages of the project interventions. In 5.11(d)i items like fish production, changes in weed growth and mosquito menace are recorded. The table shows that, according to 56.52% of farmers fish production in ponds have increased, while 39.13% opined a decrease in fish production. As subsequently discussed, this is due to the fact that fish production through organised pisiculture has shown substantial increase in Cooch Behar, while the same is not true for Jalpaiguri and Darjeeling. Fish production in the rivers has for obvious reasons decreased. This may be primarily due to the fact that most of the rivers now have very little flow in the summer. In the opinion of farmers (45.65%), weed growths have decreased in the project area. There are a number of small ponds and water pools, where thick carpets of weeds can be seen. However, compared to the total water bodies such areas are not large. No formal attempt towards reduction in weed growth are taken, except through the use of chemicals in the fields for controlling weeds mostly in case of farmers having three harvests. There is a universal perception that mosquito menace has increased. This issue has been discussed elsewhere in the report .

The perception of the farmers regarding the advantages of the project is recorded in terms of the structures as well as the extent of land holdings. In both cases most of the farmers have opined that advantages are medium (68.13%) to high (17.58%). However, among the users of different types of structures 50% of the users of the STW recorded the advantages as high and 25% of the HTW and the 20% of the RLI users commented the advantages to be low. Similar perceptions are found amongst the different groups of land holders, most of whom considered the advantages to be medium. This feeling is more prominent for the groups owning 1 - 2 ha. of land. This group has almost equal percentages declaring the project advantages to be high and low. The perceptions of those having less than 1 ha are also more or less the same.

PERCENTAGE OF FARMERS INTERVIEWED	PDW			HTW			STW			DTW			RLI			TOTAL		
	I	D	NC	I	D	NC	I	D	NC	I	D	NC	I	D	NC	I	D	NC
	15.22			32.61			6.52			23.91			21.74			100.00		
REQUIREMENT OF FERTILIZER	85.71	0.00	14.29	80.00	6.67	13.33	100.00	0.00	0.00	90.91	9.09	0.00	100.00	0.00	0.00	89.13	4.35	6.52
AVAILABILITY OF IRRI. WATER	71.43	0.00	28.57	80.00	13.33	6.67	66.67	33.33	0.00	100.00	0.00	0.00	100.00	0.00	0.00	86.96	6.52	6.52
STIFFNESS OF SOIL	28.57	14.29	57.14	20.00	0.00	80.00	33.33	0.00	66.67	18.18	27.27	54.55	90.00	10.00	0.00	36.96	10.87	52.17
YIELD OF CROP	71.43	28.57	0.00	86.67	6.67	6.67	66.67	33.33	0.00	90.91	0.00	9.09	100.00	0.00	0.00	86.96	8.70	4.35
INCREASING OF INSECTS	100.00	0.00	0.00	33.33	40.00	26.67	0.00	33.33	66.67	45.45	18.18	36.36	90.00	10.00	0.00	56.52	21.74	21.74
INVASION OF WEEDS	100.00	0.00	0.00	73.33	20.00	6.67	33.33	33.33	33.33	100.00	0.00	0.00	90.00	10.00	0.00	84.78	10.87	4.35
PLANT DISEASE	100.00	0.00	0.00	40.00	26.67	33.33	0.00	33.33	66.67	90.91	0.00	9.09	100.00	0.00	0.00	71.74	10.87	17.39
WATER LOGGING	0.00	57.14	42.86	33.33	33.33	33.33	33.33	33.33	33.33	9.09	45.45	45.45	10.00	90.00	0.00	17.39	52.17	30.43
REQUIREMENT OF LIME	42.86	14.29	14.29	6.67	6.67	13.33	0.00	0.00	0.00	18.18	0.00	27.27	60.00	10.00	20.00	26.09	6.52	17.39
NO USE OF LIME	28.57			73.33			100.00			54.55			10.00			50.00		
INCIDENCE OH EARTHWORMS	28.57	42.86	28.57	20.00	13.33	66.67	0.00	33.33	66.67	18.18	54.55	27.27	10.00	90.00	0.00	17.39	45.65	36.96

Table 5.11 (c) ii PERCEPTION OF THE BENEFICIARIES' MAKING LESS THAN THREE CROPS ABOUT CHANGE IN LANDFORM AGAINST IRRIGATION STRUCTURE USED

PERCENTAGE OF FARMERS INTERVIEWED	PDW			HTW			STW			DTW			RLI			TOTAL		
	I	D	NC	I	D	NC	I	D	NC	I	D	NC	I	D	NC	I	D	NC
	6.82			54.55			6.82			20.45			11.36			100.00		
REQUIREMENT OF FERTILIZER	33.33	0.00	66.67	58.33	8.33	33.33	66.67	0.00	33.33	77.78	0.00	22.22	100.00	0.00	0.00	65.91	4.55	29.55
AVAILABILITY OF IRRI. WATER	66.67	0.00	33.33	75.00	20.83	4.17	33.33	33.33	33.33	88.89	0.00	11.11	100.00	0.00	0.00	77.27	13.64	9.09
STIFFNESS OF SOIL	33.33	33.33	33.33	29.17	8.33	62.50	0.00	0.00	100.00	0.00	11.11	88.89	40.00	20.00	40.00	29.55	9.09	65.91
YIELD OF CROP	66.67	33.33	0.00	37.50	41.67	20.83	33.33	66.67	0.00	77.78	0.00	22.22	20.00	60.00	20.00	47.73	36.36	18.18
INCREASING OF INSECTS	66.67	0.00	33.33	37.50	12.50	50.00	33.33	66.67	0.00	44.44	0.00	55.56	20.00	0.00	80.00	43.18	11.36	50.00
INVASION OF WEEDS	66.67	0.00	33.33	83.33	4.17	12.50	0.00	66.67	33.33	33.33	11.11	55.56	100.00	0.00	0.00	88.18	9.09	22.73
PLANT DISEASE	66.67	0.00	33.33	62.50	16.67	20.83	33.33	33.33	33.33	55.56	0.00	44.44	80.00	0.00	20.00	63.64	11.36	27.27
WATER LOGGING	0.00	100.00	0.00	8.33	75.00	16.67	33.33	0.00	66.67	33.33	44.44	22.22	20.00	20.00	60.00	15.91	63.64	25.00
REQUIREMENT OF LIME	0.00	0.00	0.00	0.00	4.17	4.17	0.00	0.00	0.00	22.22	0.00	0.00	20.00	0.00	60.00	13.64	2.27	13.64
NO USE OF LIME	100.00			91.67			100.00			77.78			20.00			79.55		
INCIDENCE OH EARTHWORMS	0.00	100.00	0.00	45.83	25.00	29.17	0.00	33.33	66.67	0.00	66.67	33.33	40.00	60.00	0.00	29.55	43.18	27.27

NOTE : I - INCREASE
D - DECREASE
NC - NO CHANGE

Table 5.11(c) ■ USERS' PERCEPTION REGARDING CHANGES IN FARM LAND AFTER PROJECT INTERVENTION AS PERCENT OF IRRIGATION STRUCTURE USED

SURVEYED HOUSEHOLD : 91 *

	PDW			HTW			STW			DTW			RLI			TOTAL		
	I	D	NC	I	D	NC	I	D	NC	I	D	NC	I	D	NC	I	D	NC
PERCENTAGE OF FARMERS INTERVIEWED	11.11			43.33			6.67			22.22			16.67			100.00		
REQUIREMENT OF FERTILIZER	70.00	0.00	30.00	66.67	7.69	25.64	83.33	0.00	16.67	85.00	5.00	10.00	100.00	0.00	0.00	77.78	4.44	17.78
AVAILABILITY OF IRRI. WATER	70.00	0.00	30.00	76.92	17.95	5.13	50.00	33.33	16.67	95.00	0.00	5.00	100.00	0.00	0.00	82.22	10.00	7.78
STIFFNESS OF SOIL	30.00	20.00	50.00	25.64	5.13	69.23	16.67	0.00	83.33	10.00	20.00	70.00	73.33	13.33	13.33	30.00	11.11	58.89
YIELD OF CROP	70.00	30.00	0.00	56.41	28.21	15.38	50.00	50.00	0.00	85.00	0.00	15.00	73.33	20.00	6.67	66.67	22.22	11.11
INCREASING OF INSECTS	90.00	0.00	10.00	35.90	23.08	41.03	16.67	50.00	33.33	45.00	10.00	45.00	66.67	6.67	26.67	47.78	16.67	35.56
INVASION OF WEEDS	90.00	0.00	10.00	79.49	10.26	10.26	16.67	50.00	33.33	70.00	5.00	25.00	93.33	6.67	0.00	76.67	10.00	13.33
PLANT DISEASE	90.00	0.00	10.00	53.85	20.51	25.64	16.67	33.33	50.00	75.00	0.00	25.00	93.33	0.00	6.67	66.67	11.11	22.22
WATER LOGGING	0.00	70.00	30.00	17.95	58.97	23.08	33.33	16.67	50.00	20.00	45.00	35.00	13.33	66.67	20.00	16.67	55.56	27.78
REQUIREMENT OF LIME	30.00	10.00	10.00	2.56	5.13	7.69	0.00	0.00	0.00	20.00	0.00	15.00	46.67	6.67	33.33	16.67	4.44	13.33
NO USE OF LIME		50.00			84.62			100.00			65.00			13.33			65.56	
INCIDENCE OH EARTHWORMS	20.00	60.00	20.00	35.90	20.51	43.59	0.00	33.33	66.67	10.00	60.00	30.00	20.00	80.00	0.00	23.33	44.44	32.22

Table 5.11 (c) iv PERCENTAGE OF USERS' PERCEPTION REGARDING CHANGES IN FARM LAND AGAINST OPERATIONAL LAND HOLDING IN HECTARES

SURVEYED HOUSEHOLD : 91 *

	LESS THAN 1 HA			1 - 2 HA			ABOVE 2 HA			TOTAL		
	I	D	NC	I	D	NC	I	D	NC	I	D	NC
PERCENTAGE OF FARMERS INTERVIEWED	54.44			28.89			16.67			100.00		
REQUIREMENT OF FERTILIZER	71.43	8.16	20.41	88.46	0.00	11.54	80.00	0.00	20.00	77.78	4.44	17.78
AVAILABILITY OF IRRI. WATER	85.71	10.20	4.08	84.62	3.85	11.54	66.67	20.00	13.33	82.22	10.00	7.78
STIFFNESS OF SOIL	30.61	10.20	59.18	30.77	11.54	57.69	26.67	13.33	60.00	30.00	11.11	58.89
YIELD OF CROP	69.39	18.37	12.24	65.38	23.08	11.54	60.00	33.33	6.67	66.67	22.22	11.11
INCREASING OF INSECTS	44.90	22.45	32.65	46.15	11.54	42.31	60.00	6.67	33.33	47.78	16.67	35.56
INVASION OF WEEDS	69.39	16.33	14.29	84.62	3.85	11.54	86.67	0.00	13.33	76.67	10.00	13.33
PLANT DISEASES	55.10	16.33	28.57	88.46	0.00	11.54	66.67	13.33	20.00	66.67	11.11	22.22
WATER LOGGING	20.41	57.14	22.45	11.54	50.00	38.46	13.33	60.00	26.67	16.67	55.56	27.78
REQUIREMENT OF LIME	12.24	2.04	16.33	23.08	11.54	7.69	20.00	0.00	13.33	16.67	4.44	13.33
NO USE OF LIME		69.39			57.69			66.67			65.56	
INCIDENCE OH EARTHWORMS	14.29	46.94	38.78	34.62	38.46	26.92	20.00	60.00	20.00	21.11	46.67	32.22

I - INCREASE
D - DECREASE
NC - NO CHANGE
* - ONE HOUSEHOLD HAS NO OPERATIONAL FARM LAND

VARIABLES	COMBINED		
	I	D	NC
FISH PRODUCTION IN PONDS	56.52	39.13	4.35
FISH PRODUCTION IN RIVERS	9.52	83.34	7.14
CHANGES IN WEED GROWTH	17.39	45.65	36.96
CHANGES IN MOSQUITO MENACE	100.00	0.00	0.00

I - INCREASE
D - DECREASE
NC - NO CHANGE

Table 5.11 (d) ii USER'S ASSESSMENT OF THE PROJECT EXPRESSED AS PERCENT OF IRRIGATION STRUCTURES USED

ADVANTAGE

VARIABLES	PDW	HTW	STW	DTW	RLI	TOTAL
VERY HIGH	0.00	0.00	0.00	0.00	0.00	0.00
HIGH	20.00	17.50	50.00	20.00	0.00	17.58
MEDIUM	80.00	57.50	50.00	80.00	80.00	68.13
LOW	0.00	25.00	0.00	0.00	20.00	14.29
VERY LOW	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

Table 5.11 (d) iii USER'S ASSESSMENT OF THE PROJECT EXPRESSED AS PERCENT OF OPERATIONAL LANDHOLDING

ADVANTAGE

VARIABLES	< THAN 1 Ha	1-2 Ha	2-4 Ha	ABOVE 4 Ha	TOTAL
VERY HIGH	0.00	0.00	0.00	0.00	0.00
HIGH	16.33	15.38	26.67	0.00	17.78
MEDIUM	69.39	73.08	53.33	0.00	67.78
LOW	14.29	11.54	20.00	0.00	14.44
VERY LOW	0.00	0.00	0.00	0.00	0.00
TOTAL	100.00	100.00	100.00	0.00	100.00

6.0 PROJECT STRUCTURES : OBSERVED PROBLEMS AND PROPOSED REMEDIES

6.1 Project Structures

The project structures were briefly described in Chapter 3.0. Following observations are made on the basis of field visits.

6.1.1 Hand Tubewells (HTW)

HTWs are the most numerous of all the structures under the NBTDP and are widely spread over the project area. These are quite familiar structures for the users. HTWs are used for irrigation and for drinking water.

(a) *Defects Observed*

Following minor defects were observed in the design, construction and maintenance which need correction to optimise their usefulness :

(i) Some of the HTWs do not have a masonry platform around the pipe, thus creating a pool of water. Water from the stagnated pool is polluted with wastes from domestic sullage, livestock and poultry as also through rotting process. This polluted water percolates down the annular space between the pipe and its bore to foul the ground water source of the tubewells. Direct entry also takes place through defective jointing of the flange of the pump head with the main pipe at ground level.

(ii) In most cases, where platforms are constructed, due to unequal settling or bad workmanship a discontinuity occurs between the platform surface and the adjoining ground which creates stagnation and percolation of water as described in (i) above.

(iii) Drainage away from the HTWs is by earthen channels which are not properly consolidated, thus leading to wastage of water and water-logging in small pools.

(iv) The classical type of HTWs heads made of CI which are used here are heavy to operate and need bending of the body by the user at every stroke. This increases human drudgery which can be avoided by introduction of India Mark II or Mark III pumps which pump out more water with less physical exertion.

(v) CI pump heads once broken cannot be repaired locally and have to be replaced, which renders HTWs ineffective for long periods.

(b) *Remedies Proposed*

(i) All HTWs should have the area surrounding the installation well compacted for at least 3 m sloping away from the structure.

(ii) The standard circular platform with raised rim and an outlet towards the lowest point need be constructed with good materials using brick masonry over a lean concrete base.

(iii) The area surrounding the platform should be filled with compacted materials sloping away from the structure.

(iv) The fields meant for irrigation by the HTW should be identified and drains leading to these should be constructed with compacted earth after removing vegetation, straws etc.

(v) Bathing, washing of utensils, washing of clothes at the platform should preferably be avoided. A separate well-drained area with a brick platform may be constructed for this purpose (preferably 10 m away from the HTWs).

(vi) Possibility of replacing CI, pump heads with metal sheet ones (Mark II) may be considered to reduce human drudgery, to facilitate maintenance and to achieve higher yields. This will, however, increase the cost per installation.

6.1.2 Pumped Dug Wells (PDW)

Pumped dug wells are the next most numerous structures under the NBTDP. Since 5 farmers jointly receive the benefit of a PDW, such wells are often located away from the homesteads. However, since ring wells which form the basic structure, are commonly used for drinking water in the houses, these PDWs are also used for drinking water by nearby houses through dipping of buckets at the end of a rope.

(a) *Defects Observed*

(i) Some PDWs do not have a masonry platform and drain around the structure. As a result, the area surrounding the structure is always water-logged. Growth of vegetation is also very common. Wastes from domestic sullage, livestock and poultry also contaminate the area.

(ii) Earthen drains to carry water from the PDWs to the fields are made without consolidation and proper grading, leading to wastage of water and water-logging along the drains.

(iii) There are frequent complaints of delay in repair of the pumps and other defects of the system.

(b) *Remedies Proposed*

(i) While it may not be necessary to provide a masonry platform and drain around each such structure PDWs located near homesteads should have this facility to prevent pollution of the water with back-flow from the stagnated pools.

(ii) Other PDWs should have a compacted earth platform sloping away from the structure with compacted earth properly laid in grade to facilitate adequate disposal of waste of water without stagnation.

(iii) Local arrangements for repairs are necessary and some of the beneficiaries may be trained for this purpose. Stocks of spares are to be located at places easily accessible by the beneficiaries.

6.1.3 Shallow Tubewells (STW)

The shallow tubewells, allotted to groups of 4 and 5 farmers, are located away from homesteads. But during non-irrigation periods these tubewells are, in some cases, fitted with hand-pumps for drawing of drinking water.

(a) *Defects Observed*

(i) The STWs do not have a masonry platform along with a drain. Hence, they suffer from the same deficiencies of water logging and pollution as in the case of HTWs and PDWs.

(ii) Some of the beneficiaries of STWs complained of sand in water. Small quantity of sand in water may not be harmful for irrigation, but such sand pumping damages the pump

(iii) Users complained about delay in repair of defects both in the tubewell and the pump.

(b) *Remedies Proposed*

(i) Same as for PDW (i).

(ii) The inflow of sand may be reduced by providing a blank pipe below the strainer pipe to store deposited sand during the non-pumping hours so that this may not enter into the pumped water.

(iii) The underground aquifer structure needs proper study through systematic boring and collection of bore-logs so as to identify appropriate layers for placement of strainers. Preformed shrouded strainers may be used in case placing of strainers in fine sand layer becomes unavoidable.

(iv) High rate of pumping of the well before commissioning may be done to grade the aquifer surrounding the strainer.

(v) The remedial measures to avoid wastage, pollution and to reduce delay in repair and consequent stoppage of pumping steps mentioned in para (ii) and (iii) of PDW should be implemented.

6.1.4 Deep Tubewells (DTW)

(a) In the case of Deep Tubewells the following problems were observed :

(i) The major problems of DTW relate to the electric pump and supply, which include :

- Electric power supply with frequent stoppage. Sin periods may not coincide with the availability of th lives away from the site, supply of water is irregu' ick
- Irregular attendance of the Operator, who controlled by the beneficiaries.
- Low voltage in the supply system equipment, both electrical and mechar :h are nay be uries or
- Direct connection of motors to po control equipment. ılferage of
- Delay in repairing of power c

(ii) Delivery system of the DTV located at the delivery r simultaneously with a r measurement. Both the forming breeding plac leaves and algae. agh NGOs to with.

(iii) The valves cont heads remove around. Thi of breedin he river, the type is given in para ing the winter and But in other cases river training works rosion at the suction und that many of the w.

(iv) The ea comp lost B not universal but quite

(b) Remedies Proposed

(i) Improvement in power supply through discussion with the West Bengal State Electricity Board (WBSEB). Certain specific periods may be earmarked for supply of electricity in appropriate voltage to the areas where DTWs are located. Such periods may be staggered between locations and the operators assigned duty hours accordingly.

- Use of better motor control system so that the connection trips during low voltage thus saving the costly equipment.
- Frequent check by trained electricians to ensure that the controlled equipment are not tampered with along with identification of some beneficiaries to be given responsibility for ensuring that such tampering are not done.
- Organisation of electric maintenance system amenable to quick response.

(ii) Remodeling of the delivery system to eliminate the weirs, which are not of much use in proper measurement of discharges. These may be replaced with direct system of flow measurements through venturies or otherwise.

(iii) Beneficiaries are to be organised to keep watch to prevent pilferage of valve parts and damages thereof.

(iv) Younger people of the area are to be properly trained through NGOs to recognise the structures as useful and not to be tampered with.

6.1.5 River Lift Irrigation Schemes (RLI)

Each RLI Scheme is of a specific type depending upon its location on the river, the type of river and its flow, the types of banks etc. A general description is given in para 3.3(e). For some of the schemes the flow of water gets reduced during the winter and the intake area has to be deepened by excavation (e.g. Pet Bhata). But in other cases there is no appreciable reduction of water. Similarly in some cases river training works had to be done with boulders to stabilise the river banks against erosion at the suction side (e.g. Bara Kamath). However, during the survey, it was found that many of the schemes suffer from some of the common problems as given below.

(a) *Problems*

General problems for the RLI schemes (which again are not universal but quite prominent in some of the cases) are :

(i) Creation of small pool of water through bunding. The pool is also used for bathing and ablution thus causing a polluted water body. Mosquito breeding and weed growth are quite common.

(ii) Suction mouths are choked by debris and floating weeds, which have to be repeatedly cleaned This is also primarily due to bunding which prevent free flow of water.

(iii) The problem of sand deposition near the intake site was reported in most of the RLI structures in Jalpaiguri area, though the problem is less acute in Cooch Behar. However, in all the areas some clearing of sand is carried after the rains.

(iv) None of the pump houses has any proper drainage system. Leaking water from the glands of the pump combined with floor washing and oil & grease are found forming a pool outside the pump houses.

(v) Exhaust fumes and noise from the diesel pump operation are noticeable, but not to any alarming extent.

(vi) In Naljuapara, where the pumping system is placed on a pontoon located in the deep channel with steep banks, the pumps are to be lifted to the banks during the floods to protect them from getting overturned; while during the dry season bottom of the pontoon almost touches the sand bed under the load of three diesel engines.

(vii) In many cases only one of the three diesel engines was found to be operating, while the other two were out of order. Frequent complaints were heard about delay in repair and irregular attendance by the pump operators.

(viii) Here again the problem of damage of valves and wastage of water from poorly constructed earth channels are noticed, as in the case of DTWs.

(b) *Remedies Proposed*

(i) In many cases bunding is essential to create a small pool of water required for the foot valve of the suction pipe. However, bunds may be dismantled at least once a week during non-pumping hours to clean the accumulated pool of polluted water along with the weeds so that the problems of pollution and debris accumulation are reduced.

(ii) The RLI on pontoon shall have to be designed in a better way considering the stability and portability of the pontoon under the different loading conditions including its attachment to the shore. Use of a small flexible gangway makes operation easier. Alternatively, a pump house on the bank along with a flexible suction mains on a float may be tried.

(iii) Maintenance and repair of diesel pumps call for improvement, which in turn will require better training of the operating and repair personnel.

(iv) Instead of putting the exhaust pipe in an inclined position through the window, it may be arranged vertically with a proper rain cover so that the smoke gets dispersed over a wider area instead of being concentrated near the ground level.

(v) Proper drainage of the floor washing, which contains diesel and grease, is to be arranged to avoid the obnoxious pools and to prevent overflow reaching the fields thus damaging crops. Properly designed grease traps with skimming arrangements may be introduced for this purpose.

6.1.6 4 Ha Units

(a) *Problems*

Layouts of the 4 ha units have mostly been done without proper survey, so that the grades given are not always conducive to free flow of irrigation water under gravity. The quality of construction of the masonry drains are also poor and many of these are already broken. The junctions between the masonry drains and the earth drains are not properly treated and much water is lost through these points. The defects of the earthen drains have already been mentioned.

(b) *Remedies proposed*

For optimal utilisation of water, it is essential that the micro drainage system including the masonry drains are designed in a comprehensive manner after proper survey and identification of the plots to be benefited. The quality of construction will also have to be improved with use of proper mortar and its curing. The masonry channels should be packed with gravel and earth on either side to ensure their stability and to reduce chances of cracks due to unequal setting of the base. The delivery points from the masonry channel to the earthen channels shall have to be properly designed.

6.1.7 Soil Conservation

This is a commendable project component, aiming at making degraded land available for cultivation and reclamation of lands affected by erosion, sand deposition and flooding etc.

(a) *Observations*

The following observations has been considered for further improvement of the efficiency of these works :

(i) The problem of stability of bunds through planting of vegetation has already been dealt with in para 5.9.

(ii) In case of reclamation of sand laden areas (e.g. Dakshin Changmari), sand was deposited through a breach in the Teesta Bund in 1977, and the area was over-grown with weeds. Embankments have been constructed along with uprooting of grass/reeds, and cultivation is being done on the sandy areas without adequate irrigation facilities. As a result, the production is low and farmers complained of not being able to recover the expenses.

(iii) Under gully control activities (e.g. Uttar Dhupjora), gully formations have been prevented with embankments and hume pipe culverts. Though this has prevented loss of soil, prevailing high percolation rates, precludes intensive cropping in absence of supplementary irrigation.

(iv) In another case (e.g. Paitkakocha) gully formation over a large area has been prevented by construction of a masonry broad crested weir. This has reduced the velocity of flow, thus preventing upstream gully formation . Availability of water in the stream throughout the year has also resulted in an upward movement of root moisture zone. However, the soil being of good quality, more intensive cultivation could have been achieved with irrigation facilities. In this particular case, the weir disrupts the continuity of the embankment where a foot bridge is necessary.

(v) Combination of leveling, graded bunding and uprooting of grass/reeds have resulted in extension of cultivation in the areas previously fallow (e.g. Domohani). However, drainage remains a problem.

(b) *Remedies Proposed*

Funds permit, a more comprehensive land reclamation programme could be considered to replace the present single technique of soil conservation. An integrated approach along with irrigation, humus formation and agricultural extension could improve mainly farmer's lot , while current programmes in many cases raise hope without fully satisfying the expectations.

6.2 General Problems

Some of the problems are found to be common to more than one interventions and some are common to the project area in general as listed below :

(a) *Problems*

(i) People in the project area are largely unaware of issues of personal hygiene and the transmission of diseases through anal/oral route, and the role of waste-water in the spread of such diseases.

(ii) There is no active line of communication between the users and the Operation & Maintenance people, and delayed response from O & M personnel is common.

(iii) While at the individual level motivations of the water users are high as in the case of single user structures e.g. HTW motivations, optimising the benefits from communal structures, i.e. PDWs, DTWs and RLIs are hampered by intercine problems.

(iv) With no proper knowledge transfer in use of fertilizer and pesticide, initiatives are left with individual users, which often results in wrong choice of chemicals, excessive and improper doses resulting in the farmer finally loosing faith in such chemicals.

(v) Inadequate marketing facilities result in the farmer getting non-remunerative price for the products.

(vi) Higher prices are charged for fertilizers & pesticides by the local dealers and there is no certification of qualities of chemicals in many cases.

(b) *Remedies Proposed*

(i) The farmers, specially the user of HTWs, STWs and PDWs are to be given proper training in locating their latrines, away from the project structure (at least 10 m) and in the downslope side. It is desirable to canvass user specific low cost sanitation systems among the farmers to improve their hygienic conditions.

(ii) Training shall be given in personal hygiene and cleanliness so that the utensils for storage of water and the areas surrounding the water sources are kept cleaned and dry. Other personal hygienic habits are also to be inculcated.

(iii) Proper line of communication to be established between the operation & maintenance personnel and the beneficiaries through joint participation in beneficiaries committees by the Government Official and the O & M staff. Simultaneously, suitable persons from some beneficiary families can be trained in operation & maintenance of pumps and structures to facilitate quick action.

(iv) Beneficiary Committees will have to play a more active role in optimising the use of water from community structures.

(v) Agricultural extension works are to be intensified with proper training of the farmers on crop rotation and in safe use of appropriate fertilizers and pesticides in collaboration with the beneficiaries' committees. The extension workers shall advise on the adverse effects of fertilizers and pesticides if used in excess quantities.

(vi) Availability of fertilizers and pesticides at reasonable prices through local dealers or co-operatives is to be arranged to ensure ready supply with guarantee of quality.

(vii) Storage and marketing facilities for products are to be ensured either through co-operatives or through Government Departments.

NGOs can play a significant role in ensuring all the remedies mentioned in this Chapter.

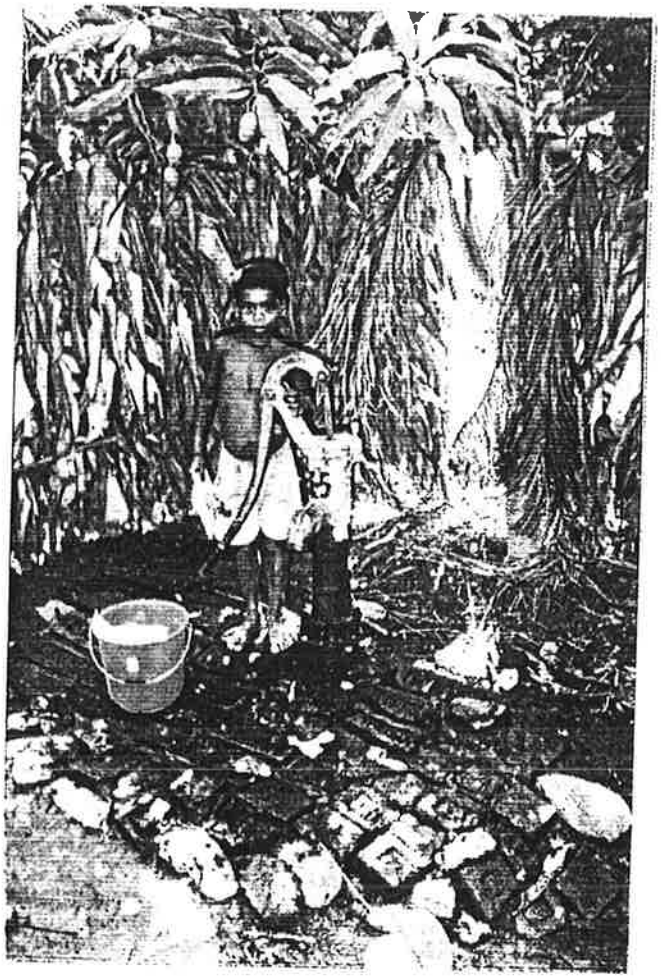


FIG 1 : HTW with dilapidated platform.

FIG 2 : STW with water pool. Hand Pump used for drinking water.

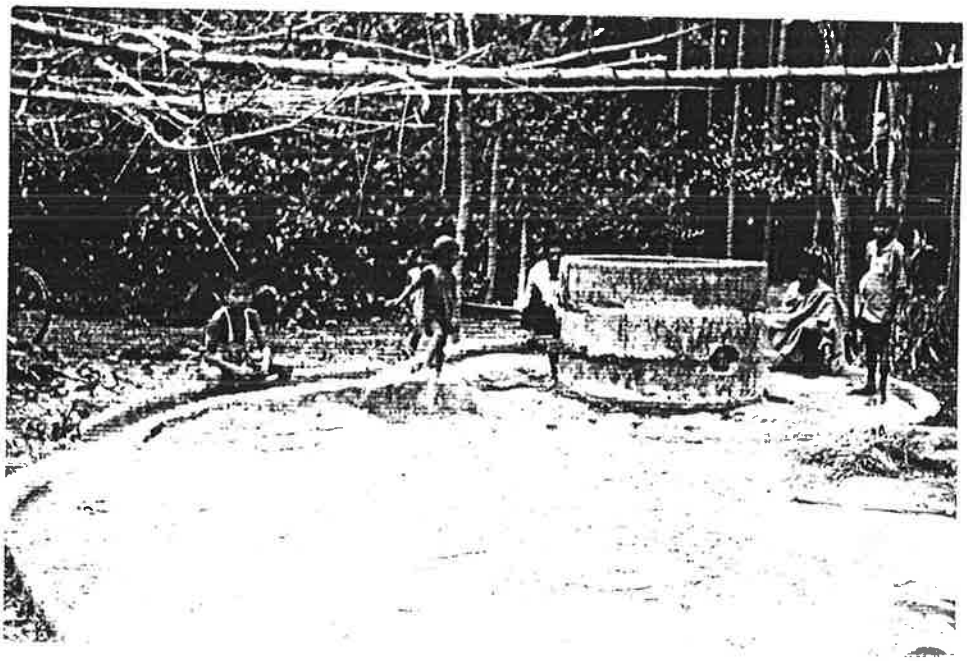


FIG 3 : PDW with broken platform. Used for drinking water also.

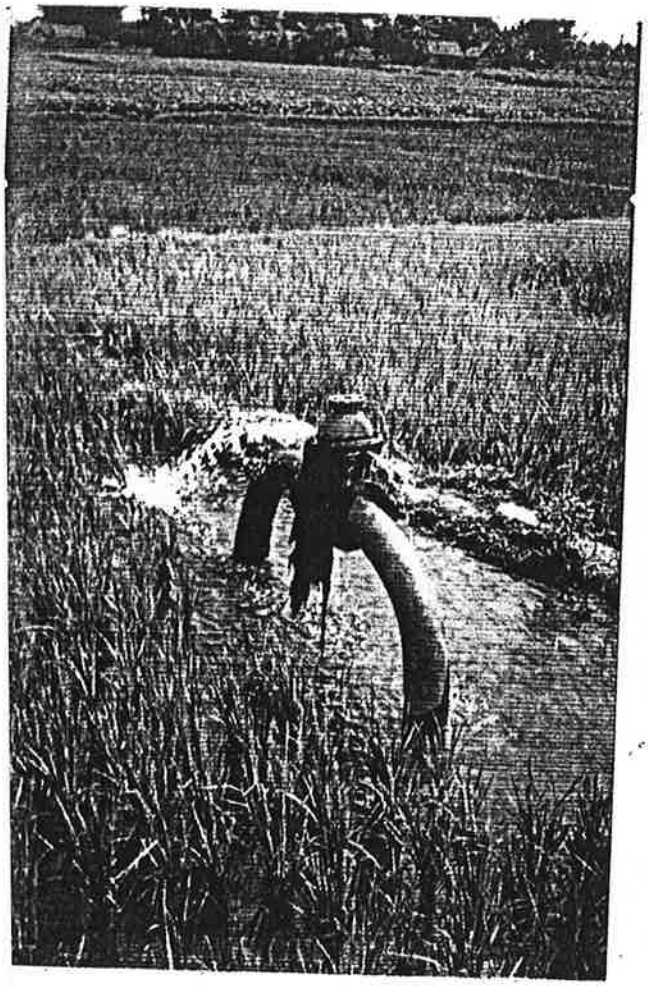


FIG 4(i): Leaking valve forming water pool.

FIG 4(ii): Water pool at headworks.

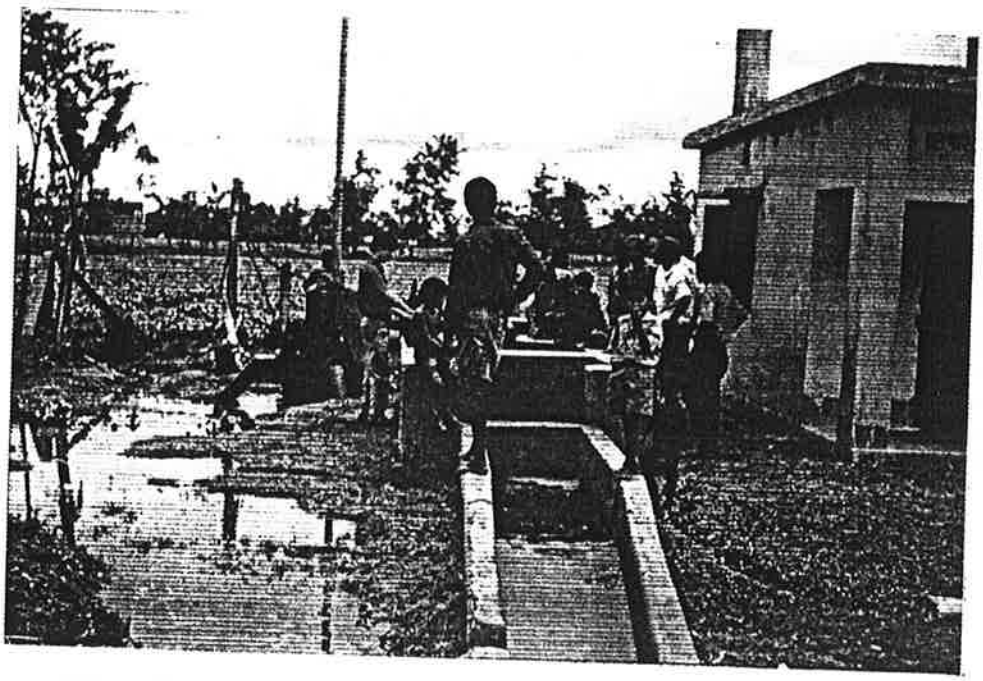


FIG 4(iii): Water pool at headworks and wier chamber.

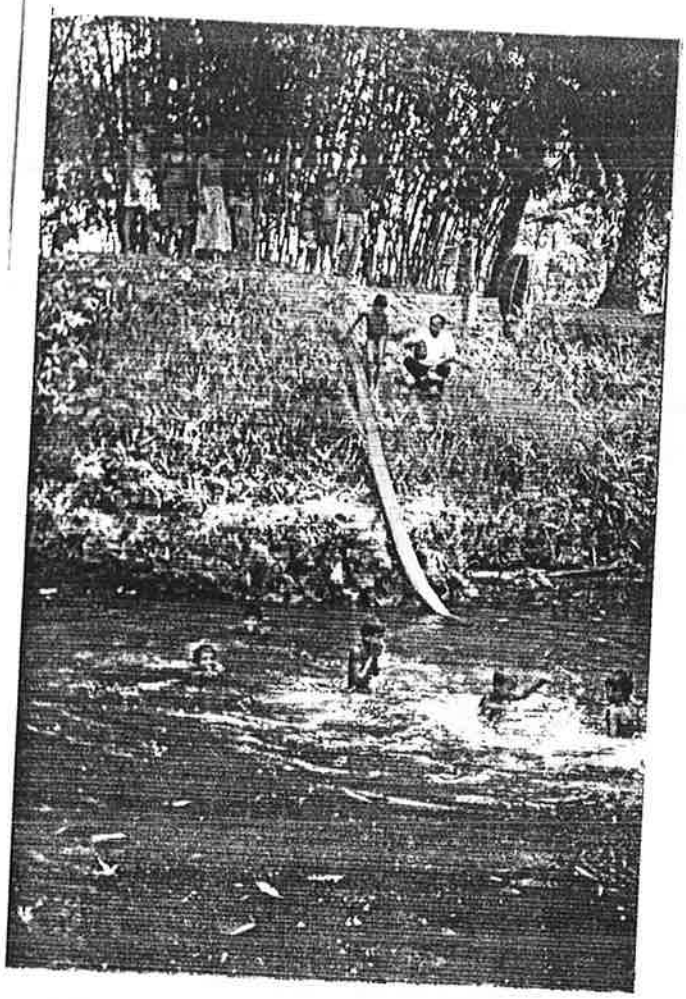


FIG 5 : RLI - Water pool created by bunding. Used for bathing,etc.

FIG 6 : Grease and floor washing pool around RLI Pump House.

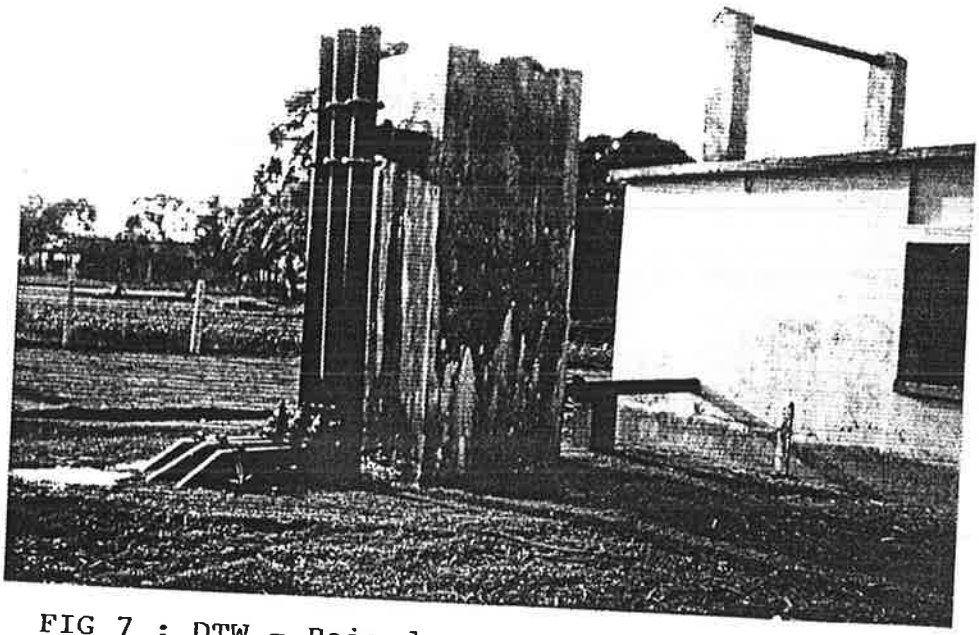


FIG 7 : DTW - Raised masonry structure forming water pool.

7.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS

7.1 Introduction

The environmental issues related to the project area both 'independent of the project' and 'with the project` have been identified under environmental issues in Chapter-3. In this Chapter, an attempt is made to describe the environmental impacts due to natural forces and man made actions in the project area in general along with specific impacts due to project interventions, wherever relevant.

7.2 Impact Related to Natural Forces and Cultural Practices

7.2.1 Rainfall

Rainfall by itself is a premier natural force modifying the environment in the project area. It serves as a major source of replenishment of ground water. Rainfall also results in flooding and sedimentation which have major adverse impacts in raising the river beds and spreading silt and sand on the adjoining areas. Apart from the direct havoc created by such floods, which now occur frequently in the project area, in the upper reaches the sediment load comprising primarily of sandy particles destroys much tracts of agricultural land through sand deposition. However, in the lower parts of the project area, sedimentation results in increasing soil fertility through spread of loamy soil. Leaching of soil matter and nutrient is another impact of rainfall which is dealt with in para 7.2.8.

7.2.2 Ground Water Extraction

Estimates of ground water potential and extraction [para 5.2(b)] indicate that on an average level of ground water extraction over the project area (6.38%) is well within the safe limit of 60% prescribed for `White Area' and no adverse impact of ground water depletion arising from overdrawal is as yet expected. However, in certain blocks notably Cooch Behar II and Dinhata I in Cooch Behar district, the percentage of extraction is 31.25% and 24.13% respectively, which is relatively high, though still well within the 'white area' safty limits. Caution is necessary for future extraction of ground water. Ground water yield test on a scientific basis is therefore necessary along with a ground water extraction plan to be jointly prepared by authorities responsible for irrigation and drinking water supply.

Some of the STW's of the NBTDP are reported to have pumped fine sand with water (para 6.1.3). This is a combined problem of site location and pumping and may be aggravated if systematic study of lithology for strainer location is not made through preservation and analysis of borelogs of tubewells.

7.2.3 Quality of Ground Water for Agricultural Use

Analyses of data available from SWID show that the quality of water in all the cases is well within permissible limit so far as the Sodium Absorption Ratio (SAR) is concerned. This is true also for the samples tested under this study. Low levels of SAR indicate that there is no possibility of Sodium hazards leading to formulation of Sodium Hydroxide (NaOH) and subsequent higher alkalinity which is detrimental to paddy cultivation. The range of salt concentration as indicated by EC is also low in all places signifying low levels of total dissolved solids (TDS) i:e salinity. At this level of EC, the water does not pose any salinity hazard for the crops. In case of Residual Sodium Carbonate (RSC), the levels are low in most cases, though in certain blocks in Cooch Behar, for the years 1989 and 1993, the levels are found to be medium. The 1993 data from Jalpaiguri also show RSC to be medium at three locations. The samples collected for this study (1995) show RSC data high in the Alipurduar I and medium in Dinhata II. The higher level of RSC in water indicates possibility of carbonisation through release of carbonates and bicarbonates which combines to increase acidity. Use of lime to neutralise the acid in such cases is recommended. In these specific cases, further detailed studies of water quality is recommended for formulation of remedial measures.

7.2.4 Quality of Surface Water in RLI for Agricultural Use

The historical data of ground water quality for agricultural use available from SWID do not include RLI's. During, under this study three samples of water from RLI were collected and analysed. Results [Table : 5.3(a)iii] show that all three water samples are good for agricultural use.

7.2.5 Pesticides

Records and discussions show that pesticides have been used by farmers primarily for HYV crops (para 5.6.4). This is primarily because of the low income of the farmers, lack of knowledge about the type and quantity to be applied and their availability at the right time. Since threshold values for fertilizer use have not been reached in the project area, there is little possibility of land and water pollution by excess chemical fertilizers. In the plantation area, where inorganic fertilizer and pesticides were much in use, the recent trend is to divert to organic fertilizers and pesticides because of required standard for export. This trend will result in a reduction of adverse environmental impact as compared to the earlier days of high use of inorganic chemicals by the tea estates. Data generated in the present study [Table 5.3(c)] clearly indicate no residual effects of pesticides in samples of drainage water in respect of Dicofol, Dieldrin and Chloropyriphos. Some concentration of Endosulfon and Ethion residues have been noted which are too low to create problem. The majority of pesticides degrade rapidly to prevent residual accumulations in soils, a few resist degradation and may cause for environmental damages.

7.2.6 **Nutrient Enrichment**

In table 5.3 (d) data on analysis of samples collected by this study for nutrient enrichment are given. The data collected from impounded water bodies show that all have dissolved oxygen and very low concentrations of N, P and K. Thus permanent degradation of confined water bodies through eutrophication is not expected.[1]

7.2.7 **Drinking Water Quality**

(i) Chemical

Data on drinking water quality are available both from secondary sources [SWID - Ref : Table 5.3(a) iii] as also from the 18 samples for quality of water tested for their suitability for agricultural use. Besides, 6 samples collected from HTWs and PDWs were analysed in detail for water quality in terms of the Indian Standard (IS : 10,500 - 1983). The results of the study of historic data show that in many cases water has iron (Fe) in excess of permissible limits. All the 18 samples of water for agriculture quality also showed high levels of iron. Excess iron causes staining of clothes and choking of pipes besides causing bitter taste, and is also indirectly responsible for some of the gastrointestinal problems. The data tested for water quality given under Table - 5.2.7(i) show the water to be fit for drinking, with the exceptions of iron and fluoride which may need removal in specific cases. Otherwise, these water by themselves do not present adverse environmental implications.

(ii) Bacteriological

Bacteriological tests relate to the project structures, as shown in Table - 5.3(e)iv. Out of the 40 HTWs tested, 6(18%) samples are unsafe because of bacterial contamination. In case of PDW, 90% are similarly unsafe; while for STW all the samples proved unsafe, 25% of the DTW sources tested are unsafe, while in case of the RLI all the sampled water are unsafe. It is pertinent to note that such contamination leading to gastroenteric diseases and other health problems, are directly related to the design, execution, operation and maintenance of the project structures and are thus directly project related (Chapter 6.0).

7.2.8 **Soil**

Air and water exert tremendous impact on soil properties. In the Terai regions of North Bengal, such impacts on soil properties are distinctly noticeable. Two very important soil physical components, viz. soil texture and soil structure which are essential factors of soil productivity, have been influenced by the existing environmental factors. High intensity of rainfall and increased use of irrigation water have exerted textural changes in many areas of the region and these changes have taken place mainly due to washing out of finer soil particles like clay and silt. In some areas frequent flooding by rivers and their tributaries have also resulted in deposition of sands. As a result, changes in soil

[1] A word of caution here - Samples for agro-chemicals and nutrient enrichment were collected only in a limited way due to constraints of time. The period proceeded with few monsoon showers was also not conducive for collection of such samples. A thorough study of these aspects with a network of sampling points spread randomly over the project area with data collected and analysed at least 4 times a year are required to obtain reliable results on this aspect.

textural composition have taken place in many areas and such changes have loamy to sandy loam texture. Deforestation, absence of cover crops on field have greatly accelerated this process. At the onset of the rain the rainfall with high kinetic energy strikes the soil cover and easily removes residual soil particles. The impact of such changes may exert unfavourable influences on other physical properties resulting in low stability of soil structure, low availability of soil moisture and greater erodibility indices etc. Studies on baseline data generated by this study and also various data on soil physical components (Chapter 5) corroborate with the above apprehension.

Another important impact on the soil environment is related to changes in soil reaction. The majority of areas under Siliguri Sub-division, Jalpaiguri and Cooch Behar districts, the soil reaction is acidic - the pH ranges between 4.5 to 6.5. This may be either due to indirect effects of Al^{+3} ions in the exchange complex or leaching of basic cations from the colloidal complexes by rain and irrigation water. The findings (vide Chapter 5) indicate that exchangeable Al^{+3} concentrations are always at low level and hence possibilities of formation of aluminum hydroxyl ions and hydrogen ions are minimum. Excessive leaching of basic cations (Ca, Mg, Na, K) due to high rainfall and light textural composition of soils might have resulted in increase of soil acidity. This problem arises particularly due to the fact that very few farmers practice liming in their tillage operation. Any process that will encourage high levels of exchangeable base forming cations, such as Ca^{+2}, Mg^{+2}, K^{+}, Na^{+}, will contribute towards a reduction in acidity. Recycling of these cations by deep-rooted plants brings them to the surface and soil organisms incorporate them into the top soil.

Soil salinity hazards were assessed by several investigations. In most of cases, except in submerged areas, no accumulation of soluble salts like chlorides and sulphates of Na, K, Ca, Mg have been recorded beyond permissible limits. Accordingly, salinity hazard as revealed by EC values is nil or negligible. Climatic factors like excess rainfall and light textured composition of surface soils are conducive for intensive leaching of soluble salts of basic cations.

It is difficult to assess of soil losses due to erosion. The area is mostly flat in topography and bunded fields are protected against sheet erosion from run-off. Textural composition of soils are not conducive to serious spash erosion because of the high percentage of relatively larger soil particles. However, soil losses through erosion (wind and water) by themselves, natural phenomena and could not be totally prevented under any circumstances. Recycling of organic wastes, use of protective cover or planting cover crops, cultivable measures such as cropping sequences or cropping pattern, conservative tillage and implementation of proper agricultural extension programmes can greatly reduce the problem of soil erosion from agricultural fields.

Cropping practice also has direct influence on status of soil fertility and biological activities of a soil system. In this region factors responsible for fertility levels of soil have been studied by various Institutions/Universities etc. It has been found that although C : N ratios have been stabilised in the range of 10 : 1 to 12 : 1, the levels of organic carbon and total N are low in concentrations as compared to Gangetic alluvium.

Temperature and rainfall exert a dominant influence on the amount of nitrogen and organic matter found in soils. Besides these, numerous other local inter-relationships are involved in building up of organic matter and ultimately of nitrogen fixed or retained in the soil. Organo-mineral complexes of soil always help to protect the

nitrogenous proteins and, in turn, the organic matter from degradation. The textural composition of soil plays a vital role in this.

Leaching of soil nutrients and nutrient restoration are very important aspects of soil fertility management. In these areas several soils have shown low to medium levels of available N (NO_3-N and NH_4), available P and K, low status of Zn availability. Baseline data as generated by this study and also supporting data from other studies are in agreement to identify and classify this region as an area of medium soil fertility. Climatic conditions like high intensity of rainfall might be one of the factors responsible for such soil condition.

7.2.9 Biodiversity

In the wake of an organised thrust in irrigation development input in the Terai region, the crop farming scenario is also changing in respect of use of other inputs. Amongst these, two very important inputs are seeds and fertilizers. The first two impacts thus witnessed are increased use of HYVs and chemical fertilizers. This has increased crop production and has led to more diversified farming and multiple cropping, but also, it has led to increase the application of plant protection chemicals and chemicals fertilizers.

Increased use of HYVs, fertilizers and pesticides in turn has created a situation threatening the erosion of old and local genotypes of different crop species. This calls for appropriate steps for conservation of germplasm of the Terai area without any further delay so that the process of gene erosion may be checked.

Again, continuous use of improved varieties and HYVs for long periods may cause alarming deterioration in the agricultural environment in the sense that dependence on chemical fertilizers, herbicides and pesticides increase to such extent that environmental pollution hazards become acute. Therefore, to reverse the trend, it is very necessary to plan and execute a progressive and more realistic cropping programme incorporating rotation of varieties (gene rotation) alongside rotation of crops.

Increasing dependence of chemical fertilizers in concurrence with increased use of HYVs and hybrid seeds will gradually lead to shift in the use organic manures in the Terai area. In fact, overemphasis on continuous cropping for generating more cash will increasingly create an environment of declining soil fertility, soil exhaustion and depletion of organic matter content from agricultural fields. This trend has to be halted, for instance, by emphasizing a two - pronged approach (i) production of organic manure (cowdung manure, compost etc.), and (ii) increased use of green manuring and incorporation of leguminous crops (including fodder legumes) such as Sesbania, Crotalaria, Phaseolus spp., Tephrosia Lathyrus etc. for soil amelioration and increase in soil nitrogen and organic matter content.

Pursuit for cropping schedules heavily tilted in favour of immediate cash returns has led to virtual neglect of animal husbandry and livestock farming. As a result, genetic upgrading of livestock, poultry and ducks and fodder farming are almost forgotten chapters in the Terai districts. Remedial actions in this direction have to be vigorously stepped up. Breeding for livestock improvement (including procurement, preservation and use of artificial insemination techniques) and fodder farming as a component of cropping schedule and also of agroforestry should be executed throughout the Terai region.

Intensified extension work and programme of incentives through liberal institutional finance in all villages for fodder cultivation are also to be adopted. Any further indulgence in the practice of post-harvest grazing in crop fields may seriously affect the soil health and lead to soil erosion.

7.2.10 **Impacts from the Beneficiaries' View Point**

Farmers' appreciation of project intervention are given in [Tables 5.11 (d) ii and iii]. Increase in the mosquito menace is reported along with increase of Malaria and Gastroenteritis which are only partly due to the deficiencies in design and implementation of project structures as also lack of extension services in personal hygiene. Farmers making three crops per annum have also reported increasing stiffness of soils, increase of insects, invasion of weeds and increases in plant diseases. This is specially true for the users of PDW and RLI though users of HTWs and DTWs also, to an extent, share the views, specially in relation to invasion of weeds and increases in plant diseases.

7.3 **Impacts of Deforestation**

Impacts of deforestation in the project area are on two fronts, e.g. (a) Deforestation in the Mountains and foothills north of the project area and (b) Deforestation within the project area.

(a) Impacts of deforestation north of the project area is directly felt through an increase in sedimentation in the rivers, with origin in those areas, through removal of top soils leading to direct erosion and land slides. Another impact is the decrease in water retention in the catchment, resulting in lesser percolation of water to the confined aquifer deep below the Terai Region, and higher runoff.

(b) Deforestation within the project area combined with degradation of quality of forests have resulted in accelerated flow of rain water eroding soils and depositing the same as sediment through the rivers originating in the project area, effects of which have already been described. Unplanned cutting of trees and re-plantation with inappropriate species are also leading to long term disequilibrium of the environment in the project area which is likely to have adverse impacts on farm lands causing ecological imbalances. Encroachment on to forests lands has also disturbed the habitats of already decreased wildlife and forced them to their periodic exodus into the neighbouring farm lands, causing damage to crops, cattle and human life.

7.4 **Impacts due to Project Interventions**

Project interventions primarily comprise several engineering structures - such as different types of tubewells, RLIs and soil conservation measures. The impacts related to these are catalogued below under positive and negative impacts.

(a) Positive Impacts :

(i) Project interventions have led to improvements in supply of water in times of need for agriculture. As a result all recipients reported an increase in crop production resulting in economic benefits and higher income.

(ii) Many of the project tubewells are used for drinking water supply, which, if properly managed, are beneficial to health and reduce human drudgery of carrying water from distances.

(iii) Soil conservation measures have resulted in reclamation of lands lost to agriculture and have thus provided economic benefits to the owners of much lands.

(iv) Improved irrigation facilities and available extension services have exposed the farmers to improved types of farming using better seeds, fertilizers and multiple cropping practices providing them with increased income.

All these have improved the livelihood styles of the farmers, which if properly guided, is expected to have a positive influence on education, health and family welfare.

(b) Negative Impacts :

(i) Lack of proper extension services has already led to use of fertilizers and pesticides without proper assessment of requirements and types. This practice, if continued, will reduce the fertility of soil resulting in poorer yields, disturbances of soil structures and textures and environmental contamination and health hazards (pesticide residue). Already increase in stiffness of soil has been reported by 90% of the farmers doing triple cropping (para 5.11).

(ii) Improper combination of crops for immediate maximisation of cash income, ignoring their long term repercussions because of poor knowledge of the such, may lead to damage to soils and negative impacts of plants/crop growth.

(iii) Deficiency in design of structures and poor levels of maintenance have led to bacteriological pollution of water in many of the project interventions. Since some of these also serve as sources of water for domestic use, health risks are quite real. In many cases, inadequate design/implementation have led to creation of pools of water breeding mosquitoes and other disease vectors. In fact, increase of mosquito has been universally reported in the project area (para 5.11).

(iv) Some of the soil conservation projects, mainly the ones concerned with reclamation of sand covered lands, have not been taken to their logical end for restoring good soil structure. As a result, the yields are poor. Coming from organised sources, such deficiencies will lead to users' disenchantment to the project and damage its relevance to the agricultural improvement in the project area.

(v) Improper maintenance of pumps and electrical equipment may lead to serious accidents damaging the credibility of the project.

The deficiencies of project structures and the remedies thereof are already discussed in Chapter 6. Adverse environmental impacts - both physical and socio-economical may result, though in a small way, in case these corrections are not quickly rectified. It is pertinent, to note that the project structures being small, there are no adverse impacts during the construction stage, whatsoever, nor is there any displacement of people calling for resettlement and rehabilitation programmes. The project-related environmental impacts noted above are also common to all other minor irrigation structures in the project area, whether NBTDP or not, and are also true for many of the major irrigation projects. Thus, most of the impacts are general rather than project specific in nature.

8.0 ENVIRONMENTAL MANAGEMENT PLAN AND ENVIRONMENTAL MONITORING

8.1 Environmental Management Plan (EMP)

The previous chapter clearly indicates that the direct impacts on environment by project interventions are few and quite limited in their extent. However, physico-chemical characteristics of the soil and actions taken by people and natural elements in the past have produced adverse environmental impacts both at regional and local levels. This may continue in the future unless proper control and monitoring are done to optimise returns from investments by this project as well as by other projects. Management considerations of some of the major issues are discussed below.

8.1.1 Water Management

(i) The project area gets sufficient quantities of rainfall with heavy intensities during the monsoon months. It also gets water from outside the project area, from the hills and foothills through its major rivers, almost throughout the year. Some of these waters during the monsoon create floods, damaging habitations and agricultural fields. This is mainly due to heavy deforestation in the catchment areas of these rivers and improper terracing for cultivation which has destroyed the water retention capacities of the soil in these areas. Solution of this problem lies in extensive afforestation in the foothill areas together with proper contour bunding and terracing. Within the project area the rain water conservation attempts are negligible except through major irrigation projects like Teesta Barrage Project. Proper afforestation in the project area and rotation of crops, aiming at increasing the binding capacity of the soil and its water retention potential, are required to optimise utilisation of rain water. Incidentally, part of the rain water within the project area contributes to the re-charging of the confined aquifer. This will improve when water retention capacity and percolation increase as a result of such measures.

(ii) At project level water is mainly required for irrigation in the non-monsoon period. In most structures, loss of water was noticed (Chapter 6.0). Improvement of pipe appurtenances e.g. valves and bends, better design of spouts and improvement in the masonry drainage system and their connections with the earthen channels, construction of properly graded and compacted earth channels, repair of burrowed holes will go in a long way in preventing water losses. This, coupled with laying of micro channels in the command area after proper survey of field levels, will optimise the use of water. Besides these technical impacts, the water management will depend on managerial efficiencies. The managerial part needs to prevent misuse of water by over-irrigating in violation of the considerations that water is to be released only to suit the time and space of a particular crop demand. The essential components for this will be

(a) comprehensive land development with land reclamation and soil and water conservation measures, adequate water budget in tune with the optimum cropping pattern

(b) application of irrigation water with introduction of water measuring devices

(c) improvement of communication for feedback for managerial decisions

(d) roster of pump operation with monitoring of performance of the operating schedule, the coverage of irrigated area, crop yields and social and economic benefits to evaluate the extent of the fulfillment of the objectives and target envisaged for this study

(e) involvement of beneficiaries of the project and realisation of revenue.

Quality of ground water for irrigation purposes is mostly within acceptable limits (para 5.3). Only the samples from DTW of Alipurduar and STW of Dinhata show higher levels of Residual Sodium Carbonate (R S C) with low levels of Hardness, as found from the samples tested under this study. One ground water sample in Cooch Behar II also shows high RSC values in 1993. These stray cases need further detailed investigation for appropriate action as proposed in the monitoring plan. Surface water samples (RLI) were all found to be suitable for agricultural use.

8.1.2 Management of Project Interventions

In Chapter 6.1 problem with the project interventions have been discussed in detail along with the defects observed and remedies proposed. Adverse impacts here comprise bacteriological degradation of water quality leading to problems of health, breeding of mosquitoes and other vectors in stagnant water pools and loss of water through defective components. All these have technological solutions which are indicated in Chapter 6. However, beyond these technological solutions, steps are to be taken to involve the beneficiaries with the project design and implementation as also in its operation & maintenance. Lack of knowledge on sanitation is an area of primary concern here and proper canvassing of basic information on sanitation and personal hygiene is recommended (preferably through NGOs) in this field. Introduction of low cost sanitary systems may be a step in the right direction but, for this proper motivation has to be done and the design of sub-soil disposal of human excreta will have to be properly taken care of.

8.1.3 Management of Water Quality (Drinking)

Except for bacterial contamination of dug wells and HTWs in the project area, for which management need has already been stressed, quality of ground water do not have much cause for alarm. Iron (Fe) in water is excess in all the samples tested. However, at individual level iron elimination is problematic. For organised water supply at group level, iron elimination through aeration will be the way out. No arsenic was noted in any of the sample water. But vigilance is needed in the future.

The quality of water for agriculture is already dealt with in para 8.1.1.

8.1.4 Management of Ground Water Extraction

As discussed in Chapter 5.2 the project area falls under the classification of 'White Area'. So there is no immediate danger of over-tapping ground water resources. But there is an apprehension that the rate of recharge in the Himalayan foothills, which in turn recharges the confined aquifers of the project area, is decreasing with time due to deforestation activities. Moreover, for various developmental activities, a number of deep tubewells are coming up in this area, tapping the confined aquifers, call for cautious approach in ground water development.

The management of the ground water region will have to be carried out on the basis of the data generated through the monitoring plan. The modern approach for optimum production and efficient management of ground water resources is the application of analog and more extensively digital models simulating the conditions in ground water reservoir. In the context of ground water management, model simulation techniques should be employed for :

- Prediction of water levels and effects of storage conditions for a wide range of operations and conditions.
- Evaluation of optimal well-spacing and pumping pattern in relation to storage and sources of recharge.
- Evaluation of relative economic benefits for a range of alternative plans for artificial recharge operations in ground water basins which is not so important for this area at this moment.
- Evaluation of the sensitivity of water management models for optimum utilisation of ground water by conjunctive use.
- Prediction of the physical and economic aspects for water quality changes and pollution.

Ground Water Legislation

Two aspects relating to ground water development and management that require legislation are

i) Control and regulation of ground water use to prevent over draft and mining of aquifers. In particular, control of private well drilling and registrartion on pumped volume are required.

ii) Prevention and control of ground water pollution.

Ground water being a state subject, as per : Entry 17 of List II of the Seventh Schedule of the Constitution of India only states are empowered to enact laws to control and regulate ground-water exploitation.

8.1.5 Management of Soil & Soil Fertility

The earlier discussions (para 5.5) on soil properties have highlighted several problems in textural and structural make-ups, low status of available moisture, soil loss due to

erosion, soil acidity, nutrient loss by leaching and overall low fertility status of agricultural fields The following management programmes are suggested to improve the situation :

i) Building up of a soil horizon rich in organic matter by application of bulk organic manures (FYM, compost and processed animal wastes), recycling of organic wastes, crop or root residues together with short stubbles and green manuring practices. These will not only improve the physical properties of soils but also lead to improvement in nutrient status of soils, enhance biological activities of the soil organisms, in addition to raising the organic carbon percent in soils. The old practices of preparing composts by the farmers should be revived. Pit or trench method of composting will serve the purpose. In many places, vermiculture has been adopted for making quick compost. This can also be tried with effective species of earthworm.

ii) Many agronomic practices are of immense importance for soil and water conservation and also maintenance of soil fertility. Proper selection of crop cover or crop canopy utilizing cowpea/groundnut/green gram/sunhemp, usefulness of grass cover (like Chrysopogon zeylanicus). crop selection based on erosion-resistant capacities or inclusion of suitable legumes in crop rotation, planting of crops with maximum canopy synchronizing with high intensity rains thus reducing the impact of raindrops on land are some of the practical recommendations.

Mulching of open land surface by spreading stubbles, or straw mulching or dust mulching are some of the practical ways to check soil loss by erosion and conversation of soil moisture particularly during dry seasons.

iii) The concept of land capability classifications of soils should be examined effectively and crop management programme should be made accordingly. The preparation of cropping sequences or making schedule for good crop rotation involving legumes with cereals in a sequence to take advantages of different feeding zones, both for nutrients and water and also to offset disadvantages of monocropping in controlling insects, pests and diseases, etc. and adjustment of sowing date for assuring enough ground cover prior to high intensive rainfall, optimum crop geometry (to avoid excess population), mixed cropping (examples, sorghum and pigeon pea, wheat and gram), strip cropping - growing of few rows of erosion-resistant and erosion-permitting crops in alternate strips on contour basis or across the slope are some of effective indirect measures against soil losses due to erosion and nutrient loss by leaching.

iv) Because of the linkage between soil nitrogen and organic matter, management practices must maintain adequate nitrogen inputs as a pre-requisite for adequate organic matter levels. Accordingly, the inclusion of legumes in the crop rotation and judicious use of N-fertilizers to enhance high soil productivity are the two desirable practices.

v) Mechanical stirring of the soil by tillage are needed to control weeds and maintain adequate soil aeration. This should be associated with conservation tillage practices

that minimize tillage to leave much of crop residues on or near the soil surface thereby slowing down the rate of residual decay. At times, this could lead to higher organic matter level.

vi) Decreasing soil acidity by addition of liming materials - referred to as agricultural limes (carbonates, oxides or hydroxides of Ca and Mg compounds) should be advocated.

Farmers should practise liming every alternate year. Quantum of lime requirement should be carefully determined since it is dependent on buffer capacity of soil, change in pH, fineness of the liming materials and their chemical compositions. Chemical guarantee of liming materials must be also checked.

The standard neutralising abilities or $CaCO_3$ equivalent values for different liming materials are as follows :

Burnt lime	182
Hydrated lime	140
Dolomite limestone	100

vii) Use of biofertilizers and farmers` awareness regarding `mycorrhizae` (mutually benefited symbiotic association between numerous fungi and roots of higher plants) should be encouraged and made available to them. This is particularly true for Azolla and Blue-green algae which have wide applications in rice cultivation. Inoculants of Rhizobium, Azotobacter and Azospirillum have shown promise for biologically controlled nitrogen fixation and Phosphobacterin for solubilisation of insoluble phosphates in soil.

viii) Applications of fertilizers to supply N, P and K are essentially needed. Quantities of fertilizers required should be assessed by soil test values and the nature of crops. Necessary guidelines are to be provided to the farmers for quality control of fertilizers, method of application and the time of application. Split applications of both N and K fertilizers are recommended for most of the Terai regions to minimize nutrient loss by leaching in light intensity rainfall zones. General recommended dose for N, P and K - 80 kg N, 40 kg P_2O_5 and 40 kg K_2O per hectare.

List of Fertilizers Recommended

Straight Fertilizers

N : Urea, Ammonium Sulphate

P : Superphosphate, Basic Slag or Bone meal

K : Muriate of Potash

Complex Fertilizers

DAP, Sufala (15:15:15), Ammonium Phosphate Sulphate (20-20-0). IFFCo. has different types of NPK complex fertilizers.

Micronutrient Fertilizers

Application of Borax at the rate of 10 kg/ha at the time of final land preparation is a general recommended dose.

8.1.6 **Management of Biodiversity**

As indicated in para 5.6 agricultural practices in the project area are going through a major change with the introduction of irrigation water leading to a multi-crop regime replacing mono-cropping, use of hybrid varieties in preference to local ones, use of chemical fertilizers and pesticides in preference to manure. Adverse impacts of such farming practice (para 7.2.9) may lead to extinction of some of the local species and concentration of agriculture around a few selected hybrid species supported by a chemical environment. While the chemical environment would create adverse reactions in soil and water, the farming practice will reduce biodiversity. Management of biodiversity will thus call for conservation of germ plasm of the local genotypes of species. Species and varieties to be preserved shall include the local varieties mentioned in tables of paragraph 5.6 including Table 5.6.1 series for Rice, capsularis jute, Nainital and Darjeeling Red round for potato, old varieties for brinjal and Nicotiana tabacum for tobacco as the major ones.

Simultaneously, with the preservation of genes, control on the use of the pesticides and chemical fertilizers is required to avoid adverse effects on soil and bio-life. A major move away from chemicals to bio-fertilizers and bio-pesticides has already started in the tea garden areas under pressure from the tea-importing countries. Similar pressure in the long run may be exerted on agairultural products which are likely to be exported in future. Hence, the management of fertilizers and pesticides becomes important.

Embankment stabilisation through planting of suitable tree species for soil protection

The light textured soil of the area and the preponderance of coarse sand, the constructed embankments call for stabilisation against scouring and bank collapse. These risks are not related to Terai soil conditions alone but have a lot to do with hill deforestation, Dolomite mining etc. in the hill areas further north. The constructional and technical solutions apart, judiciously balanced plantation of trees on embankments, with an eye towards economically remunerative outcome from most of such trees also, becomes essential for durable soil protection so that soil conservation schemes may function efficiently and the land areas adjoining the embankments do not require frequent reclamation. Multiple-row tree and grass planting along the embankments is the most suitable approach. This, of course, will depend upon the nature of soil and width of embankment land available for planting of the rows. Trees like Sissoo (Dalbergia sissoo) and Babul (Acacia nilotica) have been considered to be erroneous choice for NBTDP area since they require heavy soil with permanent moisture. However, in view of its high popularity as timber yielding permanent shade tree in several blocks of Jalpaiguri and Cooch Behar districts, Sissoo tree plantation cannot be discarded. Only,

it has to be accommodated in one of the relatively back rows in embankment plantations. Alternatively, it can continue growing in regular forest areas.

The first-row embankment plantations must have trees with strong taproot system which are not likely to develop root system passing on to berm or embankment ledge in search of water. These reasons seem to have mitigated against Acacia nilotica as soil protective embankment tree of the first row. Again, very tall and dense canopied trees are also not suitable for raising embankment plantations as they may cause serious obstruction in water flow in the event of their being uprooted or buckled due to strong wind. Mixed first row planting may also be done at some places. In subsequent rows too, mixed tree planting is preferred.

Suitable first-row trees species for the embankment stabilisation may include :

Leucaena leucocephala
Acacia catechu #
Albizia procera, Albizia lebbeck
Terminalia myriocarpa (or other spp)
Ailanthus spp
Tamarindus indica
Terminalia chebula
Tectona grandis
Eucalyptus deglupta
E. camaladulensis (E. rostrata)
E. gomphocephala
E. grandis
E. Hybrid i.e. E. botryoides x E. tereticornis or E. robusta x E. tereticornis
E. tereticornis (E. umbellata)

The species for subsequent rows may be Dalbergia sissoo, other -Acacia spp, Michelia champaca, Emblica officinalis, Shorea robusta, Chukrasia velutina (C. tabularis), Madhuca indica, Dipterocarpus macrocarpus, Anthocephalus kadamba, Albizia falcataria, Cordia alleodera, Azadirachta indica, Ficus lacor, Syzygium cumini, Buchanania lanzan, Terminalia bellirica, Mangifera indica, Artocarpus heterophyllus and others.

The species mentioned as first-row trees could also be mixed with back-row species. Mixed plantations have also been advocated in other places as a useful layout for embankment stabilization.

Ground cover species such as grasses and trees such as turmeric, ginger, citronella and black pepper may be grown at various stages in embankment plantations.

At one time, a popular species for Katha or Khair manufacturing in Jalpaiguri District (Madarihat).

Fodder Production

The World Bank aided project for fodder development has helped in initiation of cultivation of the such fodder grasses and legumes. As grazing land is becoming more and more scarce, fodder production for stall feeding is bound to catch up. With the increasing popularity of HTWs, STWs and other minor irrigation projects, irrigation-aided cultivation of fodder grasses and legumes, planned development of permanent grasslands, inclusion of fodder crops (maize, bajra etc.) in multiple cropping schedules and promotion of silage could be undertaken in Terai region, otherwise animal resource development through breeding and introduction of improved stocks will be very difficult to achieve. Consequently, milk, egg and meat production will suffer and the use of animal power in farming and transport will be hampered. In the context of agricultural lands of Terai region being already used for cropping of cereals, vegetables, pulses and oilseeds, fodder production has to become an integral part of the cropping system. It is only through these steps, taking advantage of irrigation projects, that the crying need for fodder (specially for stall feeding) production can be met - at least to a considerable extent.

8.1.7 **Management of Forests**

The status of forest in the project is described in Chapter 2.6 with impacts given in para 7.3. Afforestation in the project area is done by the Forest Department, Government of West Bengal. Current levels of deforestation partly due to failure of this Department to prevent illegal felling of trees. But as a result of constant decreasing of forest areas and low yield of minor forest produce, many tribals and others who have a stake in the forest, also undertake illegal felling of trees for additional income for their families. Forest management with community participation, involving people directly affected by depletion of forest resources, is increasingly being undertaken. The main features of such programmes are :

(i) contribution of the future beneficiaries to the development effects

(ii) sharing equitably the benefits derived from re-generation of forests and its produce

(iii) participation in decision making in respect of goals and in formulating policies and planning to achieve the same.

People in homogenous groups in terms of resources and problems are considered for such participation. They develop rules, behaviours, customs and traditions for smooth running of the schemes and adjust between the individual and group behaviours. This practice involves strip planting along major roads, canal sides and river embankments for timber and fire-wood, planting trees in permanent fallow lands, controlled agriculture in forest land etc. In each Terai District a number of Forest Production Committees (FPC) are constituted with the help of beneficiaries who are entrusted with the protection and management of forest resources in the area. There were 35 such protection committees in Jalpaiguri, 14 in Darjeeling and 6 in Cooch Behar and the numbers are increasing every year. Their role in participatory management of forest re-generation is already bearing fruit. However, management and administrative inputs are

necessary with expert advice for optimising effects of this programme. Awareness about forest protection and participation in forest management has already developed in the Terai, but for success larger group of people are to be made interested in forestry with equitable share of benefits. Coordination roles in this may be played by the NGOs.

8.1.8 Management of Pesticides Use

a) Need for management

As regards residual toxicity of commonly used chemical products, no definitive comments can be given at this stage. Repeated applications of hazardous pesticides belonging to chlorinated hydrocarbons, organophosphorus compounds and carbamates are to be avoided. In this way the problem of residual toxicity can be contained. Thus, agricultural extension shows focus on rapidly degraded least toxic compounds. However, due precautions are required, like keeping the children and animals away from these harmful chemicals and changing of clothes after every use, washing with soap etc. Use of treated crop products for human consumption calls for awareness campaigns on the importance of thorough washing, boiling or cooking prior to consumption. For such horticultural and agricultural field products as edible fruits, toxicity gets drastically reduced mostly within 10-15 days after the crop or tree application. The small quantity of pesticide residue has to be removed through repeated washing before consumption.

At a time when integrated pest management is yet to take roots in Indian agriculture, use of pesticides cannot be avoided. However, persistent awareness campaigns highlighting issues like toxicity effects, use of approved and allowed pesticides, adoption of precautionary measures, etc. have to be carried on. Although in the Terai region, pesticide use, agriculture as a whole is still far below the risk level of in the quantitative terms, the need for much awareness campaigns is urgent.

b) Storage, handling, application and disposal

Pesticides should be stored at an isolated place high enough to avoid flood water and/or coming in contact with water sources. The packaging containers (drums, sacks, fibre board cases, wooden cases, etc.) should be secure enough and placed in such a way that the pesticides inside would not come in contact with the floor. The storage duration should not be more than the prescribed shelf life (roughly two years from manufacturing date for majority of the pesticides).

Pesticides handling requires wearing of protective clothing and respiratory devices. They should be handled in a properly ventilated working area. Spillage of pesticides, should be immediately removed either by sweeping or by soaking with the help of some absorbing material like saw dust and the resultant heaps shall be properly placed in marked containers for proper disposal.

Depending on the nature of the pesticides, the various methods that are adopted for their application are spraying, dusting and fumigation. The instruction on the package cover or container should be strictly followed regarding the method of application. In applying these chemical, due note should be taken of the wind direction to avoid secondary poisoning.

For safe disposal of products and packing materials, one or more isolated trenches (60-90 cm long, 45 cm deep and 15 cm deep) should be dug and used. One such trench is sufficient for disposal of 5 litres of liquid or 5 kg of solid pesticide. The pesticide has to be first mixed with an approximately equal volume of sand or soil in the trench and then decomposing agents (like alkalis, acids, oxidizing agents, reducing agents etc.) should be slowly added and well mixed with the pesticide. In the end, the trench should, be filled and closed with tightly packed soil.

c) Prescribed dosage and frequency of application

The prescribed dosage and frequency of application of pesticides will vary from crop to crop. It is, advisable that the extension workers should first ascertain these data from the subject matter specialists of the area and then formulate their programmes of extension activities on plant protection.

d) Integrated Pest Management (IPM) :

There are various measures applied for the control of crop pests and diseases. The integration of all these measures, or a number of these measures, into a common basket, according to the situational need and class of pest species, is known as `Integrated Pest Management (IPM)'. The measures commonly adopted are as follows :

(i). Cultural Methods (agronomic practices)

(a) Crop rotation

(b) Crop location

(c) Trap crops

(d) Tillage

(e) Altered timings

(f) Clean cultures

(g) Soil manuring and fertilization

(h) Pruning and thinning

(i) Crop refuse and destruction

(j) Growing resistant varieties

(k) Management control

(ii) Mechanical methods

(a) Hand picking

(b) Shaking and beating of branches

(c) Banding

(d) Wire gauge screen

(e) Trench digging

(f) Trapping

(g) Pest - smashing / Pest collecting device

(h) Flooding and drainage

(i) Uprooting and burning

(iii) Physical methods

(a) Cooling

(b) Heating

(c) Radiant energy

(iv) Legal methods

Strict adherence to the statutory `do's' and `don'ts' in case of locust invasion, epidemics of cross border nature.

(v) Biological methods like biological control through introduction of selective pest predators or through a effective genetically induced male sterility.

(vi) Chemical methods

(a) Insecticides

(b) Chemosterilant

(c) Antifeedants

(d) Atractants

(e) Repellants

(f) Semi chemicals

Awareness campaigns with audio-visual aids, posters and T & V methods have to be implemented to help initiate effective methods of IPM.

8.1.9 **Extension Services**

(a) An essential component of Environment Management Plan will be extension services to transfer knowledge to the project beneficiaries for environmental protection or improvement. The extension messages shall comprise :

(i) Messages on Health & Personal Hygiene

Bacterial transfer of diseases through anal/oral routes and the transmission path through soil and water will be stressed. Personal cleanliness, i.e. washing of hands after ablution and after meals, washing of utensils and clothes with clean water, cleaning and washing of food materials before cooking and the like and use of safe water for drinking and domestic use will form essential components of this knowledge transfer. Village level health workers may play the key role in the knowledge transfer after getting proper training and guidance from the Department

of Health. Anganwadi workers and NGOs working in the rural health field will also be utilised.

(ii) Messages on Crop Combination and Crop Rotation

Continued maintenance of soil fertility and optimum yield of crops will depend in the long run on proper crop rotation and crop combination (para 8.1.5). Messages on these are to be transferred through extension services of the Department of Agriculture (DOA) with supply of appropriate seeds and use of demonstration plots.

(iii) Messages on Rational Livestock Keeping

In the long run, rearing improved breeds of cattle and other livestock will enhance economic growth among the farmers in the project area. This has to be combined with cultivation of proper fodder and arrangement of stall feeding to reduce degradation of soil cover through over grassing of grass lands. Knowledge transfer on these aspects is to be done by Department of animal Husbandry (DOAH) and DOA.

(iv) Messages on Use & Abuse of Fertilizers and Pesticides

Need for Management of Pesticide and Fertilizer use has already been stressed in the perspective of degradation of soil and water and also in terms of future loss of agricultural production (para 5.6.4, 7.2.5). Extension messages must include effective fertilizer application , identification of various plant diseases, selection of proper fertilizers and pesticides, checking on their quality and quantity, method of application, precautions for storage, handling and application, safe disposal of packaging materials, knowledge of toxicity and their antidotes and information of alternative measures, such as Integrated Pest Management, cropping measures (timing, planting and harvesting) to optimise the fertilizers and pesticides requirements. Such extension messages are to be imparted by Department of Agriculture with assistance from local bodies. Information on Government rules & regulations on pesticides use, their toxicity and preventive measures are given in Annexure 8.1.9. Management of pesticides and Integrated Pesticide Management has already been stressed (para 8.1.8).

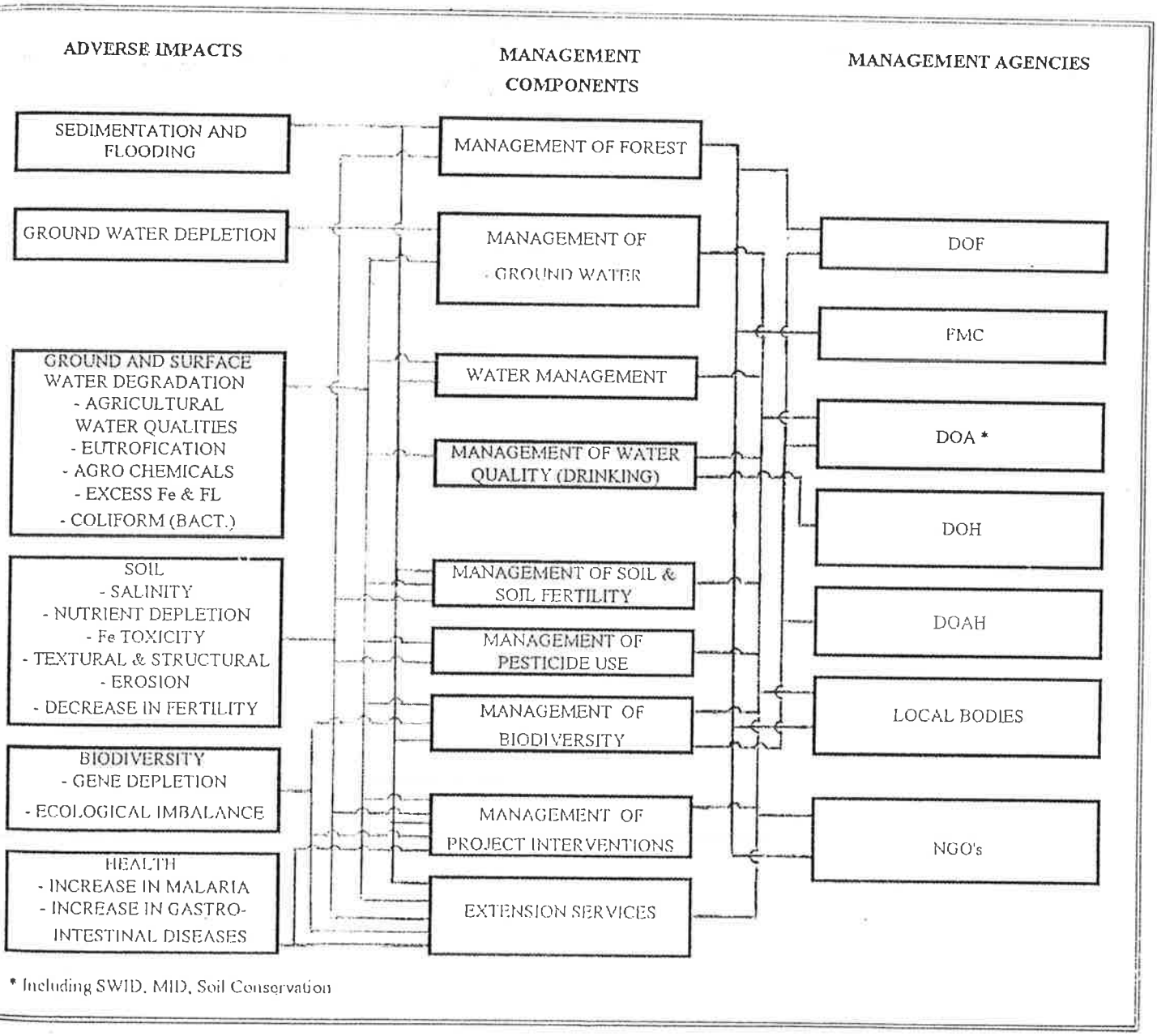
(b) A multi-media approach is recommended for the dissemination of extension messages using talks, demonstrations, model farming plots and posters, video shows, flip charts and publication of brochures detailing the message conveyed, An inter departmental extension group is recommended to canvass the messages with assistance from local bodies and NGO's which will perform knowledge transfer in cooperation with the Beneficiaries' committees.

8.2 Environmental Monitoring Plan (EMP)

The EMP, so far discussed, is basically a set of future actions. In view of the remaining uncertainties, it is necessary for the project authority to continue monitoring of other certain environmental indicators. This will signal any potential environmental problem and allow for timely intervention and implementation of corrective measures. It will also allow validation of many of the assumptions made in preparing this complex

Environmental Management Plan

Fig 8.1



* Including SWID, MID, Soil Conservation

assessment. At the physical level the monitoring will include field observations, pumping tests and physico-chemical analysis of samples to have a total quality control of the entire project cycle and to assess the actual impacts which result from the implementation and operation of project components. At the support services level it will oversee the extension and training activities to bridge the knowledge gaps that may cause suboptimal use of the project facilities.

The monitoring programme should be established immediately to provide a baseline for comparison. Monitoring of physical environmental indicators on a routine fashions is proposed from a pre-selected network of sampling/monitoring stations randomly distributed over the project area.

Suggestions for an Environmental Monitoring Prrogramme are given below.

8.2.1 Quality Assessment of Water for

(a) Irrigation Use : Surface & Ground Water

In the NBTDP, five major sources of irrigation water have been identified:

(i) Pump Dug Well

(ii) Hand Tubewell

(iii) Shallow Tubewell

(iv) Deep Tubewell

(v) River Lift Irrigation System

The quality of irrigation water should be tested at least twice a year (pre and post-monsoon periods) for ten consecutive years the following parameters should be included in these tests :

(i) Turbidity

(ii) pH

(iii) Sodium Absorption Ratio (Na, Ca, Mg)

(iv) Salinity

(v) Electrical Conductivity of Saturation Extract (EC_e)

(vi) Total Dissolved Solids

(vii) Total Hardness

(viii) Residual Sodium Carbonate (Residual Carbonate, Residual Bicarbonate)

(ix) Iron

(x) Heavy Metals

Site Selection

20 monitoring stations will cover the 5 sources prorata with their numbers in each subdivision spread over the entire project area, spread over the project area as follows :

District	Sub-division	No. of Monitoring Stations
Darjeeling	Siliguri	4
Jalpaiguri	Jalpaiguri (Sadar)	4
	Alipurduar	4
Cooch Behar	Cooch Behar	2
	Dinhata	2
	Mathabhanga	2
	Mekhliganj	2
Total Samples		**20**

In many areas, the drainage water from tea gardens is used for irrigation of adjoining agricultural fields. Hence it is proposed to analyse an additional 4(four) samples of drainage water from the tea gardens for quality assessment.

(b) Agrochemical Pollution : Surface & Ground Water

Leaching of agrochemicals into ground and surface water has already been discussed (Chap. 5,7). Based on the probability of vertical leaching and consequent contamination, the sampling schedule for agro-chemical pollution may be restricted to the following project components :

(i) Pump Dug Well

(ii) Hand Tubewell

(iii) Shallow Tubewell

(iv) River Lift Irrigation Schemes

Parameters for testing include :

(a) Nitrate (NO_3)

(b) Phosphate (PO_4)

(c) Potash (K_20)

(d) Arsenic

(e) Pesticide Residues :

(i) Dicofol

(ii) Endosulfan

(iii) Dieldrin

(iv) Chlorpyriphos

(v) Ethion

The frequency of sampling should be twice a year (pre and post monsoon periods) for ten consecutive years.

Site Selection

There should be altogether 20 monitoring stations spread over the entire project area with the distributive pattern as follows :

District	Sub-division	No. of Monitoring Stations
Darjeeling	Siliguri	4
Jalpaiguri	Jalpaiguri (Sadar)	4
	Alipurduar	4
Cooch Behar	Cooch Behar	2
	Dinhata	2
	Mathabhanga	2
	Mekhliganj	2
Total Samples		**20**

To assess future nutrient leaching for enrichment and eutrophication of ponds, basins and other receiving water bodies in the project area. It is required to assess the extent of surface water eutrophication at 10(ten) selected sites and quantify its impact on aquatic life. Special attention to be given to N, P and K content of water, as well as BOD and COD.

(c) Drinking Water Purpose

The quality assessment of drinking water is essential to ensure protection against potent health hazards. The project components involved in drinking water quality assessment shall include pump dug wells and hand tubewells. The frequency of sampling will be once a year, spread over the project area as follows :

District	Sub-division	No. of Monitoring Stations
Darjeeling	Siliguri	2
Jalpaiguri	Jalpaiguri (Sadar)	2
	Alipurduar	2
Cooch Behar	Cooch Behar	1
	Dinhata	1
	Mathabhanga	1
	Mekhliganj	1
Total Samples		**10**

Both chemical compositions and bacteriological contaminations are to be tested. Parameters to be monitored shall be as per IS;10500 1991 guidelines.

8.2.2 **Assessment of Soil Quality & Fertility Status**

Monitoring of soil quality and fertility status will be done through testing of the following parameters.

(i) Physico-chemical
- Acidity
- Salinity
- Electrical Conductivity of Saturation Extract, EC_e
- Base Saturation %

(ii) Organic Carbon, Available P & K

(iii) DTPA Extractable Fe, Cu, Mn, Zn

(iv) Hot Water Extractable Boron

(v) Lime Requirement

(vi) Soil Nutrient

Establishment of a data bank for soil parameters could be considered by well-equipped Soil Science Laboratories, the site selection should be made for each sub-division in the three districts, with once in a year sampling schedule, as follows:

District	Sub-division	No. of Monitoring Stations
Darjeeling	Siliguri	4
Jalpaiguri	Jalpaiguri (Sadar)	4
	Alipurduar	4
Cooch Behar	Cooch Behar	2
	Dinhata	2
	Mathabhanga	2
	Mekhliganj	2
Total Samples		**20**

8.2.3 **Ground Water Monitoring**

Considering the ground water potential, the geological condition and the intensity of rainfall a comprehensive ground water monitoring plan is recommended.

The current ground water monitoring as conducted by SWID is only partial because there is no location mapping available. Moreover their hydrograph network stations from which water levels are measured four times a year only tap unconfined/water table aquifer. In para 2.4 it has been discussed that there are two types of aquifers - unconfined/water table aquifers and confined aquifers present in this area. The deep tubewells tap confined aquifers, from which not data is available.

In order to make the monitoring comprehensive following plan is proposed :

- Selection of the network hydrograph stations spread over the project area, tapping confined and unconfined aquifers and locating these stations separately on the maps on the basis of the aquifer nature. Network stations should be at least 2 stations in each block.
- Measuring of the reduced level (RL) above mean sea level of these points.
- Carrying out of water level measurement of all these points four times in a year as usual(routine measurement).
- Preparation of ground water contour maps both for water table and piezometric levels and assessing the flow direction of the ground water. These maps will help to find the relation between ground water regime and river systems, and provide indications on the zone of recharge.
- Preparation of the fluctuation maps based on the difference of water level between pre-monsoon and post-monsoon seasons.
- On the basis of these maps, ground water budgeting using the water balance fluctuation method, for each year blockwise, can be prepared.

Lithologs from the borehole and the assembly design of all future deep tubewell should be will be preserved in a proper manner and slot size of the strainers will be decided on the basis of sieve analysis of the granular zones. The pump test should be must for all the deep tubewells. In order to ascertain the aquifer characteristics (storativity and transmissivity) this pump test must be carried out in two phases, i) Aquifer performance test (step down test), and ii) Well performance test will also help to find the safe distances between the tubewells and step draw down test will help to calculate the safe yield of the tubewell.

Both SWID and CGWB have the infrastructure and potential to carry out this type of works. However, SWID is preferred being a State Government outfit. However, some independent agencies with their background in this type of studies with proper infrastructure, resources and expertise resources can also handle the work.

Study of ground water monitoring on a selected interfluvial zone has not been started yet.

8.2.4 Monitoring Plan in Biodiversity

Cropping as well as livestock and fish farming should be routinely monitored (at least once in 2 years) by Government departments, specialists from Universities and research

institutes and outside agencies like NGOs to ascertain the progress or decline in performance yield, use of number of varieties of species being cultivated/cultured, the extension or decrease in area of their culture, the cropping sequences being practised, the extent of crop diversification, and crop mixing, relay farming and the type and quantities of chemical and other inputs being used. Seed multiplication, seed storage and seed supply programmes should be monitored every year jointly by state and private agencies, and by NGOs.

The parameters to be monitored will include :

- replacement of traditional varieties by HYVs and hybrids
- crop performance in different seasons
- weed incidence and diversity
- crop yield and, crop duration
- number of crops grown and their sequence in a year
- seed source and quantity used per crop
- fish types/species per unit of water area
- meat, milk and egg production per litre per year.
- analysis of surveillance reports and their relationship with output growth in agriculture.

The units to monitor the above parameters have to be established in each subdivision of the Terai districts and a Central Data Bank at Siliguri or Jalpaiguri may be established for the use of whole of Terai region in regard to further planning for improved crop and animal farming and better forest covers.

Close monitoring of plans and action programmes for promoting fodder (grasses, legumes and trees), cultivation and financial support there of from institutional agencies (banks, Government and schemes etc.) is also very essential in the project area.

The monitoring centres will have to be entrusted with estimation and reporting of nature and extent of gene erosion and the required degree of conservation of germplasm in crops, animals and fish.

8.2.5 Assessment of Performance of Project Interventions

Deficiencies in the performance of project interventions and remedial measures have been discussed in Chapter 6 and also in para 8.1.2. Efficacy of the recommended improvements as regards bacteriological quality of water will be monitored as under para 8.2.1(c). Loss of water through the project interventions and other deficiencies will however have to be monitored periodically through field check by the Department of Agricultural Officials at senior level and actions taken for removal of the defects. This shall be a part of the routine maintenance of the project installations.

8.2.6 **Monitoring of the Performance of Extension Services**

The extension services proposed in para 8.1.9 will have to be monitored by a team of inter-disciplinary experts who will develop indicators to check the impacts in

(i) Health & personal hygiene : a crude estimate of this may be available from the health statistics of the Government, but for better monitoring, annual surveys for collection of primary data from the project beneficiaries has to be undertaken in line with the survey done during this study.

(ii) For message of biodiversity the result of monitoring under para 8.2.4 will describe the success of the extension programme. For the other aspects the following items need be considered :

(a) Trends in Use of Agro-chemicals

- Fertilizers :
  - Names and doses of different macronutrient fertilizers - N, P and K; their methods and time of application.
  - Names and doses of different micronutrient fertilizers (namely, Zn & B), their methods and time of application.
  - Constraints in supply of fertilizers.
  - Quality control.
- Pesticide
  - Names and quantum of application
  - Constraints in supplies
  - Quality control.

(b) Trends in loss of traditional and domesticated crop varieties and use of HY-varieties of crops and vegetables : Total period of use of these selected varieties.

(c) Trends in incidence of agro-related crops, pests and diseases.

(d) Common cropping sequences prevalent in the area :

- Monocrop/double crop/triple crop priorities
- Conventional rotational/cropping practices.
- Information regarding grass land farming and fodder crops.

(e) Trends in use of cash crops and plantation crops.

(f) Trends in use of cowdung as manure and fuel.

A team of inter-disciplinary experts has to be constituted for the purpose of monitoring activities including monitoring of the data base preparation. This may be done every alternative year.

8.2.7 Cost of Monitoring

Cost of environmental management will have to be built in within the departmental budgets of the respective agencies proposed to be involved in the management and monitoring activities for the project, for which adequate provisions have to be kept. However, the collection and analysis of samples proposed under the monitoring programme will need establishment of laboratories and training of personnel. Alternatively, this may be done at the existing laboratories by paying the necessary charges. A preliminary estimate suggests that the proposed collection and analysis of sample will cost about Rs.250,000/- per annum in addition to the departmental cost for organising the sampling programmes.

8.2.8 Monitoring Agencies

Monitoring of certain environmental parameters for soil and water is already being carried out by the existing Government Departments like SWID, CGWB and others. Some academic institutions like BCKV and the North Bengal University are also doing some sporadic studies. However, the experience during the current study indicated that the data generated by the various agencies are in many respects non-compatible and in certain cases fail to fulfill the project objectives. Lapses of the on-going monitoring activities, non-randomness in selection of sample and lack of proper interfacing between the agencies have been frequently encountered. Shortage of technically qualified man-power and proper infrastructural facilities are acute. In this perspective institutional arrangement for environmental management and monitoring in the project area need proper strengthening.

Annexure 1.1

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Annexure 1.4

LIST OF OFFICES AND INSTITUTIONS

(A) GOVERNMENT DEPARTMENTS & OFFICES

Agriculture Department

1. Joint Director of Agriculture (JDA), Jalpaiguri
2. Principal Agricultural Officer (PAO), Jalpaiguri District
3. Sub Divisional Agricultural Officer (SDAO), Jalpaiguri Sub Division, Jalpaiguri
4. Soil Conservation Officer (SCO), Jalpaiguri Sub Division, Jalpaiguri
5. District Agricultural Development Officer (ADO), Jalpaiguri Sadar, Jalpaiguri
6. Sub Divisional Agricultural Officer (SDAO), Siliguri Sub Division, Siliguri
7. Soil Conservation Officer (SCO), Siliguri Sub Division, Siliguri
8. Agro-Economist Evaluation Wing, Siliguri
9. Sub Divisional Agricultural Officer (SDAO), Alipurduar Sub Division, Alipurduar
10. Principal Agricultural Officer (PAO), Cooch Behar
11. Soil Conservation Officer (SCO), Cooch Behar Sub Division, Cooch Behar
12. Block Development Officers/Agricultural Development Officers at all block levels
13. Sub Division Agricultural Officer (SDAO), Dinhata, Cooch Behar
14. Mohitnagar Seed Agricultural Farm, Mohitnagar, Jalpaiguri
15 Director of Agriculture, Calcutta
16. Joint Director of Agriculture (Rice), Calcutta
17. Bureau of Agricultural Statistics, Calcutta
18. State Agricultural Research Laboratory, Calcutta
19. Evaluation Wing Directorate of Agriculture, Calcutta
20. Soil Survey Wing, Calcutta

Agri-Irrigation Department

1. Executive Engineer, Agri-Irrigation, Jalpaiguri
2. Executive Engineer, Agri-Mechanical, Jalpaiguri
3. Superintending Engineer, Agri-Mechanical, Jalpaiguri
4. Assistant Engineer, Agri-Mechanical, Jalpaiguri

Irrigation Department

1. Chief Engineer, Irrigation, Siliguri
2. Executive Engineer(s), Siliguri Irrigation Offices, Siliguri
3. Executive Engineer, Teesta Monitoring & Evaluation, Siliguri
4. Chairman, North Bengal Flood Control Commission, Jalpaiguri
5. State Water Investigation Directorate (SWID), Calcutta & Jalpaiguri

Annexure 1.4 (Contd.)

(E) ACADEMIC INSTITUTIONS/UNIVERSITIES

1. Department of Geography and Applied Geography, North Bengal University, Siliguri
2. Department of Life Sciences, North Bengal University, Siliguri
3. Department of Civil Engineering, North Bengal Regional Engineering College, Jalpaiguri
4. Bidhan Chandra Krishi Viswavidyalaya, North Bengal Campus, Pundirbari, Cooch Behar
5. Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia
6. Department of Geology, Presidency College, Calcutta
7. Department of Geography, Presidency College, Calcutta
8. Centre for Study of Man & Environment, Calcutta
9. Department of Soil Science & Agricultural Chemistry, Calcutta University
10. Department of Botany, Calcutta University
11. Department of Zoology, Calcutta University
12. Department of Geography, Calcutta University
13. University College of Agriculture, Calcutta University
14. Indian Institute of Bio-Social Research & Development, Calcutta

(F) PRIVATE ORGANISATIONS

1. Production Manager, Hindusthan Lever Corporation, Jalpaiguri
2. Effluent & Water Treatment Engineers, Malbazar, Jalpaiguri

(G) INDIAN TEA ASSOCIATION (ITA)

1. Duars Branch Indian Tea Association (DBITA), Binnaguri, Jalpaiguri
2. Tea Research Association (TRA), Nagrakata Sub Station, Jalpaiguri

Annexure 4.3

List of Samples : Water Quality for Agricultural Use, Drinking, Pesticide Residue, Mineral Enrichment
: Soil Samples

District	Block	Village	Structure	No. of Samples for					Soil Samples
				Agri. Use	Drinking Purpose	Pesticide Residue Analysis		Mineral Enrich-ment	
						S.W	T.G		
Darjeeling	Matigara	Lachka	HTW	2					
	Kharibari	Kharibari	PDW	2					
	Matigara	Lachka	HTW		1				
	Kharibari	Kharibari	PDW		1				
	Kharibari	Adhikari	Pond					1	
	Naxalbari	Bangajote	Pond					1	
	Matigara	Lachka	HTW						1
Jalpaiguri	Dhupguri	Purba Attagram	RLI	1		1			
	Dhupguri	Madhyaboraguri	DTW	1					1
	Dhupguri	Uttar Dangapara	HTW	2	1				
	Alipurduar I	Dakshin Sonapur	DTW	1					
	Alipurduar I	Purba Bholardabi	HTW	1	1				
	Maynaguri	Pashamerdanga	RLI	1		1			1
	Jalpaiguri	Barkamath	RLI	1		1			1
	Jalpaiguri	Tarininagar	DTW	1					
	Maynaguri	Maynaguri	Pond					2	
	Dhupguri	Charchurabhand	Pond					1	
	Dhupguri	Dharaiguri	Pond					1	
	Jalpaiguri	Vivekanandapally	Pond					2	
	Kumargram	Dk. Kamalakshya	PDW						1
	Mal	Ranichora	Tea Estate				1		
	Dhupguri	Gajarkata	Tea Estate				1		
	Nagrakata	Bhagatpore	Tea Estate				1		
Cooch Behar	Dinhata I	Phulbari	DTW	1					
	Dinhata I	Jhuripara	HTW	1	1				
	Dinhata II	Kalamati	STW	2					1
	Haldibari	Kasibari	PDW	1	1				
	Dinhata II	Dk. Bononachina	Pond					1	
	Haldibari	Kasibari	Pond					1	
	Haldibari	Kasibari	DTW						
Total				18	6	3	3	10	6

Annexure 4.3

List of Samples : Farmers Survey
: Bactereological Test of Water

District	Block	Village	Structure	No. of Questionnaire	No. of Bac. Sample
Darjeeling	Kharibari	Prosadujote	HTW	1	1
	Kharibari	Kharibari	PDW	1	1
	Matigara (Formerly Naxalbari - Phansidewa)	Lachka	HTW	2	2
Jalpaiguri	Aliporeduar I	Purba Bholardabri	HTW	3	3
	Aliporeduar I	Dakshin Sonarpur	DTW	5	1
	Kumargram	Dakshin Kamakshyaguri	HTW	2	2
	Kumargram	Dakshin Kamakshyaguri	PDW	2	2
	Kalchini	Uttar Mandabari	HTW	2	2
	Madarihat	Purba Madarihat	PDW	2	2
	Jalpaiguri	Kuchua Nndanpur	HTW	3	3
	Dhupguri	Purba Altagram	RLI	5	1
	Maynaguri	Pashanardanga	RLI	5	1
	Dhupguri	Uttar Dangapara	HTW	3	3
	Dhupguri	Madhya Boragari	DTW	5	1
	Maynaguri	Singhimari	HTW	3	3
	Mal	Rajadanga	HTW	3	3
	Mal	Paschim Dalaigoan	PDW	2	2
	Jalpaiguri	Barakamath	RLI	5	1
Cooch Behar	Tufangunge I	Ghugharkuthi	HTW	4	4
	Cooch Behar II	Kaljani	HTW	2	2
	Dinhata II	Sikarpur	HTW	3	3
	Dinhata II	Kalamati	STW	6	2
	Dinhata I	Jhuripara	HTW	3	3
	Dinhata I	Phulbari	DTW	5	1
	Cooch Behar I	Maghpala	DTW	5	1
	Cooch Behar I	Kanchamari	HTW	3	3
	Mekhliguni	Changrabandha	PDW	1	1
	Haldibari	Kashiabari	PDW	1	1
	Haldibari	Santinagar(Dangapara)	PDW	1	1
	Haldibari	Kshiabari	HTW	3	3
			TOTAL	91	59

Annexure 4.3

HOUSEHOLD SURVEY QUESTIONNAIRE

Perception study

1.0 Identification

1.1 Name of Respondent : .....

1.2 Name of Head of Household : .....

1.3 Relationship of Respondent to the Head of Household : .....

1.4 Name of Village : .....

1.5 Name of Block : .....

1.6 Name of District : .....

1.7 Type of Infrastructure used : PDW/HTW/STW/DTW/RLI

1.8 Date of commissioning of this Infrastructure : .....

2.0 Ethnicity

2.1 Scheduled Tribe : Yes/No

2.2 Scheduled Caste : Yes/No

2.3 Others : Yes/No

3.0 Social Status

3.1 Educational Status
(*Note the number of persons*)

Level of Education	Adult Male	Adult Female	Minor	Total
Illiterate				
Literate				
Primary Level				
Madhyamik Level				
Higher Level				
Total of all levels				

3.2 Area of Homestead land (including living quarters, cowshed, grain store, kitchen, garden etc.)
(*Record what the respondent says*) .....

3.3 Living Quarters

(a) Structure — Kutcha/Semi Pucca/Pucca

(b) Tenancy — Owned/Rented

3.4 Is the living quarters served by electricity — Yes/No

3.5 Sanitation Facility most frequently used

(a)	In-house:		Yes/No
(b)	Outside	:	Yes/No
(c)	Open field	:	Yes/No
(d)	Pit latrine	:	Yes/No
(e)	Bucket latrine	:	Yes/No
(f)	Sanitary latrine	:	Yes/No
(g)	Community latrine	:	Yes/No

3.6 Source of Drinking & Cooking water

(a)	In-house:		Yes/No
(b)	Outside	:	Yes/No
(c)	Pond	:	Yes/No
(d)	Dug well	:	Yes/No
(e)	Hand Tubewell	:	Yes/No
(f)	Powered Dug well	:	Yes/No
(g)	Shallow Tubewell	:	Yes/No
(h)	Deep Tubewell	:	Yes/No
(i)	River lift	:	Yes/No
(j)	River	:	Yes/No

3.7 Source of water for bathing, washing etc.

(a)	In-house	:	Yes/No
(b)	Outside	:	Yes/No
(c)	Pond	:	Yes/No
(d)	Dug well	:	Yes/No
(e)	Hand Tubewell	:	Yes/No
(f)	Powered Dug well	:	Yes/No
(g)	Shallow Tubewell	:	Yes/No
(h)	Deep Tubewell	:	Yes/No
(i)	River lift	:	Yes/No
(j)	River	:	Yes/No

3.8 Number of Earning Members in the Household Male ..... Female .....

3.9 Number of Non-earning members in the Household Male ..... Female .....

3.10 Sources of Income (*Note the number of cases*)

Source	Male	Female
Cultivation		
Agricultural labour		
Animal husbandry		
Collection of Forest Products		
Household industry		
Industrial Labour		
Government Service		
Teaching		
Other Services		
Trading		
Money lending		
Transport		
Others		
Total		

3.11 How many members of the household suffered from the following ailments in the last 12 months (*Note the number of persons*)

Type of ailment	Adult Male	Adult Female	Minors
(1) Malaria			
(2) Gastro-enteritis			
(3) Pulmonary problems			
(4) Worms			
(5) Snake bite			
(6) Food poisoning			
(7) Poisoned drinks			
(8) Other poisons (Name it)			
All Together			

3.12 Repeat question No. 3.11 and ask

(a) Who diagnosed the ailment : .....

(b) Who administered medicine : .....

(c) Was there any death : .....

4.0 Land holding

4.1 Do you own any land : Yes/No

4.2 If the answer to question 4.1 is **yes**, then state

(a) Area under homestead : .....

(b) Area under farm land : .....

(c) Area under uncultivable land : .....

(d) Area under any other category : .....

Total Area owned : .....

4.3 (a) Did you lease-out any land : Yes/No

(b) If **yes**, how much land did you lease-out : .....

4.4 (a) Did you lease-in any land : Yes/No

(b) If **yes**, how much land did you lease-in : .....

4.5 What was the total area of operational farming by you : .....

4.6 (a) Do you irrigate your farm : Yes/No

(b) If **yes**, how much of your farm land is irrigated : .....

(c) What is the source of irrigation

(Please note that a person may use multiple sources of irrigation. So, note all, if possible the area under each source)

(i) Open Dug well : .....

(ii) Powered Dug well : .....

(iii) Hand Tubewell : .....

(iv) Shallow Tubewell : .....

(v) Deep Tubewell : .....

(vi) River Lift Irrigation : .....

4.7 (a) Did you depend on rain for any part of your farm land : Yes/No

(b) If **yes**, how much of area was dependent on rain : .....

4.8 (a) Do you have your farm land as a single compact unit : Yes/No

(b) If **no**, in how many fragments do you have it : .....

4.9 Over how many years are you irrigating your farm land partly or wholly : .....

5.0 Landuse

5.1 (a) Do you raise only one harvest in a year from all your farm land : Yes/No

(b) If **no**, then how much land do you use to raise : Two harvests in a year .....

: Three harvests in a year .....

(*Note if only such harvests are raised from the same plot*)

5.2 Did you raise any of the following crops and use any of the specified inputs
*(Record only "**YES**" answer)*

Crop	YES Raised this Crop	Irrigation	Organic Manure	Industrial manure	Organic Pesticide	Industrial Pesticide	HYV Seeds
Rice (Aus)							
Rice (Aman)							
Rice (Boro)							
Wheat							
Maize							
Any other Grain							
Vegetable (summer)							
Vegetable (rainy)							
Vegetable (winter)							
Potato							
Oilseeds (winter)							
Oilseeds (summer)							
Pulses (winter)							
Pulses (summer)							
Pulses (rainy)							
Onions							
Garlic							
Chili							
Ginger							
Turmeric							
Jute							
Tobacco							
Any Other Crop (name it)							

5.3 Are you noticing any of the following changes in your farm

Sl. No.	Variables	Increasing	Decreasing	No Change
1	Requirement of fertilizer			
2	Availability of irrigation water			
3	Stiffness of soil			
4	Yield of crop			
5	Invasion by Weeds			
6	Invasion by insets			
7	Plant diseases			
8	Water logging			
9	Requirement of lime			
10	Incidence of earthworms			

5.4 In the water-bodies (like ponds, tanks, rivers and swamps) near your village are you noticing any of the following changes

* Type of Water Bodies	Variables	Increasing	Decreasing	No Change
	Fish production			
	Death of fishes			
	Frogs (incidence)			
	Weeds (incidence)			
	Mosquitoes			

* **NOTE** : P = Pond; T = Tank; R = River; S= Swamp

6.0 Overall Assessment by the Respondent on the Effects of Irrigation Infrastructure for himself

Variables	Scale				
	Very High	High	Medium	Low	Very Low
Advantage					
Disadvantage					

Date of Investigation

Signature of Investigator

Date of Checking by the Supervisor

Signature of Supervisor

Annexure 8.1.9

1. Information of Government Regulations on Pesticides Use

Use of pesticide is regulated every where in India by the Insecticide Act, 1968 (No. 46 of 1968), Insecticide Rules, 1971 and its amendment in 1977 and Insecticide (Amendment) Act, 1977 (No. 24 of 1977) of Govt. of India.

Within the provisions of these Central Government regulations, State Governments can also make their own rules regarding pesticide use.

These regulations and the various Government orders, both at Central and State levels, issued from time to time in pursuance of the Act help the farmers in knowing the names and labels of approved pesticides, their manufacturing details, whether these have been properly packed and stored according to rules and the risk factors, tolerance limits for insecticide residues and the safety measures to prevent risks.

These regulations have to be followed in manufacturing, colouring, labeling, packaging, selling, storing, importing, notification to users of poisoning effects, risk factors and safety procedures and obtaining licenses by the manufacturers and dealers.

Hence, before the purchase of any pesticide from a dealer, the farmers or other users should satisfy themselves in regard to the points indicated in the preceding two paragraphs. Any contravention of specified regulations and Government orders in regard to pesticide sale and use should immediately be reported to appropriate authorities of the area. It has to be clearly kept in mind that while pesticides are effective tools against incidence of diseases and insect pests, their indiscriminate and injudicious use may pose great hazards to the environment and thus to health and lives of people, animals and crops and other plant species of the area.

2. List of 'prohibited' and 'restricted use' products.

Prohibited

1. Calcium Arsenate
2. Lead Arsenate
3. Carbophenthion (Trithion)
4. Azinophos Methyl (Gusathion)
5. EPN
6. Melvinphos (Phosdrin)
7. 2, 4, 5 - T
8. Vamidothion
9. Mephosfolan
10. Azinphos Ethyl
11. Binapacryl
12. Dicrotophos
13. Nitrofen
14. Toxaphene

15. Dibromochloropropane (DBCP)
16. Thiodemeton/Disulphoton
17. Fentin Acetate
18. Fentin Hydroxide
19. Chinomethonate (Morestan)
20. Ammonium Suphanate
21. Leptophos (Phosvel)

Restricted

1. Dieldrin
2. Aldrin
3. Heptachlor

3. Colour Code used for Pesticides classification according to toxicity/hazard class in India

	Extremely Toxic	**Highly Toxic**	**Moderately Toxic**	**Slightly Toxic**
Colour	Bright Red	Bright	Bright Black	Bright Green Yellow
Symbol & Label	Poison, written in Red Colour	Poison, written in Red Colour	Danger, written in any colour	Caution, written in any colour

4. Note on Toxicity of Commonly Used Products :

The toxicity hazards are of different kinds like :

Mild skin irritation (Examples : Chlorfenson, Dalaphon, Diwron, Formaldehyde, Paraquet etc.)

Severe skin irritation (Examples : Lime Sulphur, Phenyl Mercury Acetate)

Breakdown in nervous system (Examples : Organophosphorus pesticides and carbamets)

Based on their level of toxicity, the pesticides have been grouped under various classes :

i) Acute or Extremely toxic (Examples : Aldicarb, Endrin, Hydroorganic acid etc.

ii) Highly toxic (Examples : Aldrin, Carbofuran, Phenol, Phosphomidon etc.)

iii) Moderating toxic (Examples : BHC, Colomel, 2, 4 - D salt etc.)

iv) Mildly toxic (Examples : 2, 4 - D acid, Bordeayx mixture, Dicofol etc.)

v) Practically non-toxic (Examples : Calcium arsenate, DDT, Maleic hydrazide, Malathion etc.)

vi) Relatively harmless (Examples : Ammonium Thiocyanate, Captan, Amitrole etc.)

According to Government of India regulations, those who handle these pesticides have to use protective clothing, wear appropriate respiratory devices, etc

STORAGE, HANDLING, APPLICATION AND DISPOSAL

Pesticides should be stored in an isolated site and should be high enough to avoid flooding and/or coming in contact with water sources. The packaging containers (drums, sacks, fibre board cases, wooden cases) should be secure enough should be placed in such a way that they should not come in contact with the floor. The storage duration should not be more than shelf life (roughly two years from manufacturing date for most of the pesticides).

Pesticides should be handled after wearing protective clothing and respiration devices. They should be handled in a ventilated working area. Spills of pesticides on the floor of any storage place should be immediately removed either through sweeping for gathering up or by soaking with the help of some absorbing material like saw dust and the placed in marked containers for disposal.

Depending on the nature of the pesticides, the various methods of their application are spraying, dusting and fumigation. The instruction on the package cover or container should be strictly followed regarding the method of application.

For safe disposal of products and packing materials, one or more isolated trenches (60-90 cm long, 45 cm deep and 15 cm deep) should be dug and used. One such trench is sufficient for disposal of 5 litres of liquid or 5 kg of solid pesticide. The pesticide has to be first mixed with an approximately equal volume of sand or soil in the trench and then the decomposing agent (alkali, acid, oxidizing agent, reducing agent etc.) should be slowly added and well mixed with the pesticide. The trench should, in the end, be filled and closed with tightly packed top soil.

PRESCRIBED DOSAGE AND FREQUENCY OF APPLICATION

The prescribed dosages and application frequency of pesticides will vary from crop to crop. It is not possible to give the details in a short write-up. It is of course, advisable that the extension workers should first ascertain these data from the subject matter specialists of the area and then formulate their programme of extension activities on these topics of plant protection.

INFORMATION ON ALTERNATIVE MEASURES OF PEST CONTROL

There are various measures of pest control. The integration of all or a number of these measures into a common basket according to situational need and the class of pest species is called the Integrated Pest Management or IPM. The measures are

1. **Cultural Methods (agronomic practices)**
   - (a) Crop rotation
   - (b) Crop location
   - (c) Trap crops
   - (d) Tillage
   - (e) Altered timings
   - (f) Clean cultures
   - (g) Soil manuring and fertilization
   - (h) Pruning and thinning
   - (i) Crop refuse and destruction
   - (j) Growing resistant varieties
   - (k) Management control

2. **Mechanical methods**
   (a) Hand picking
   (b) Shaking and beating of branches
   (c) Banking
   (d) Wire gauge screen
   (e) Trench digging
   (f) Trapping
   (g) Pest - smashing / Pest collecting device
   (h) Flooding and drainage
   (i) Uprooting and burning

3. **Physical methods**
   (a) Cooling
   (b) Heating
   (c) Radiant energy

4 **Legal methods**

5. **Biological methods** like biological control through introduction of selective pest predators or through a effecting genetically induced male strictly.

6. **Chemical methods**
   (a) Insecticides
   (b) Chemosterilant
   (c) Antifeedants
   (d) Attractants
   (e) Repellents
   (f) Semi chemicals
   (g) IGRS

Awareness campaigns with audio-visual aids, posters and T & V method have to be carried on to help initiate effective methods of pest control under IPM umbrella.

As regards residual toxicity of commonly used products, no definite suggestions can be given at this stage of crop and animal farming in Terai region or elsewhere in India. If repeated applications are avoided, most of the common pesticides belonging to groups like chlorinated hydrocarbons, organophosphorus compounds and carbonates are found to degrade within a few days leaving the sprayed surface, the other plant parts, soil and water with no or much less (compared to tolerance limit) problem of residual toxicity and environmental pollution. However, due precautions like keeping the children and animals away and changing of clothes, washing with soap etc. have to be taken to ward off mammalian toxicity. Use of such treated crop products for human consumption calls for awareness campaigns on the importance of thorough washing, boiling and/or cooking prior to consumption. For such horticultural and agricultural field products as edible fruits, toxicity gets drastically reduced mostly within 10-15 days after crop or tree application. The small quantity of residual toxicity has to be removed through repeated washing before consumption.

At a time when integrated pest management is yet to take roots in Indian agriculture, use of pesticides cannot be avoided. However, persistent awareness campaigns on above points (toxicity, approved most usable pesticides, precautionary measures etc.) have to go on. Although Terai region agriculture as a whole is still far from the risk level of pesticide use in the quantitative sense, the need for above awareness campaigns should not be glossed over.