

NBSS Publ. 27

Soils of India Series 1



SOILS OF WEST BENGAL FOR OPTIMISING LAND USE

NBSS & LUP

b. Executive Summary



National Bureau of Soil Survey & Land Use Planning
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
NAGPUR-440 010.

In Co-op. with :

**Department of Agriculture, West Bengal and
Bidhan Chandra Krishi Viswa Vidyalaya, West Bengal.**



**SOILS OF
WEST BENGAL**
*: Their Kinds, Distribution, Characterization
and Interpretations*
FOR
OPTIMISING LAND USE
b. Executive Summary



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NBSS-9



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About the NBSS&LUP

The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Nagpur, a premier Institute of the Indian Council of Agricultural Research (ICAR), was set up in the year 1976 with the objective to prepare soil resource maps at state and district level and to provide research inputs in soil resource mapping, soil correlation and classification, soil genesis including soil mineralogy and soil micromorphology, remote sensing applications, land evaluation, land use planning, land resource management, and database management using GIS for optimising land use on different kinds of soils in the country. The Bureau has been engaged in carrying out agro-ecological and soil degradation mapping at the country, state and district levels for qualitative assessment and monitoring the soil health towards viable land use planning. The research activities have resulted in identifying the soil potentials and problems, and the various applications of the soil surveys with the ultimate objective of sustainable agricultural development. The Bureau has the mandate to correlate and classify soils of the country and maintain a National Register of all the established soil series. The Institute is also imparting in-service training to staff of the soil survey agencies in the area of soil survey and land evaluation, soil survey interpretations for land use planning. The Bureau in collaboration with Punjabrao Krishi Vidyapeeth, Akola is running post-graduate, teaching and research programme in land resource management, under which M.Sc. and Ph.D. degrees are awarded.

The research activities of the Bureau have resulted in identifying various applications of soil surveys and mapping. The Soil Survey and Land Use Planning of West Bengal carried out by the Bureau is one such example.

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FOREWORD

Soils are our most precious natural resource. Maintaining soils in a state of high productivity on sustainable basis is important for meeting peoples' basic needs. It is particularly important in a country like India which is largely dependent on agriculture. During the past few decades we made significant strides to achieve self-sufficiency in food grains production. In order to meet the ever-increasing food requirement for the growing population (890 million) and to maintain the quality of the environments we live in, it is essential that the soil and water resources are used rationally and in a way so as not to affect adversely the productivity but to leave a better heritage for the posterity.

A knowledge of soils in respect of their extent, distribution, characteristics, and use potential is, therefore, extremely important for optimising land use. However, we have given very little attention to the judicious use of our soil resources in the past. This is evident from the fact that about 175 m. ha of land area in the country is suffering from various kinds degradation problems. Bringing additional area under cultivation may cause environmental imbalance since area under forestry has already been declining @1 m. ha per year due to deforestation. The option lies in increasing productivity per unit area through systematic appraisal of our soils and climatic resources for optimising land use on sustainable basis.

With the setting up of the National Land Resource Commission at the Centre and Land Use Boards in the States, the necessity for soil resource maps for developing rational land use plans has assumed significance. I am pleased that the National Bureau of Soil Survey and Land Use Planning under the leadership of Prof. J. Sehgal, is engaged in bringing out soil resource maps of different states on 1:250,000 scale and of the country on 1:1 m scale. Some maps have already been released for the use of different user agencies in the states and others are in the pipeline.

The present "Soils of West Bengal" with a soil resource map in 4-sheets is one of such series of publications being brought out by the National Bureau of Soil Survey and Land Use Planning (NBSSLUP) in co-operation with other state agencies. The publication gives a charter of the soil resources in the state - their potential and problems for optimising land use. It will form the basis for most developmental work in the field of agriculture, forestry, soil conservation, determining suitability for alternative land uses and preparing perspective land use plan for the State.

I congratulate Dr. J. Sehgal and his Team of Scientists from the Regional Centre, NBSSLUP, Calcutta and other cooperating agencies (Deptt. of Agriculture and Bidhan Chandra Krishi Biswa Vidyalaya) for this monumental work.

December, 1992

N.S. Randhawa
Former Director General, ICAR
and Secretary, DARE,
New Delhi

PREFACE

Soils are a vital natural resource, on whose proper use depends the life-supporting system and socio-economic development of any country. India is facing a great dilemma between the problems of increasing food production and the deterioration of soil quality. On the one hand, there is an increasing demand for food, fodder and fibre for the existing and for the future generations because of unprecedented increase in human and animal populations. On the other hand, there is an urgent need to maintain the soil health and quality without causing undesirable side effects, such as pollution and environmental degradation, etc. With the green revolution of 1970's which involved high inputs of fertilizers, irrigation and hybrid seeds, the food production did increase, but, it resulted in decline in the soil quality and thereby increased the risk of soil degradation in a broader sense. Today there are increasing evidences to suggest that a majority of our soil resources are under different degrees of degradation, and are getting further deteriorated at an alarming rate with risk of jeopardising food security system. Developing strategies to reverse the processes of degradation and to improve or ameliorate the soil quality are the key issues which confront the Indian scientific community.

In order to confront such issues, it is imperative that we have a systematic survey and inventory of our soil resource. The same was planned and undertaken through cooperative efforts with the States Department of Agriculture (and State Agricultural Universities) on 1:250,000 scale. The maps provide information on the kinds, distribution and extent of different soils, their nature, characteristics, problems and potential, so as to develop strategies not only to increase agricultural production on sustainable basis but also to maintain the ecological balance such that the future generation may not have to ask the question, "*Here is the land, but where is the soil*".

The soil resource maps of different states along with their text are being brought out in the form of "*Soils of India Series*". The soil resource map shows several map units; each identified by a unique symbol, colour (and shade) and comprises one or more soil families (the family being the most important category for plant growth), with phases (shown by shades). The phases are chosen to create units useful for predicting about use, management and behaviour of soil. From the master soil resource map, a number of *thematic maps*, including soil degradation, can be generated, depending on the needs of the user agencies. The "*legend*" (an organised list of map units) narrates the important soil properties, such as texture, depth, drainage, calcareousness, mineralogy, available water holding capacity, etc. besides the soil taxonomic names, for understanding the taxa internationally. For publication, the soil resource maps (on 1:250,000 scale) have been reduced (to 1:500,000 scale) without any generalisation in order to bring the soils information on 2 to 4 sheets for easy perusal and rationalising their use as per their capability.

The soil map of West Bengal shows 115 map units. The text in the Bulletin contains six chapters preceding with a note on "*How to Use The Soils Bulletin*". The first chapter is on *Introduction*; the 2nd is on *Geographical Setting*; the 3rd highlights the *Methodology* used; the 4th chapter is on *Soils* which describes soils in each of the agro-ecoregion (mainly rice-based) established in West Bengal. The 5th chapter is on *Soil Problems*; and the 6th chapter deals with the *Soil Degradation and its Status*.

The bulletin, it is hoped, will prove of use to different land user's including farmers, extension workers, administrators and planners for rationalising land use. It will also help research workers in undertaking research on established soils and in transferring agro-technology to comparable map units in the region. The Soils Bulletin, if used properly, may ensure increased agricultural production on sustainable basis.

December, 1992

J. Sehgal
Director, NBSS&LUP,
Nagpur

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- o The World Bank Team and the ICAR for providing financial support.

HOW TO USE THE SOILS BULLETIN

The soil resources bulletin of West Bengal has been prepared to provide the basic information on soils - their characterisation, classification and extent of distribution; and to highlight the problems and potential of soils. It is believed that the basic information generated would serve the needs of user agencies for rationalising use of soils for regional level planning.

Based on a 3-tier approach (landform analysis, field survey and laboratory investigation, and cartography and printing) soil resource map of West Bengal (on 1:250,000 scale) has been prepared. The map has been reduced and published on 1:500,000 scale without any generalization. It covers the entire state on 4-sheets (1-4).

The map units (polygons) on the soil map represent the associations of 2 soil families with or without inclusions (if any). Each association or map unit (polygon) has one dominant and another subdominant soil families. The dominant soil family covers 50% or more area of the map unit (polygon) while the subdominant soil family occupies less than 50% area but more than 20%. The leftout area, if any, (less than 20%), is covered by inclusion.

For calculating areas under different soils and/or problems, the following criteria are used:

60:40 ratio in units/polygons with association of two soil families (dominant and subdominant)

50:35:15 ratio in units/polygons with association of more than two (dominant, subdominant and inclusions).

The published map (1:500,000 scale) shows the soil family associations by soil map unit or polygon number, such as W041, W042.... W101, etc. On 1:250,000 scale map, these soil map units are however shown as 3-tier symbols. The upper-tier shows the diagnostic properties of the dominant soils and their phases, elucidating the following informations, viz. soil order, suborder, great group, subgroup, including phases (like soil depth, particle-size class) of family control section, surface texture, slope, erosion, while salinity, stoniness, flooding, etc. are shown by shading screen. The middle-tier shows the landform characteristics, whereas the lower-tier represents the soil family association number (polygon number). The soil resource map on 1:250,000 scale is available in ammonia sheets in an atlas form and can be provided on request (for official use only).

If one wants to know the extent and distribution of soils in an area or a district, he can locate the area of his interest with the help of the index map (given as inset in the 4-sheet map). After locating the area or the district on the relevant sheet, one has to find the soil unit numbers (polygon numbers) given in the district. For decoding the map unit number, one may refer to the legend for detailed description of each mapped unit. The legend on the map provides simple description of mapped soil pertaining to each unit. It also gives information on taxonomy of soil, but in another column, so that it does not clash with the interest of other users (development departments) who may not be interested to know the complicated and heavy taxonomic names.

If one desires to have detailed information of the mapped soils, he may refer

to the Descriptive Legend (Table 4.1.1), Extended Legend (Appendix 2) and Analytical data (Appendix 3) as given in detailed report. Besides, information about agro-climate, present land use, constraints (problems) and potentials can be observed by referring to the section dealing with characterization of soils of different agro-eco-subregions in the detailed report. The descriptive legend and extended legend of mapped units (Table 4.1.1, Appendix 2) helps the users to understand about the phases and properties of the dominant, sub-dominant soils and of inclusions (if any) in the area. The analytical data (Appendix 3) give the physical and chemical properties of surface, subsurface and subsoils, horizons/layers of soil pedon.

The soil map sheets (1,2,3 and 4) are appended with the report. This report contain 6 chapters; the 1st is on Introduc-

tion and objectives of the project; the 2nd on Geographical Settings, the 3rd on Methodology, the 4th on Soils giving description of physical features, physical and chemical soil properties, and the 5th Chapter highlights, the problems and potential soils, their description and extent of distribution, the 6th Chapter is on Soil Degradation : Status and Severity overall. In addition, detailed tables on different aspects are given at the end. The detailed information on climate, extended legends, analytical data, and codes used have been given in the appendices.

It is hoped that the information provided in the soil map and the Bulletin will prove of value to different land users, researchers, extension workers and others involved in optimizing land use on sustainable basis.

INTRODUCTION

Soils are our most precious natural resource. Maintaining soils in a state of high productivity on sustainable basis is an important task to meet the basic needs of ever increasing population in a country, which is basically dependent on agriculture.

In the past, we have made significant strides to achieve self sufficiency in foodgrain production. But there appears hardly the case of complacency towards meeting increasing food demand vis-a-vis the need for maintaining overall quality of our environments. It is, therefore, essential that the soil and water resources are used rationally not only for sustainable agricultural production but also to leave a better heritage for the posterity.

The Royal Commission on agriculture in India as early as 1928 recognised the value of Soil Resource Inventories for viable land use planning. Soil Survey Programmes were initiated from 1956 for implementing specific projects. Based on a low intensity, rapid reconnaissance survey, a soil map of West Bengal was prepared by the State Department of Agriculture. This was followed by the publication of soil maps at National Level showing soil units of higher categories, Great Groups/Sub Orders. Since these attempts were based on limited field surveys with 50 percent of delineations by extrapolations, these maps didn't prove very effective for the planning process as the mapping units were of higher categories (suborders) instead of lower categories, like soil families which are appropriate for analogous transfer of agrotechnology.

The knowledge of soils in respect of their extent, distribution, and charac-

teristics as well as their use potential are extremely important for optimising land use. Since we paid little attention to the wise use of these finite resources, these were subjected to the slow and gradual processes of degradation. In this regard, it was unanimously decided in a National Workshop held at Nagpur in 1987, to take up Soil Resource Mapping of all states in India, on 1:250,000 scale delineating different soils, assessing their problem and potential for optimising land use at Regional level.

The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) undertook this gigantic task in cooperation with the State Department of Agriculture for mapping soil resources of the state for generating soil data-base useful for optimising land uses on sustainable basis.

OBJECTIVES

The major objectives of the project were:

- Preparation of a soil resource map on 1:250,000 scale with soil families as the basic mapping units.
- Preparation of several kinds of thematic maps depending on the need of different land- user agencies.
- Identification of the nature and extent of different soils.
- Characterization and classification of different soils.
- Interpretation of different soil mapping units for determining their capability/ suitability classes for alternative land uses.

- Conducting research on established Benchmark soils for generating soil-based agro-technology transfer.
- Creation of database for storage and retrieval of data as and when desired by any user agency.
- Monitoring health of soil resources for sustained agricultural productivity.

GEOGRAPHICAL SETTINGS

2.1. LOCATION & EXTENT

The State of West Bengal is situated between 21°31' to 27°14' N latitudes and 85°51' to 89°52' E longitudes. The state territorial border is limited by Sikkim and Bhutan in north, by the States of Orissa in south-west, Bihar and the Kingdom of Nepal in west, and by the state

of Assam in north-east. The entire stretch of eastern part is bounded by Bangladesh and the southern part by the Bay of Bengal (Fig. 2.1). The state covers an area of 8.87 m ha representing 2.7% of the total geographical area of the country. It is divided into 16 administrative districts with a total population of about 68 million as illustrated in Table 2.1.

Table 2.1. Area, population and headquarters of districts

District	Area (,000 ha)	Population (m)	Headquarters
Bankura	6,882	2.799	Bankura
Barddhaman	7,024	5.979	Barddhaman
Birbhum	4,545	2.556	Suri
Calcutta	187	4.388	Calcutta
Darjiling	3,149	1.355	Darjiling
Haora	1,467	3.719	Haora
Hugli	3,149	4.352	Chinsurah
Jalpaiguri	6,227	2.789	Jalpaiguri
Koch Bihar	3,387	2.158	Koch Bihar
Maldah	3,733	2.633	English Bazar
Medinipur	14,081	8.349	Midinipur
Murshidabad	5,324	4.734	Baharampur
Nadia	3,927	3.848	Krishnanagar
Purulia	6,259	2.217	Purulia
24-Parganas	14,052	1.30	Alipore
West Dinajpur	5,358	3.132	Balurghat
	88751	67.977	

Source: Census, 1991.

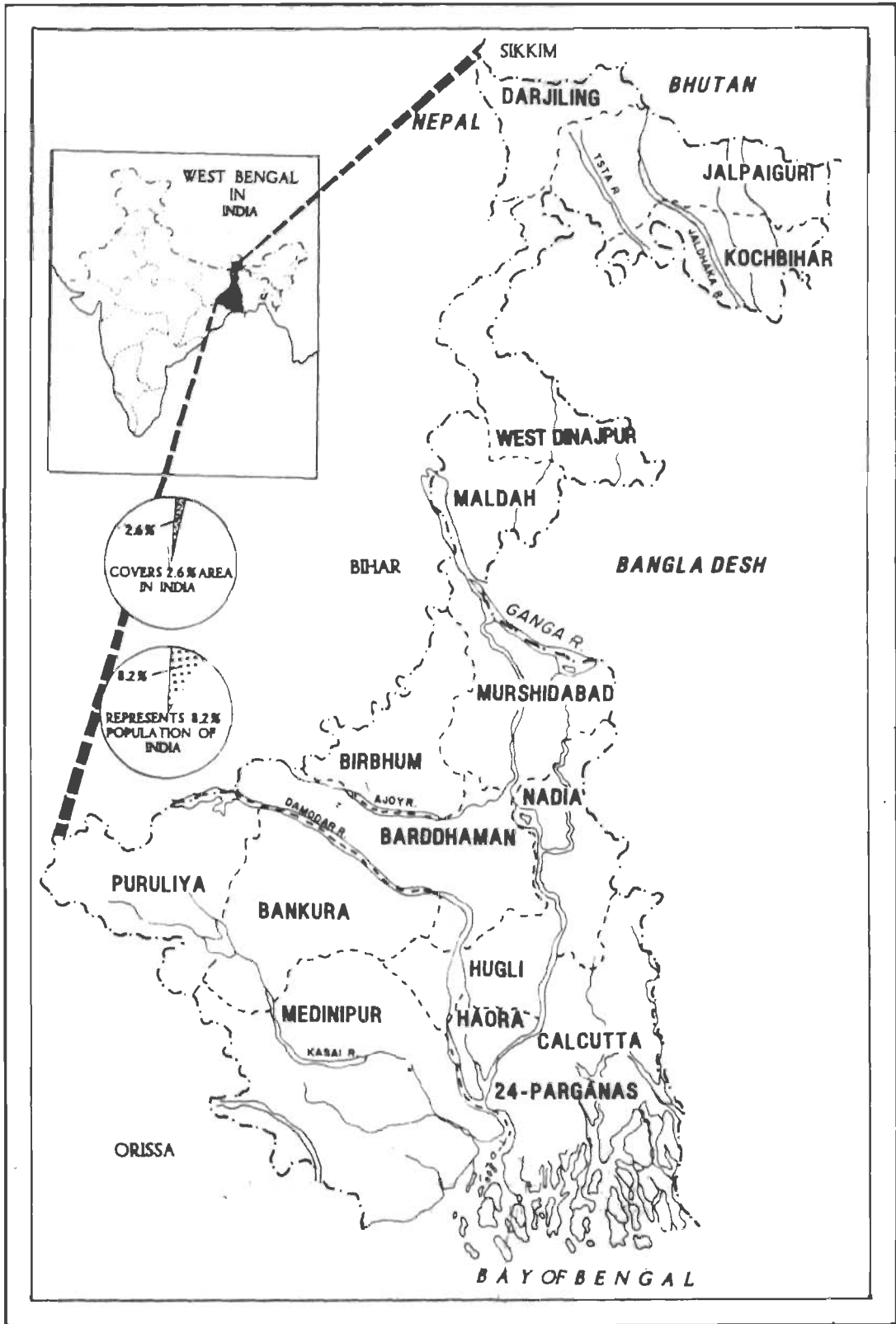


Fig. 2.1 Location of West Bengal in India and its Administrative districts

2.2 PHYSIOGRAPHY, RELIEF AND DRAINAGE

West Bengal can be broadly divided into three physiographic regions:

- **Eastern Himalayas** (in the north),
- **Eastern plateau or Chhotanagpur plateau** (in west and south west), that is extended outliers of Peninsular mass.
- **Alluvial and Deltaic plains** (in the east and south).

2.2.1 Eastern Himalayas

The Eastern Himalayas include mountainous terrain of Darjiling and northern fringe of Jalpaiguri districts, comprising foot-hills of Bhutan Himalayas. The inner terrain of Darjiling Himalayas, extending to Sikkim and Nepal, include several lofty peaks of world attraction, such as Kanchanjunga, Nandaghunti, etc. The mean elevation of the Darjiling district is 2000 m above the mean sea level (MSL) and the inner terrain, including peaks, has an elevation of 4000 m or more above the MSL.

The area is characterised by very rugged relief. Almost all the side slopes of the ridges are virtually vertically steep and break abruptly near foot slope encompassing the northern fringe of Jalpaiguri district (Tarai) with elevation ranging between 100 and 66 m above MSL. The subdued foothills encompassing northern fringe of Jalpaiguri district end abruptly on level Tista Alluvial Plain (Duars) forming southern part of the district.

2.2.2 Eastern or Chhotanagpur Plateau

The Eastern Plateau comprising Peninsular mass, known as Chhotanagpur Plateau, is a Tertiary and Post-Tertiary peneplain surface. The eastward outliers extend across the north-western part of Barddhaman, Medinipur, Bankura, Birbhum and whole of Purulia districts. The subdued spurs of laterite formation are

frequently observed in the western part of Bankura, part of Medinipur and Purulia districts. The outliers towards east having laterite base are covered by old alluvium of Peninsular rivers, like Subarnarekha, Mayurakshi, Damodar and Ajay laid in early Pleistocene period (Pascoe, 1964) as observed in Bankura, Hugli and Barddhaman districts.

2.2.3 Alluvial and Deltaic Plains

The extensive stretch of alluvial and deltaic plains in the east and south of the State are called as Bengal Basin. The Bengal Basin comprises eastward extension of Indo-Gangetic alluvial plain. The alluvial plain comprises older and newer alluvium, although it is difficult to draw a distinct line of separation between the two.

The river Ganga bifurcates into two main tributaries, viz. Padma and Bhagirathi, in the area between Rajmahal in Bihar and Murshidabad in West Bengal and start developing the Bengal Basin. The basin formation extends southward progressively by further branching off the tributaries into a number of subtributaries to meet Bay of Bengal. The Ganga river system with its tributaries and subtributaries meander severely leaving meandering scars (dead channel) in the flood plain and/or deltaic plain.

The drainage pattern in general is dendritic while it is mostly subdendritic in northern part comprising the Ganga-Tista alluvial plain. Thus, the Ganga Alluvial Plain can be broadly divided into two parts, viz. Ganga-Tista or Tista Alluvial Plain in north/northeast, known locally as Duars and Ganga Deltaic Plain, known as Bengal Basin.

The Block diagram (Fig. 2.2) illustrates the physiography and drainage characteristics of the state.

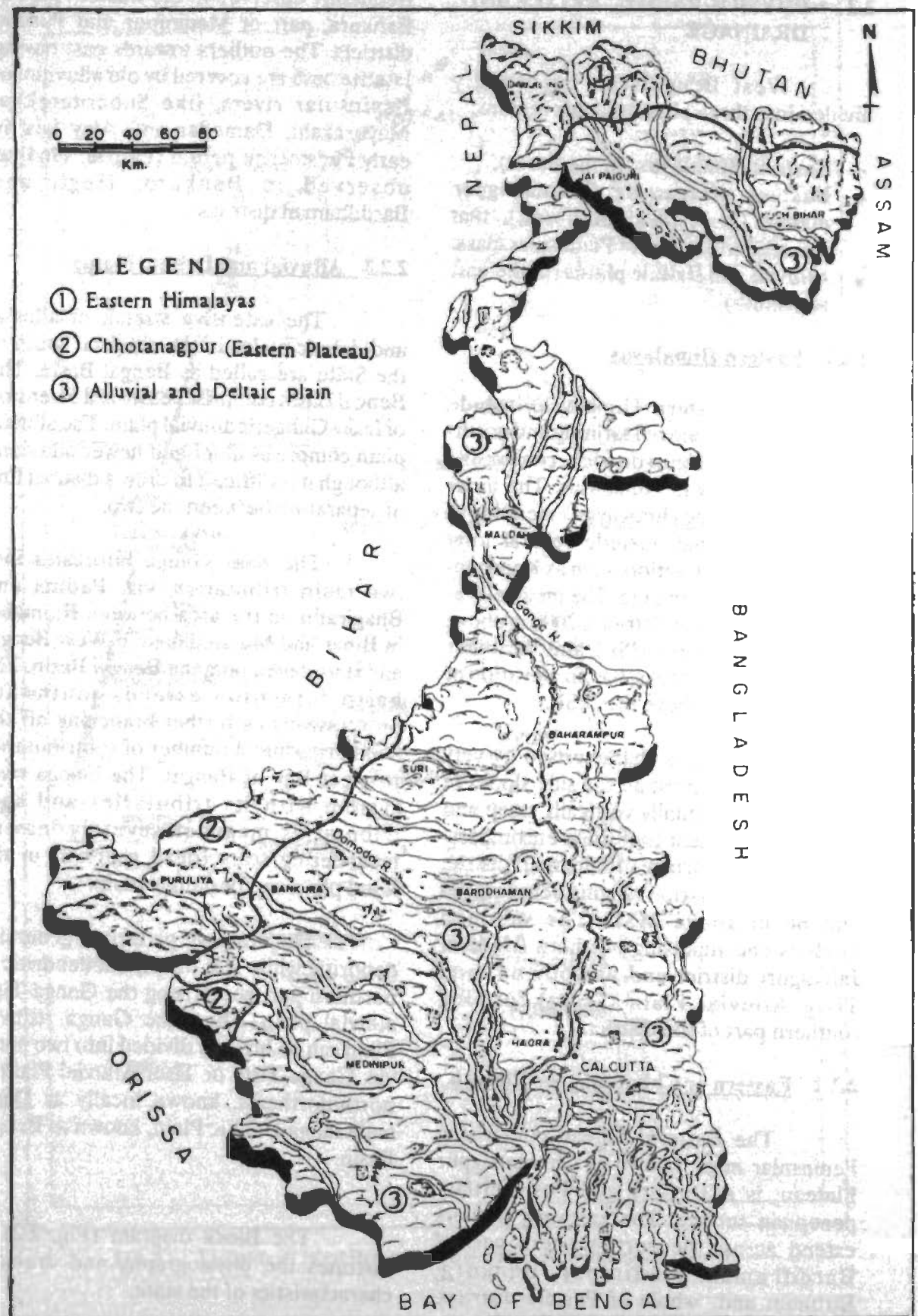


Fig. 2.2 Physiography and drainage of West Bengal

2.3 GEOLOGY

The geological formations in West Bengal are diverse in origin. It comprises the archaen, metamorphics to subrecent and recent alluvium formations. About 75 per cent of the land mass comprises the subrecent and recent alluvial deposits while the remaining part abounds in a wide variety of rock formations, like crystallines, sedimentaries and basic flows. The metamorphics include various types of schists and gneisses of Precambrian age, associated with acid and basic intrusives. The sedimentaries include essentially the Gondawana formations (Barakar formations, etc.) in Eastern Plateau (Outliers) that belong to the Permo-Carboniferous to Triassic age whereas the Siwalik formations (Sedimentaries, metamorphics, etc.) belong to the Tertiaries in Eastern Himalayas. The basic flows belong to the upper Mesozoic age forms a conspicuous horizon setting between the two broad sedimentary groups.

2.4 CLIMATE

The tropic of cancer runs across the mid-part of the districts of Nadia and Bardhaman and northern part of the district of Bankura. However, the presence of Bay of Bengal, a network of river system, canals, tanks and other water bodies, moderate the extremes of climatic conditions.

The area receives NE-monsoon during June to September which accounts for about 90 per cent of the mean annual rainfall. The average annual rainfall varies from 2500 to 3500 mm in the north Hilly region of the Eastern Himalayas, while it varies from 2000 to 3000 mm in the foothills (Tarai) region and Tista Alluvial Plain (Duars) in most of the years. The average annual rainfall in Bengal Basin, varies from 1300 to 1600 mm, while it is comparatively more (1500 to 1700 mm) in the coastal strip. The relatively dry areas of the lateritic

region receive a mean annual rainfall ranging between 1100 and 1300 mm.

The minimum temperature is around 0°C in winter months in the hilly region lying in the north whereas it rises to as high as 46°C (during summer months) in the lateritic region of southwest. The maximum temperature recorded in northern hilly region (during summer months) is around 24°C and in the Gangetic alluvial plain, it reaches 38°C. The mean temperature (during winter months) declines to as low as 7 to 9°C in the lateritic region whereas in Gangetic alluvial plain (Bengal Basin), the winter temperature varies from 10 and 16°C.

The detailed climatic data, pertaining to each of the physiographic regions, have been illustrated in Appendix-1 (A-D).

2.5 NATURAL VEGETATION

The increasing population pressure has resulted in clearing most of the areas under natural vegetation and converting it to agricultural land to meet the growing food need. The major forest types and their occurrence may be correlated as under:

- Temperate forest in the Eastern Himalayas,
- Tropical forests in Duars,
- Dry/moist deciduous forests in the plateau outliers, and
- The mangrove forests in the Sundarbans (Southern delta).

2.6 LAND USE AND AGRICULTURE

2.6.1 Present Land Use

In densely populated West Bengal, there is heavy pressure on meagre land resources. About 75 per cent of the population with per capita holding of around 0.16 ha live in villages where agriculture is the

prime mean of livelihood. The present land use scenario is illustrated in Table 2.2 and Fig. 2.3.

The data in Table 2.2 shows that about 60 per cent of the total area is under cultivation and 24 per cent of the cultivated land comprising 1.28 m ha is under irrigated farming. The forest land accounts for 12 per cent while land not available for cultivation accounts for 18 per cent of the total geographical area of the state.

2.6.2 Agriculture

Agriculture contributes nearly 50 per cent of the state income and provides employment to 55 per cent of its people. The state occupies a leading position among the rice producing states of the country. The area under paddy is nearly 72.9 per cent of the total cropped area. Besides, the state accounts for 62.4 per cent of country's jute and 21.8 per cent of the country's tea.

Table 2.2. Land utilisation of West Bengal

Land Use	Area (m.ha.)
Total geographical area	8.87
Reporting area for land utilisation statistics	8.84
Forest	1.09
Area is available for cultivation	1.63
Other uncultivated land excluding fallow land	0.36
Fallow land	0.43
Net area sown	5.33

Source: Economic Review, Bureau of Applied Economics and Statistics, Govt. of West Bengal, 1988-89.

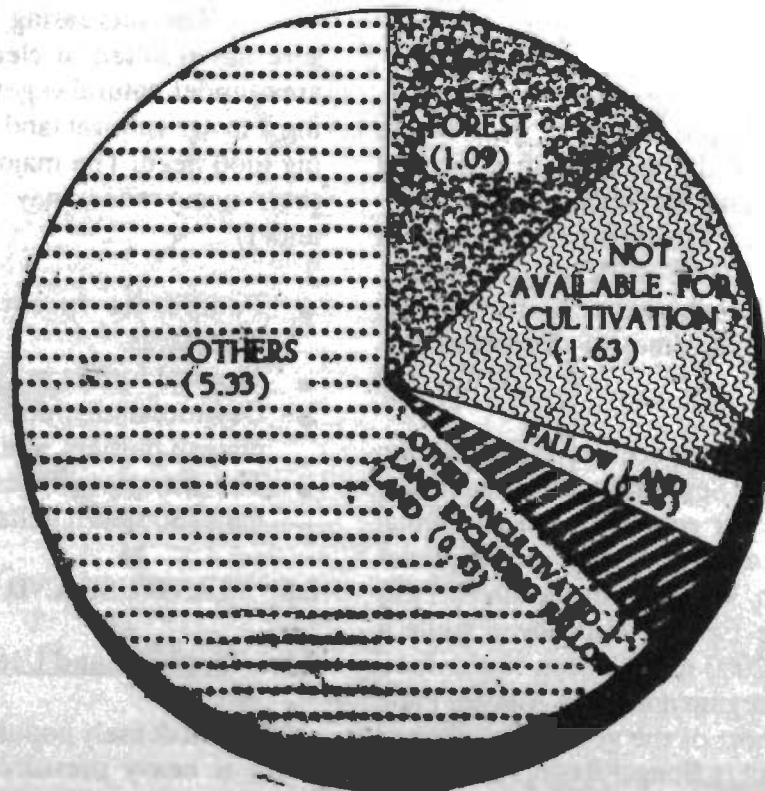


Fig. 2.3 Land Use in m. ha (1988-89)

production. As such, the state earns a considerable foreign exchange through export of its jute and tea. The major forest products are timber, bamboo, firewood, charcoal and honey.

2.6.3 Cropping System

The cropping system in the state is diversified depending on the kinds of soil, climate, water resource and socio-economic status.

The northern hilly regions are dominantly under tea and other plantation (horticultural) crops, such as orange, pineapple, citrus, pear, plum, etc. Field crops in the region include potato, maize, winter vegetables, rice, wheat, etc.

The Tista Alluvial Plain is mostly under tropical horticultural crops, such as jackfruit, mango, betel-nut, pineapple and root crops. The common agricultural cropping patterns are; jute-rice-wheat, rice-rice (short duration) - pulses, vegetables - oilseeds (mustard). Important cash crops, such as tobacco are grown in upper alluvial region supporting slightly alkaline soils. In medium and low land areas, jute- rice, mustard/pulses/ oilseeds (under rainfed conditions) and jute-wheat, rice-rice-mustard (under irrigated conditions) are cultivated successfully.

The Western Plateau, dominantly lateritic in nature, is under rice-potato, pulses-mustard (under irrigated agriculture) and maize/sorghum, pulses/groundnut (under rainfed agriculture).

The soils of coastal alluvium are cultivated for rice, vegetables, etc. The area

and production of principal crops in the state are given in Table 2.3 and Fig. 2.4.

Table 2.3. Area and production of principal crops (1991-92) in the State of West Bengal

Crop	Area (,000 ha)	Production (,000 tonnes)
Cereal		
Rice	5719.3	11954.2
Wheat	248.1	557.5
Barley	7.4	9.1
Maize	47.8	143.7
Others	21.5	
Pulses		
Gram	17.8	17.1
Tuar (Arhar)	4.3	2.2
Other pulses	247.8	155.7
Oilseeds		
Rapeseed and Mustard	412.3	307.1
Linseed	10.2	2.6
Others	151.1	141.0
Fibres		
Jute	573.4	6372.7
Mesta	13.1	94.2
Other fibres	2.1	10.0
Other		
Tea	101.2	0.16
Sugarcane	17.0	96.9
Jaggery (Gur)		
Potato	229.0	4942.9
Tobacco	13.9	13.7

Source: Economic Review, Bureau of Applied Economics and Statistics, Govt. of West Bengal, (1991-92).

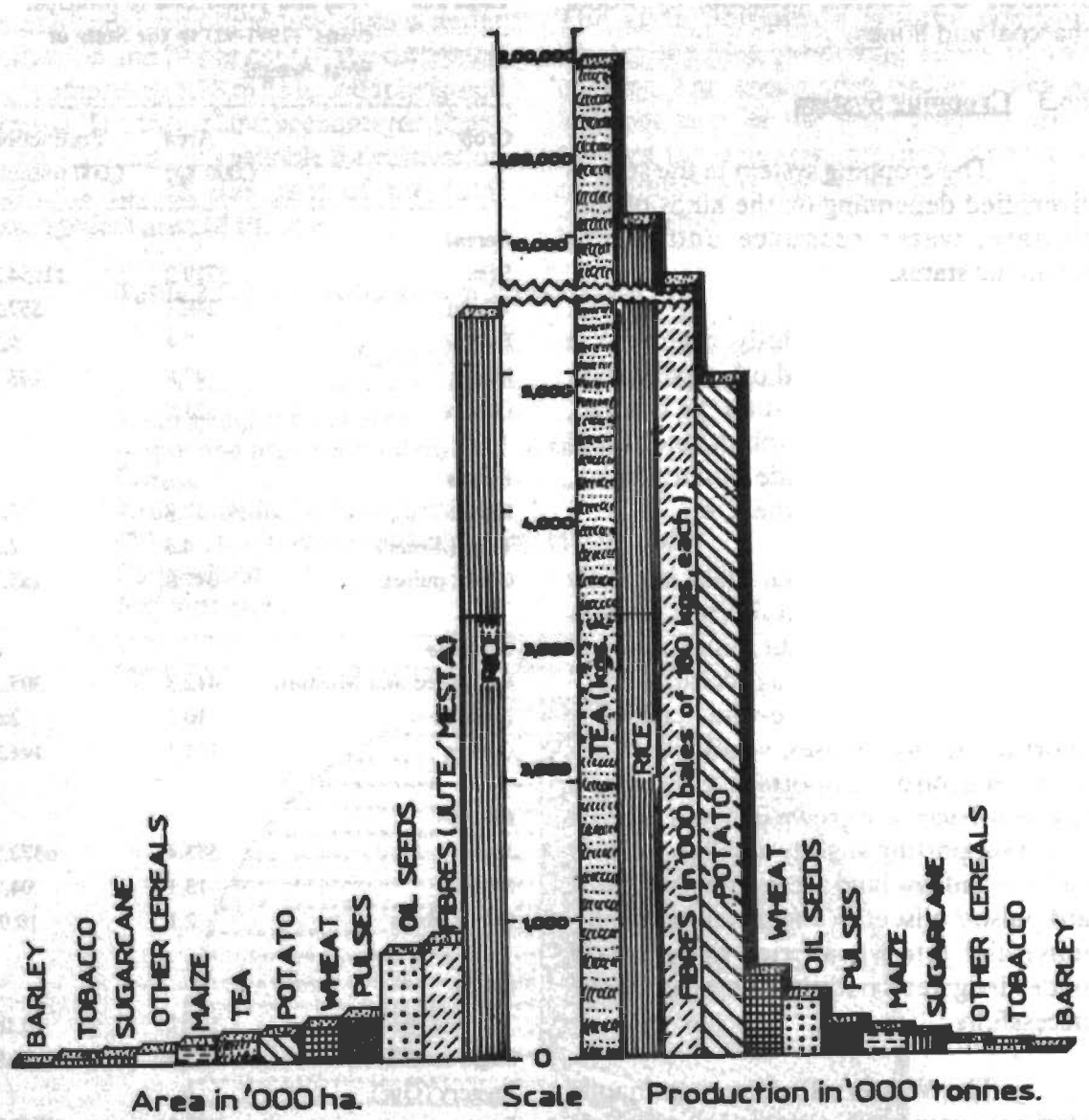


Fig. 2.4 Area and Production under Principal Crops in West Bengal (1991-92)

METHODOLOGY

3.1. SOIL RESOURCE MAPPING

Soil resource mapping in all the States of India has been undertaken, using a 3-tier approach, as detailed in NBSS&LUP Publs., Field Manual (Sehgal *et al.* 1987) and Laboratory Manual (Sarma *et al.* 1987). The 3-tier approach comprises image interpretation, field survey and laboratory analysis, and cartography and printing.

For the image interpretation, landsat imagery on 1:250,000 scale was interpreted to develop detailed legend for generating a landform analysis map of the whole country.

The information on the landsat data was transferred on the topographical sheets (1:250,000 scale) published by the Survey of India. This formed the base map for undertaking the field surveys.

For field surveys, a 3-tier approach (Fig. 3.1) was adopted. It comprises:

- A detailed study of soils by examining soil profiles in five to ten sample strips per sheet to develop soil-physiography relationship.
- Random checking by auger hole sample of different sites were done in order to confirm the soil-physiography relationship.
- A regular checking of soil samples at grid points at an interval of 10 km was done to supplement the above information and to use the data-base for digitization in order to generate thematic maps.

In total, about 500 observations were made on each sheet on 1:250,000 scale covering an area of about 1 million hectares.

A soil observation map has been brought out for further reference and monitoring purposes.

The soil samples collected (horizon-wise) were analysed for various physical and chemical properties, such as mechanical analysis, pH, EC, organic carbon, calcium carbonate, etc.

In selected samples, cation exchange capacity and base saturation were also determined. Besides, micronutrients, such as Zn, Cu, Fe, Mn have been determined.

The Benchmark soils, representing extensive and/or dominant soils of the State have been studied for detailed morphological, micromorphological, mineralogical, physical and chemical investigations to form the data-base and these have been included in the Soil Bulletin.

3.2 SOIL MAP

Based on the 3-tier approach (given in Methodology) the soil resource map of West Bengal (on 1:250,000 scale) was prepared. Since maps on 1:250,000 scale would cover a number of sheets, these were reduced to the publication scale of 1:500,000 and printed on 4 sheets. The 4 sheets on 1:500,000 scale can be combined to form 1-sheet map showing all soil units without any generalization.

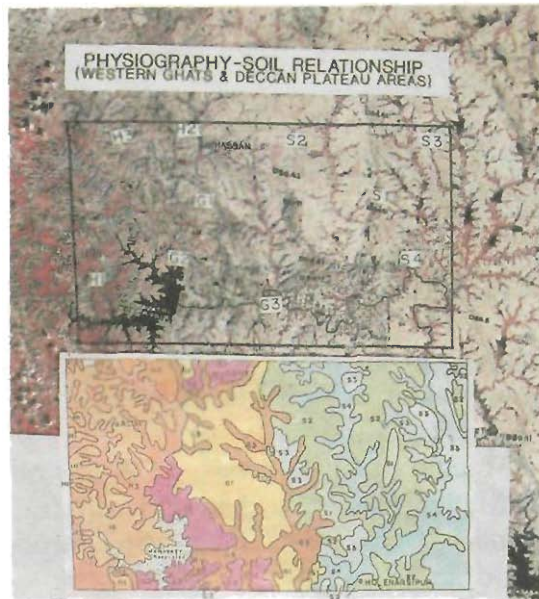
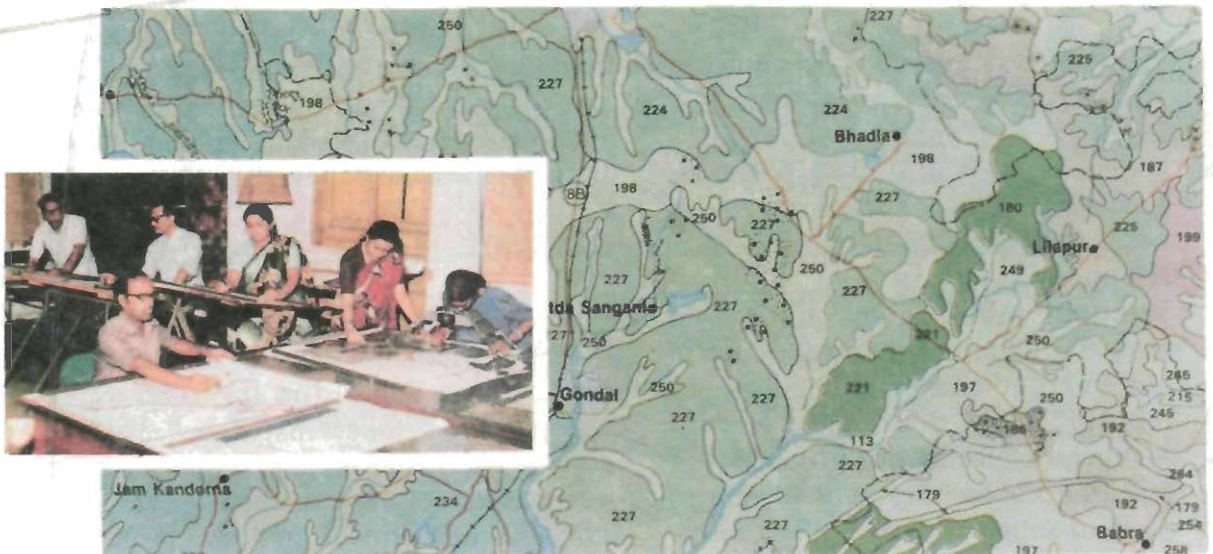


IMAGE INTERPRETATION : *1st tier*



FIELD SURVEY AND LABORATORY ANALYSIS : *2nd tier*



CARTOGRAPHY AND PRINTING : *3rd tier*

Fig. 3.1. A 3-Tier approach for soil resource mapping.

For execution of development plans, the soil resource map on 1:250,000 scale on ammonia sheets can be made available on request.

The soil map unit is an association of dominant and subdominant soil families with inclusions, if any. The dominant soils occupy 50 per cent or more area in a delineation whereas the subdominant soils occupy 20% or more but less than 50% of the total polygon area. The rest of the area in the unit (polygon), if any, is covered by soil inclusions, occupying less than 20% of the total unit or polygon area.

The map units have been assembled in a 3-tier approach as may be observed on the soil map (1:250,000 scale). The **upper tier** shows important properties diagnostic of the dominant soil and its phases. It includes,

order, suborder, great group, subgroup, soil depth, particle size class of family control section, texture of surface soil, slope, erosion class and other phases of the dominant soil family, such as salinity, flood hazards, etc. (shown on map by shading screens). The **middle tier** give landform attributes and the **lower tier** gives the mapping unit (Polygon) number. The assembly of a soil map unit has been illustrated in Fig. 3.2. The 4-sheet published soil maps (1:500,000 scale placed in jacket) show the map unit numbers (polygon numbers) as W001, W002, W003, etc. These map units (polygons) have been described (see main report) in a manner that most users can understand.

The taxonomic names of each of the soil have been given following Soil Taxonomy (Soil Survey Staff, 1975).

A 3-tier map unit symbol (IoUt F1b2/ECA3/W101)

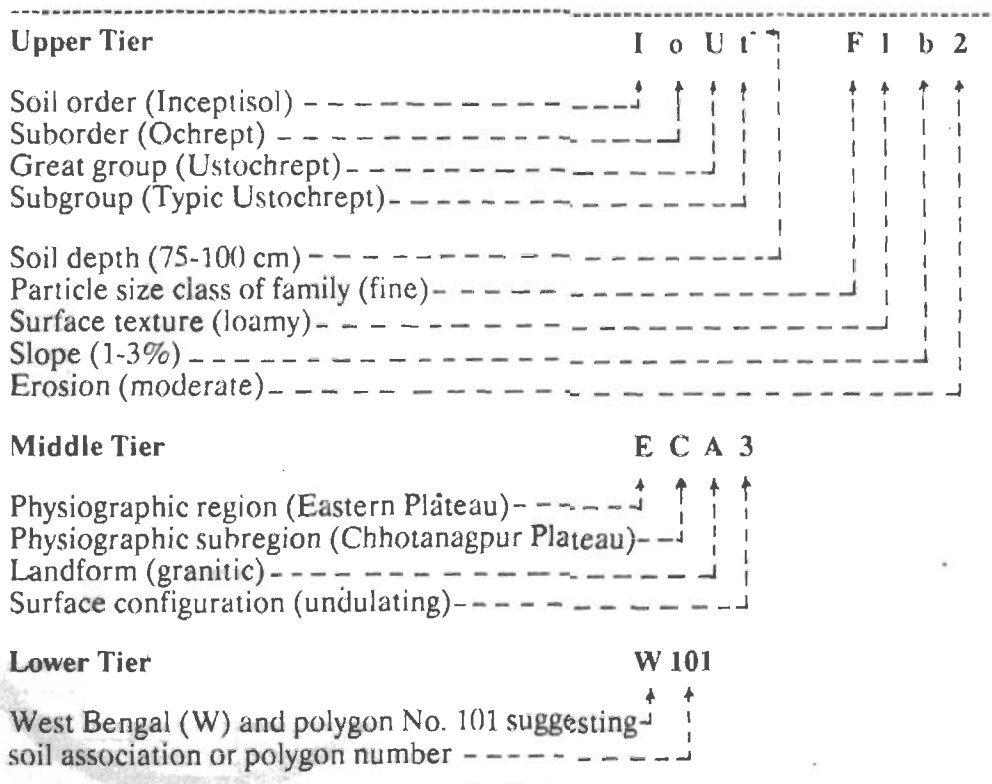


Fig. 3.2. Detailed explanation of a 3-tier symbol of a mapped unit.

SOILS

4.1 SOIL RESOURCE MAPPING

West Bengal is endowed with a wide range of climates, physiographic settings, geology and vegetation sequences. The interaction between these factors in the ecosystem with time and space lead to result in the formation of different kinds of soils with different properties, limitations and potentials.

The field survey was conducted following physiographic sequences of the terrain features. The survey included profile studies at different geomorphic situations, checking and sampling of auger bore samples at 10 km intervals of grid points, and, in addition, random checking of soils at different sites to generate soil mapping units (soil family associations) showing soil-physiographic and climatic relationship.

The map units (soil family association) have been described area-wise and in a manner that most of the land users can understand. The descriptive legends describing the mapping units have been given in detailed report. The taxonomic names of each of the soils (following Soil Taxonomy, Soil Survey Staff, 1975) have been given in the secondary place of the Descriptive Legend (Table 4.1.1 of detailed report). The details of the phases of dominant and subdominant soils in the mapping units as also of the inclusions (if any) have been illustrated in Extended Legends (Appendix 2) given in detailed report. A descriptive legend is also given on the coloured soil map given in the jacket.

4.2 DISTRIBUTION AND CLASSIFICATION OF SOILS

The distribution of different soils (Order, Suborder, Great Group and Subgroup) are presented in Table 4.1. It shows that the soils of West Bengal belong to 3 Orders, 10 Suborders, 19 Great Groups and 36 Subgroups. It is observed that the Inceptisols are the dominant soils followed by Alfisols and Entisols and occupy 52%, 23% and 22% of the total geographical area of the State, respectively.

The areawise distribution of soils at order and suborder levels of Taxonomy are given in Table 4.2 and their proportionate coverage of the terrain of West Bengal are shown in Fig. 4.1 for Orders and Fig. 4.2 for both Orders, Suborders. The distribution of soils with dominant phases deduced from the soil mapping units and Extended Legends have been summarised in Appendix 2.

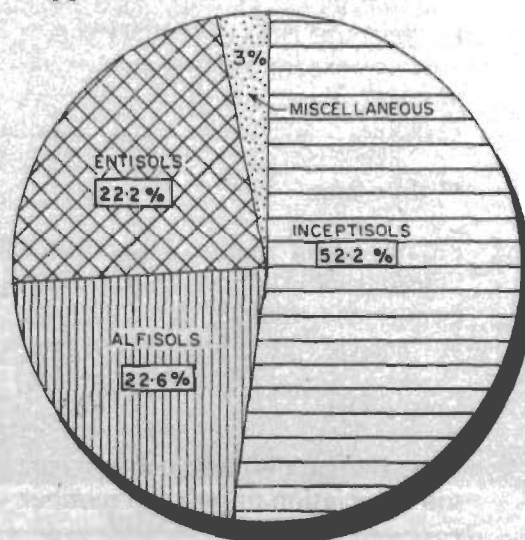


Fig. 4.1 Distribution of soils under different orders (% of T.G.A.)

Table 4.1. Distribution of different soils at order, suborder, great group and subgroup levels.

ORDER AREA (% of SOILS) (% of TGA)	SUBORDER AREA (% of SOILS) (% of ORDER)	GREAT GROUP AREA (% of SOILS) (% of SUBORDER)	SUBGROUP AREA (% of SOILS) (% OF GREAT GROUP)	LOCAL NAME
1	2	3	4	5
ALFISOLS (A)	Aa:Aqualfs	AaO:Ochraqualfs	AaOt:Typic Ochraqualfs	Old alluvial soils
2003.3 (23.2) (22.6)	592.6 (6.9) (29.6)	592.6 (6.9) (100)	123.8 (1.4) (20.9)	
			AaOv:Vertic Ochraqualfs 317.4 (3.7) (53.6)	
			AaOi:Aeric Ochraqualfs 151.4 (1.8) (25.5)	
	Au:Ustalfs	AuP:Paleustalfs	AuPt!Typic Paleustalfs	Red and lateritic soils
	1394.1 (16.2) (69.6)	382.8 (4.4) (27.5)	68.1 (0.8) (17.8)	
			AuPr:Rhodic Paleustalfs 107.5 (1.2) (28.1)	
			AuPu:Ultic Paleustalfs 146.7 (1.7) (38.3)	
			AuPa:Aquic Paleustalfs 60.5 (0.7) (15.8)	

1	2	3	4	5
		AuH:Haplustalfs	AuH:Lithic Haplustalfs	Red gravelly soils
		964.1 (11.2) (69.2)	190.8 (2.2) (19.8)	
			AuH:Typic Haplustalfs	
			627.0 (7.3) (65.0)	
			AuHa:Aquic Haplustalfs	
			146.3 (1.7) (15.2)	
		AuR:Rhodustalfs	AuR:Typic Rhodustalfs	
		3.4 (0.04) (0.2)	3.4 (0.04) (100)	
		AuL:Plinthustalfs	--	
		43.8 (0.5) (3.1)		
	Ad:Udalfs	AdH:Hapludalfs	AdH:Typic Hapludalfs	
	16.6 (0.2) (0.8)	16.6 (0.2) (100)	16.6 (0.2) (100)	
INCEPTISOLS	Ia:Aquepts	IaH:Haplaquepts	IaH:Typic Haplaquepts	Genetic & Vinchyan alluvial soil
(1)				
4639.9 (53.8) (52.2)	3109.7 (36.1) (67.0)	3109.7 (36.1) (100)	1171.2 (13.6) (37.6)	
			IaHi:Aeric Haplaquepts	
			1474.8 (17.1) (47.4)	

1	2	3	4	5
---	---	---	---	---

IaMv:Vertic
 Haploquepts
 463.7
 (5.4)
 (15.0)

Io:Ochrepts	IoU:Ustochrepts	IoUt:Typic
1509.7	1257.4	Ustochrepts
(17.5)	(14.6)	794.6
(32.6)	(83.3)	(9.2)
		(63.2)

IoUf:Fluentic
 Ustochrepts
 326.7
 (3.8)
 (26.0)

IoUl:Lithic
 Ustochrepts
 136.1
 (1.6)
 (10.8)

IoE:Eutrochrepts	IoEf:Fluentic	Tista alluvial
124.7	Eutrochrepts	soils
(1.4)	124.7	
(8.3)	(1.4)	
	(100)	

IoD:Dystrochrepts	IoUm:Umbric
127.6	Dystrochrepts
(1.5)	48.2
(8.4)	(0.6)
	(37.8)

IoDf:Fluentic
 Dystrochrepts
 31.5
 (0.4)
 (24.7)

IoDt:Typic
 Dystrochrepts
 49.7
 (0.5)
 (37.5)

1	2	3	4	5
	Iu:Umbrepts 20.5 (0.2) (0.4) (0.27)	IuH:Haplumbrepts 20.5 (0.2) (100)	IuHt:Typic Haplumbrepts 20.5 (0.2) (100)	Brown forest
ENTISOLS (E) 1972.3 (22.9) (22.2)	Ea:Aquents 546.4 (6.3) (27.7)	EaH:Haplaquents 204.8 (2.3) (37.5)	EaHi:Aeric Haplaquents 96.3 (1.1) (47.0)	Recent coastal alluvial soils
			EaHt:Typic Haplaquents 108.5 (1.2) (53.0)	
		EaF:Fluvaquents 341.6 (4.0) (62.5)	EaFt:Typic Fluvaquents 341.6 (4.0) (100)	
	Ep:Psaements 69.7 (0.8) (3.5)	EpD:Udipsaements 2.1 (0.02) (3.0)	EpDt:Typic Udipsaements 2.1 (0.02) (100)	
		EpU:Ustipsaements 67.6 (0.8) (97.0)	EpUa:Aquic Ustipsaements 4.4 (0.05) (6.5)	Sandy soils
			EpUt:Typic Ustipsaements 63.2 (0.7) (93.5)	
	Ef:Fluents 833.8 (9.7) (42.3)	EfD:Udifluents 110.9 (1.3) (13.3)	EfDa:Aquic Udifluents 110.9 (1.3) (100)	Recent alluvial soils

1	2	3	4	5
		EfU:Ustifluvents	EfUa:Aquic	
		722.9	Ustifluvents	
		(8.4)	150.1	
		(86.7)	(1.7)	
			(20.8)	
			EfUt:Typic	
			Ustifluvents	
			572.8	
			(6.7)	
			(79.2)	
	Eo:Orthents	EoD:Udorthents	EoD:Lithic	
	522.4	107.7	Udorthents	
	(6.1)	(1.3)	12.3	
	(26.5)	(20.6)	(0.1)	
			(11.4)	
			EoDt:Typic	
			Udorthents	
			95.4	
			(1.2)	
			(88.6)	
		EoU:Ustorthents	EoUt:Typic	
		414.7	Ustorthents	
		(4.8)	77.5	
		(79.4)	(0.9)	
			(18.7)	
			EoUL:Lithic	
			Ustorthents	
			337.2	
			(3.9)	
			(81.3)	

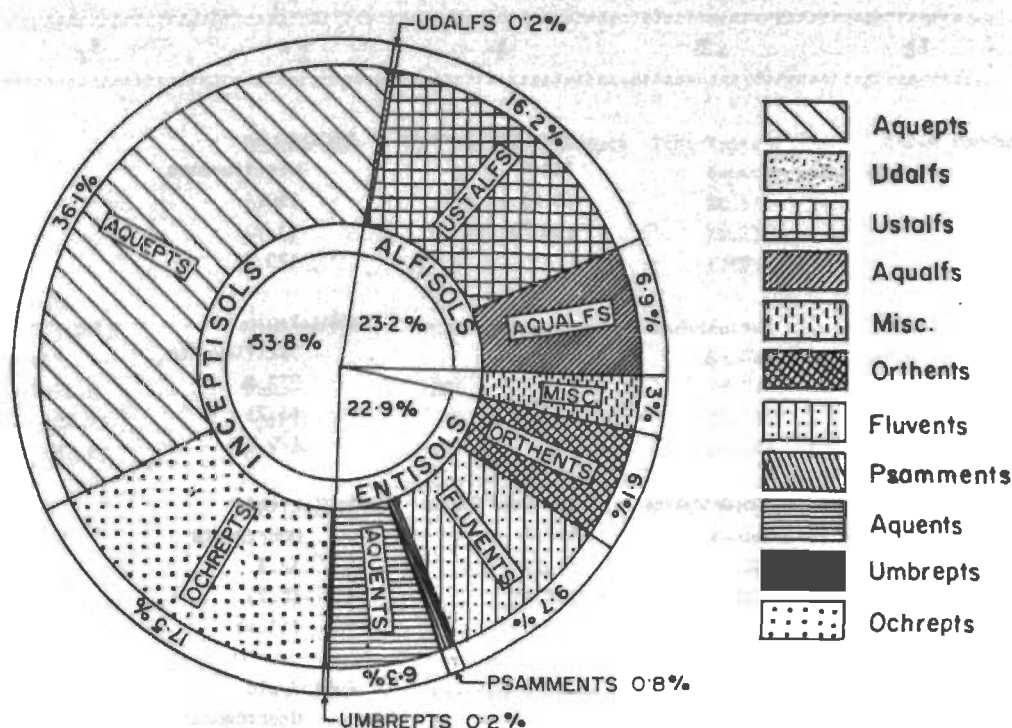


Fig. 4.2 Distribution of soils (% of TGA) under different orders and suborders

Table 4.2. Distribution of soils (Order, Suborder)

Soil Order & Suborder	Area	
	% of mapped area	% of TGA (8.87 m. ha.)
Inceptisols	53.8	52.2
Aquepts	36.1	
Ochrepts	17.5	
Umbrepts	0.2	
Alfisols	23.2	22.6
AqualFs	6.9	
Ustalfs	16.2	
Udalfs	0.2	
Entisols	22.9	22.2
Aquents	6.3	
Psamments	0.8	
Fluents	9.7	
Orthents	6.1	
Miscellaneous areas	---	3.0

4.3 CHARACTERIZATION OF SOILS UNDER DIFFERENT AGRO-ECOLOGICAL SUBREGIONS

The soils of West Bengal have been mapped, described, analysed, charac-

terised and classified under six agro-ecological subregions (Table 4.3 and Fig. 4.3). The subregions have been reported and delineated within each of the agro-ecological regions covering the state of West Bengal based on detailed criteria of separation (Sehgal et al, 1992a&b). In each of the subregions, formation, characteristics and distribution of dominant soils have been discussed.

4.3.1. Soils of Warm Perhumid Agro-ecological Subregion (Darjiling and Bhutan Himalayas) (No. 16.2)

The eco-subregion covers the district of Darjiling Himalayas (Fig. 4.3). The subregion occupies an area of 0.26 m. ha, representing 2.9 per cent of the total soil geographical area of the State. The climate of the area is warm perhumid and it is characterised by mild summers and cold winters. The LGP is more than 300 days while soil moisture and temperature regimes are udic and thermic, respectively.

Soils of the subregion are heterogenous in nature. The soils developed on steep hill slopes are shallow to very shallow, excessively drained with severe to very severe erosion hazards. These are mostly the residuum of the eroded soils and lack profile development. The texture varies from gravelly loam to loam and are classified as Lithic, and Typic Udorthents. The soils, developed on

foothill slopes and valleys are moderately deep to deep, well drained, loamy in texture with moderate erosion hazards. They show some degree of profile development and are classified as Umbric and/or Fluventic Dystrochrepts, Lithic and/or Typic Haplumbrepts. These soils are strongly to moderately acid in reaction. They are rich in humus content and generally have moderate to low base saturation.

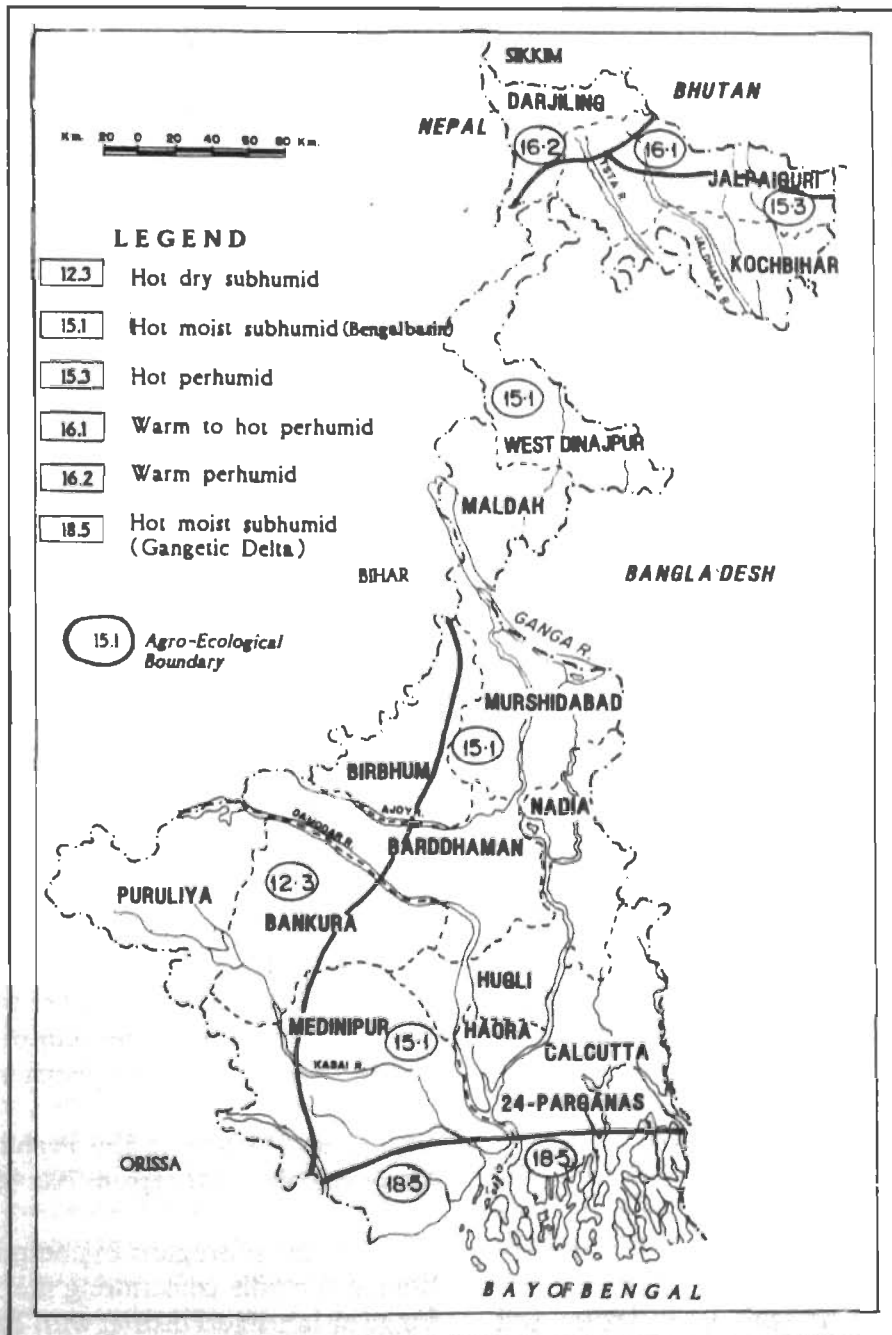


Fig. 4.3 Agro-ecological subregions, West Bengal

Table 4.3. Description of agro-ecological subregions

Agro-ecological subregion number	Description	Area (per cent of TGA) (8.87 m. ha)
16.2	Darjiling Himalayas, warm, perhumid agro-ecological subregion with shallow to moderately deep, loamy Brown and Red hill soils, low to medium AWC (75-100 mm/m) and more than 300 days of LGP.	2.9
16.1	Moderately to gently sloping foothills of Bhutan Himalayas, warm to hot perhumid agro-ecological subregion with shallow to moderately deep loamy skeletal to loamy Tarai soils, low to medium AWC (50-120 mm/m) and 270-300 days of LGP.	1.9
15.3	Level Teesta Plain, hot, perhumid agro-ecological subregion with deep, loamy to clayey alluvium-derived soils, medium AWC (100-150 mm/m) and 270-300 days of LGP.	9.6
15.1	Nearly level to gently sloping Ganga plain (Bengal Basin), hot moist-subhumid agro-ecological sub-region with deep, loamy to clayey, alluvium-derived soils, medium to high AWC (150-200 mm/m) and 210-240 days of LGP.	55.7
18.5	Gently sloping to level Gangetic lower Delta, moist sub-humid agro-ecological subregion with deep, loamy to clayey coastal and Deltaic Alluvium-derived soils, medium AWC (150-200 mm/m) and 240-270 days of LGP.	7.6
12.3	Gently sloping and/or gently undulating Chhotanagpur plateau, hot, dry-subhumid agro-ecological subregion, deep, loamy to clayey Red and Lateritic soils, medium AWC (100-150 mm/m) and 150-180 days of LGP.	22.3

4.3.1.1. Land Use

The natural vegetation comprises moderately dense forest cover with teak plantation. The area is mostly used for tea plantation. Besides, horticultural fruit crops, like oranges, etc. and agricultural crops, like paddy and maize are grown in terraces.

- Low base-status leading to toxicity of Fe and Al.

b. Potentials

- The low-base, acid soils rich in organic matter are favoured for tea plantation and plantation of horticultural crops, like pineapple, pears, peach and plum.

4.3.1.2. Problems and Potentials

a. Problems

- Soil acidity
- Heavy runoff leading to severe soil erosion hazard
- Limiting soil depth on steep hill slopes

4.3.2. Soils of Warm to Hot Perhumid Agro-ecological Subregion (No. 16.1)

The subregion encompasses the Bhutan foothills constituting the northern fringe of Jalpaiguri district with Tarai soils. The subregion covers an area of 0.17 m. ha representing 1.9% of the state area. The

climate is perhumid and characterised by warm to hot summers and cool winters. The mean annual rainfall is more than 3000 mm covering the entire annual PET excepting the period of seasonal deficit. The moisture regime is mostly udic while soil temperature regime is thermic to hyperthermic. The length of growing period (LGP) ranges between 270 and 300 days in a year. The area is much uneven with typical contrast to the Duars region. The moderately to gently sloping gradients abruptly break on the level Tista plain in south.

The soils are partly developed and/or show beginning of profile development. The soils have been in the process of developing in young alluvium and in materials on alluvial fans of foothills. These are shallow to moderately deep and at places deep with medium to fine in texture and classified as Fluventic Dystrochrepts, Fluventic Eutrochrepts and Aeric Haplaquepts. They are strongly to moderately acid while at places neutral and mildly alkaline.

4.3.2.1 Land Use

These are mostly used for tea and horticultural plantations while at places these are cultivated for upland rice.

4.3.2.2 Problems and Potentials

a. Problems

- The uneven foothills (Tarai) with moderately sloping to gently sloping topography breaking abruptly to level Tista Alluvial Plain in southern part (Duars) poses severe water management problems.
- Abrupt break of the gradient, heavy precipitation coupled with severe runoff from upper reaches cause static rejuvenation of criss-crossed ephemeral feeder streams of Tista river system. This leads to severe flood hazards in the region resulting in

destruction of plantation crops, infrastructures and affects both human and cattle population.

b. Potential

- Foothills (Tarai region) favour plantation of tea, pineapple, etc.

4.3.3. Soils of Hot, Perhumid Agro-ecological Subregion (No. 15.3)

The subregion comprising level Tista alluvial plain (Duars) below the foothills of Bhutan Himalayas covers the districts of Koch Bihar, Jalpaiguri (Southern part) and northern parts of West Dinajpur (Fig. 4.3). The subregion occupies an area of 0.85 m. ha representing 9.6% of the total geographical area of the state. The climate of the area is perhumid and characterised by warm summers and mild winters. The mean annual rainfall is more than 3000 mm. The length of the growing period ranges between 270 and 300 days in a year. The soil moisture regime is in general udic while in extreme south it is ustic at places. The soil temperature regime is hyperthermic.

The soils have developed in the alluvium laid by the rivers of Tista, Mahananda and Jaldhaka. The climate (per-humid) in conjunction with parent material, topography and vegetation dominantly influence soil formation in the area.

The soils developed in recent alluvium mostly occur in flood plain. These are moderately deep to deep, coarse to fine-loamy in texture. These are, at places, moderately well drained but in most of the cases they are imperfectly and/or poorly drained, subject to moderate flooding. They are classified as Typic Haplaquepts, Fluvaquepts, Ustifluvents, Typic- and/or Aquic Udifluvents, Typic Ustorthents and Typic Udorthents. These soils are slightly acidic to neutral while at places slightly

alkaline. They have moderate to high base saturation status.

4.3.3.1 Land Use

The area is intensively cultivated for rice and jute.

4.3.3.2 Problems and Potentials

The salient problems and potentials of these soils are:

a. Problems

- In the area (**Duars**) high relative humidity, rainfall and fairly warm temperatures that prevail during most part of the year result in prolonged wetness and/or water stagnation in low-lying areas. As such it favours the growth of wetland crops, like jute and rice or in otherwards it calls for selection of wet land crops, instead of dry land cultivars.
- The area is very much prone to severe flood hazards resulting in the frequent risk of crop failure and casualties to both human and cattle population.
- Wetness, low CEC and low base saturation are some of the salient limitations.

b. Potential

- A major part of **Duars** favours growing of wet land crops, such as jute and rice, and other tropical horticultural crops.
- High lands with slightly alkaline soils favour cultivation of Tobacco.

4.3.4. Soils of Hot, Moist Subhumid Agro-ecological Subregion (No. 15.1)

The eco-subregion comprises the Ganga Plain (Bengal Basin) an eastward continuation of Indo-Gangetic Alluvial Plain. The subregion covers the districts of Maldah, West Dinajpur (Southern part), Murshidabad, Nadia, Haora, Hughly, 24-Parganas (Northern part), Bardhaman (Eastern part), Birbhum, Bankura and

Medinipur (Eastern parts) (Fig. 4.3). The subregion occupies an area of 4.93 m. ha representing 55.7 per cent of the total geographical area of the state.

The climate of the area is moist sub-humid and it is characterised by dry and hot summers and mild winters. The mean annual rainfall ranges from 1389 to 1908 mm covering about 70 to 80 per cent of the annual PET and soils remain dry for about 3 to 4 months in a year. The LGP varies from 210 to 240 days whereas the soil moisture and temperature regimes are ustic and hyperthermic, respectively.

The soils have been developed in the alluvium laid by Ganga and its tributaries and subtributaries, viz. Mahananda, Ajoy, Damodar, Kansabati, Bhagirathi, Haldi, Rupnarayana and Matla.

These soils are greatly variable in their morphological, physical and chemical properties depending upon the geomorphic situations, moisture regime and degree of profile development.

- The soils developed on recent flood plain are deep, coarse to fine-loamy in texture and moderately well drained to well drained and are, at places, poorly drained. The soils are classified as Typic Ustifluvents, Ustipsamments, Fluvaquents, Psammaquents and Haplaquents. They are highly base saturated and neutral to slightly alkaline in reaction.
- The soils developed on low-lying areas (Meandering scars, back swamps) in the old flood plain show some degree of profile development under high water table and reduced conditions with aquic moisture regime. These are deep, medium to fine in texture and imperfectly or poorly drained. They represent Aeric, Typic and Vertic Haplaquepts, and Typic or Udic Ustochrepts. They are slightly acid to slightly alkaline in reaction and have medium to high base saturation.

- Soils developed on gently to moderately sloping uplands show appreciable degree of profile development. They are medium to fine in texture with disseminated ferruginous concretions in the subsoils and are imperfectly drained. Some soils are found to develop wide (1 to 2 cm) cracks which extend upto 40 cm of the surface. Such soils are classified as Vertic at subgroup level of Soil Taxonomy.

In general, the soils of the zone are slightly acidic to slightly alkaline and have high base saturation.

4.3.4.1 Land Use

The soils are intensively cultivated for rice, wheat, potato and oilseed crops.

4.3.4.2 Problems and Potential

a. Problems

- Bengal basin inherently suffers from improper drainage outlets. The tributaries and distributaries in spate frequently inundate the low-lying areas resulting in stagnation of water for smaller and longer periods. Such flood hazards adversely affect the normal dryland crop yields.

b. Potential

These soils with high nutrient and mineral reserve are suitable for a fairly large variety of agricultural and horticultural crops keeping in view the soils and landform conditions.

4.3.5. Soils of Hot, Moist Subhumid Agro-ecological Subregion (No. 18.5)

The subregion encompasses the coastal parts of the districts of 24-Parganas comprising mostly Sundarban areas and coastal parts of Medinipur district. It covers an area of 0.68 m ha representing 7.6 per

cent of the total geographical area of the State (Fig. 4.3). The climate is moist subhumid and characterised by hot summers and mild winters. The mean annual rainfall covers 80 to 90 per cent of the annual potential evapotranspiration. The length of growing period varies between 240 and 270 days. The soil moisture and temperature regimes are ustic and hyperthermic, respectively. The soils have been developed in alluvium laid by the rivers of Haldi, Rupnarayana and Matla. They are by and large salt impregnated due to diurnal tidal flow of sea water through creeks and subtributaries. They are deep, fine-loamy to fine in texture, imperfectly to poorly drained with moderate to very strong salinity hazards. These are classified as Typic, Aeric and Vertic Haplaquepts, Typic Fluvaquents, Typic Psammaquents, and Aquic Ustipsamments. They are neutral to slightly alkaline in reaction. They have, in general, exchangeable sodium percentage (ESP) below the critical level (15%). The soils are rich in bases.

4.3.5.1 Land Use

The soils are intensively cultivated for rice.

4.3.5.2 Problems and Potentials

a. Problems

The coastal areas which are low-lying and diurnally inundated by tidal water are affected by varying degree of salinity hazards. The soils and landform conditions are not suitable for other mesophytic crops besides few salt resistant crops. For considerable period of the year, the soils remain wet and saline.

b. Potential

The area has the potential for salt water pisciculture raising prawns and other salt-loving fishes, which can double the income.

4.3.6. Soils of Hot, Dry Subhumid Agro-ecological Subregion (No. 12.3)

The subregion comprising the outliers of Eastern Plateau (Chhotanagpur Plateau) gradually merging to Bengal Basin (Ganga Plain) includes the districts of Purulia and western parts of Bardhaman (Asansol) Bankura, Birbhum (Suri) and Medinipur (Jhargram) (see Fig. 4.3)

The area represents eastward outliers of tertiary and post-tertiary peneplain surface with frequent subdued laterite spurs covered by old alluvium laid by Peninsular rivers. The subregion covers an area of 1.98 m ha, representing 22.3 per cent of the total area of the state. The climate is dry subhumid and it is characterised by dry and hot summers and mild winters. The mean annual rainfall ranges from 1307 to 1392 covering 80 to 90 per cent of the annual PET. The LGP ranges between 150 and 180 days in a year while soil moisture and temperature regimes are ustic and hyperthermic.

The land/surface configuration is largely of undulating and rolling types. The soils have developed on parent materials which are mostly sedentary in nature. They vary from shallow to deep, reddish to yellowish red, loamy to clayey, and are imperfectly to well drained. They are very susceptible to erosion hazards. However, they show considerable degree of profile development and are classified as Lithic, Typic, Aquic Haplustalfs; Aquic, Typic, Ultic and Rhodic Paleustalfs; Typic and Aquic Ochraqualfs, Plinthustalfs, Typic Rhodustalfs, Lithic, and Typic Ustochrepts; Lithic Ustorthents and Typic Ustifluvents.

These soils are moderately to strongly acidic and have medium base saturation.

4.3.6.1 Land Use

The natural vegetation comprises tropical dry deciduous forest (Sal,

Simul Arjun, Palash, etc.). The area is cultivated for rainfed crops, such as paddy and pulses in terraces.

4.3.6.2 Problems and Potential

a. Problems

- Relatively less aggregated Red and Lateritic soils which are prone to frequent development of surface encrustation.
- The prolonged dry periods augment the hardening of the encrustation resulting in poor intake rate of rain water during stormy cloud burst at the onset of monsoon, leading to severe runoff with severe soil loss at the toe end of the topography.
- Severe and frequent occurrence of gullies on the land surface stand as severe limitation to land levelling, land consolidation and trafficability, besides hampering normal agricultural practices.
- The standing crops suffer from both the stormy cloud burst, and inter dry spell period during the growing season.
- Relatively acid reaction, low active clay, richness in hydrated oxides of iron and gibbsite in the clay complex lead to fixation of 'P' resulting in nutrient imbalance that affect response to fertilization.

The major constraints of these soils are: soil erosion, soil fertility and limiting soil depth.

b. Potential

Suitable watershed-based management, including appropriate soil conservation measures, water harvesting programmes and cropping system may help to restore higher yields of rice, wheat, groundnut, mustard and cotton under rainfed agriculture.

SOIL PROBLEMS

The soil resource mapping (SRM) of West Bengal has brought out some of the salient land characteristics within different agro-ecological subregions. The analysis of the data-base generated from SRM, reveal different kinds of soil problems, such as soil erosion, soil depth, drainage, salinity, etc. which are important for effective land use planning. The limiting soil attributes their extent and distribution are briefly described as under:

5.1 DEPTH

Effective soil depth is an important soil attribute which plays a vital role in

growing of specific crops. The effective soil depth not only governs the root development but also is a source of moisture and nutrient supply to the plants. Among the five depth classes, those affecting crop growth have been identified and call for consideration in selecting crops which can be grown profitably. These classes are described in Table 5.1 and Fig. 5.1.

5.2 INTERNAL DRAINAGE

Drainage refer to internal drainage through the soil pedons. It is governed by soil texture, landform situation and depth of ground water table. Soils of

Table 5.1. Soils under limiting depth classes

Class	Location		Affected Soil Map Units	Area affected	
	Agro-eco subregion	Distribution (District)		(,000 ha)	Per cent of mapped area (% of TGA)
Very shallow (0-25 cm)	Hot Subhumid	Purulia	W092, W093, W108, W109	30.7	0.4 (0.3)
Shallow (25-50 cm)	Warm Perhumid	Part of Darjiling	W001	15.4	0.2 (0.2)
	Hot Subhumid	Purulia, Medinipur, Bankura	W091, W092, W093, W095, W096, W099, W105, W106, W110, W113, W114, W115	303.0	3.5 (3.4)
Moderately shallow (50-75 cm)	Warm Perhumid	Part of Darjiling	W002, W004, W005	109.8	1.3 (1.2))
	Hot Subhumid	Part of Medinipur, Barddhaman, Birbhum, Purulia, Bankura	W095, W111	15.4	0.2 (0.2)

West Bengal have been grouped into six drainage classes, of which four classes have been found to adversely affect the soil and crop management. They are very poor-

ly drained, poorly drained, imperfectly drained and excessively drained soils. Areas affected by these drainage classes are given in Table 5.2 and shown in Fig. 5.2.

Table 5.2. Soils under limiting drainage classes

Class	Location		Affected Soil Map Units	Area affected	
	Agro-eco subregion	Distribution (District)		(,000 ha)	Per cent of mapped area (% of TGA)
Very poor	Hot Subhumid	Part of Medinipur, Hooghly and 24-Parganas(S)	W038,W087,W090	173.4	2.0 (1.9)
Poor	Hot Perhumid to Subhumid	Part of 24-Parganas, Nadia, Murshidabad, Jalpaiguri, Kochbihar, Malda, Medinipur, Haora and Hugli	W008,W010,W012, W013,W018,W026, W028,W029,W035, W036,W037,W038, W040-48,W050, W051,W052,W054, W055,W056,W058 W059,W061,W063, W066,W069,W070, W072,W075-90	2453.3	28.4 (27.6)
Imperfect	Hot Subhumid	Part of Barddhaman, Birbhum, Hooghly, W. Dinajpur, Malda, Medinipur & Purulia	W006,W007,W009, W011,W014,W015, W017,W018,W019, W020,W021,W024, W025,W027,W031, W032,W033,W034, W035,W036,W037, W039,W051,W053, W060,W062,W066, W071,W081,W085, W097,W098,W101, W104,W113	1747.6	20.3 (19.7)
Excessive	Warm Perhumid	Part of Darjling and Jalpaiguri	W001,W002,W003	56.1	0.6 (0.6)
	Hot Subhumid	Part of Bankura & Purulia	W093	8.6	0/1 (0.1)

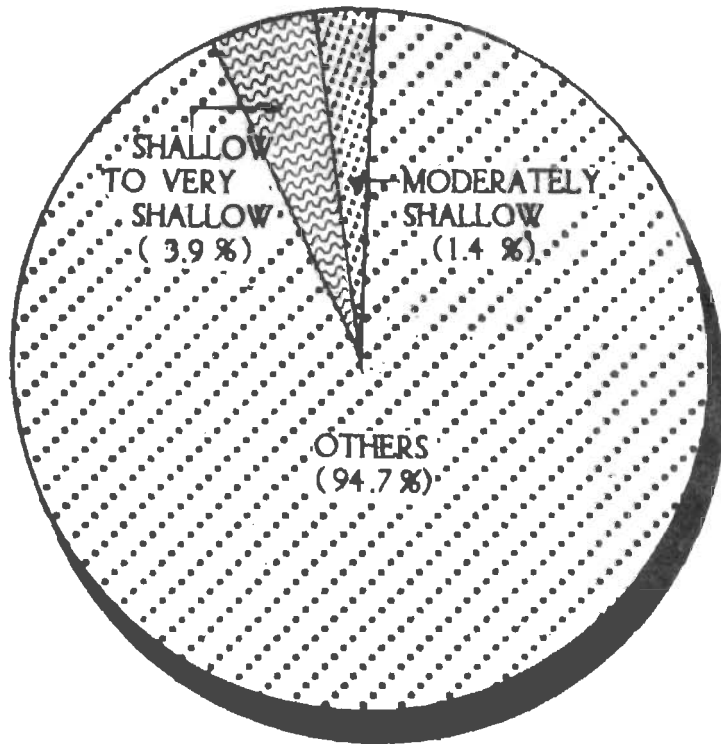


Fig. 5.1 Soils under depth classes

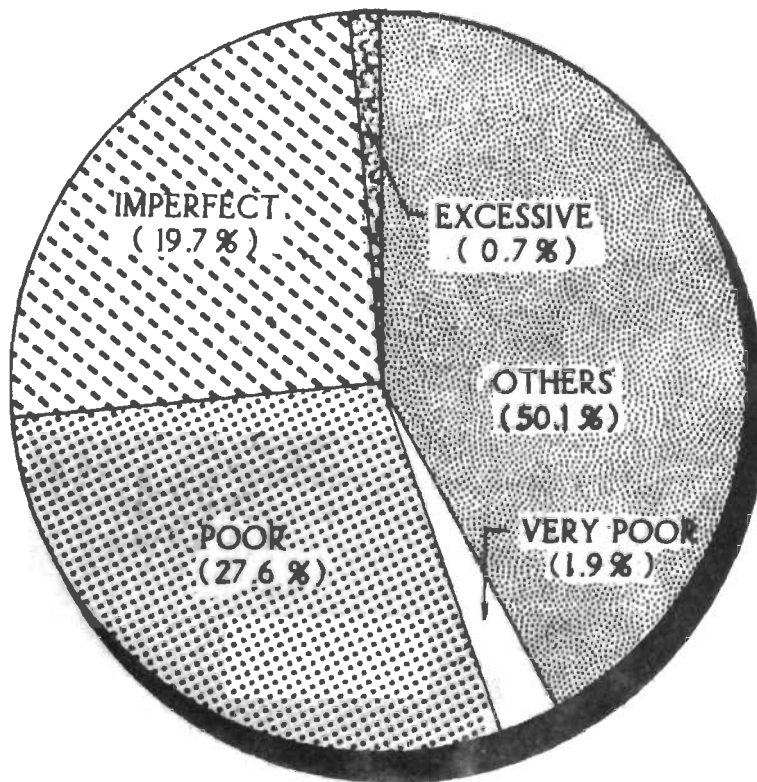


Fig. 5.2 Soils under limiting drainage classes

5.3. EROSION BY WATER

Erosion by water is observed to be one of the major soil degradation factor, in the hilly regions of Darjiling district and undulating terrains of south western plateau region where extensive areas are affected by gullies. Out of the four erosion classes observed, those needing urgent soil and water conservation measures are described. The areas affected by severe and moderate erosion hazards are given in Table 5.3 and shown in Fig. 5.3.

5.4. TEXTURE

Texture is nearly a permanent soil characteristic having an important role for crop production from the initial stage of sowing seeds upto the maturity of crops. Out of four textural classes inventoried, those hindering crop growth are described. They are sandy, gravelly loam and clayey. The area affected by these textural classes are described in Table 5.4 and shown in Fig. 5.4.

Table 5.3. Soils under limiting erosion classes

Class	Location		Affected Soil Map Units	Area affected	
	Agro-eco subregion	Distribution (District)		(,000 ha)	Per cent of mapped area (% of TGA).
Severe	Warm Perhumid	Darjiling (part)	W001,W002,W003	37.0	0.4 (0.4)
	Hot Subhumid	Western part of Purulia, Birbhum, Bankura and Medinipur	W073,W074, W091,W092, W093	20.4	0.2 (0.2)
Moderate	Hot Subhumid	Western part of Bardhaman, Birbhum, Medinipur, Bankura, Murshidabad, Malda, N&S, Dinajpur, Cooch-bihar and entire Purulia	W016,W024,W025, W028,W033,W064, W065,W066,W067, W068,W071,W072, W091,W094,W095, W096,W097,W098, W099,W100,W101, W102-110, W112-115	1137.1	13.2 (12.8)
	Warm Perhumid	Darjiling Jalpaiguri (part)	W002-7	166.0	1.9 (1.8)

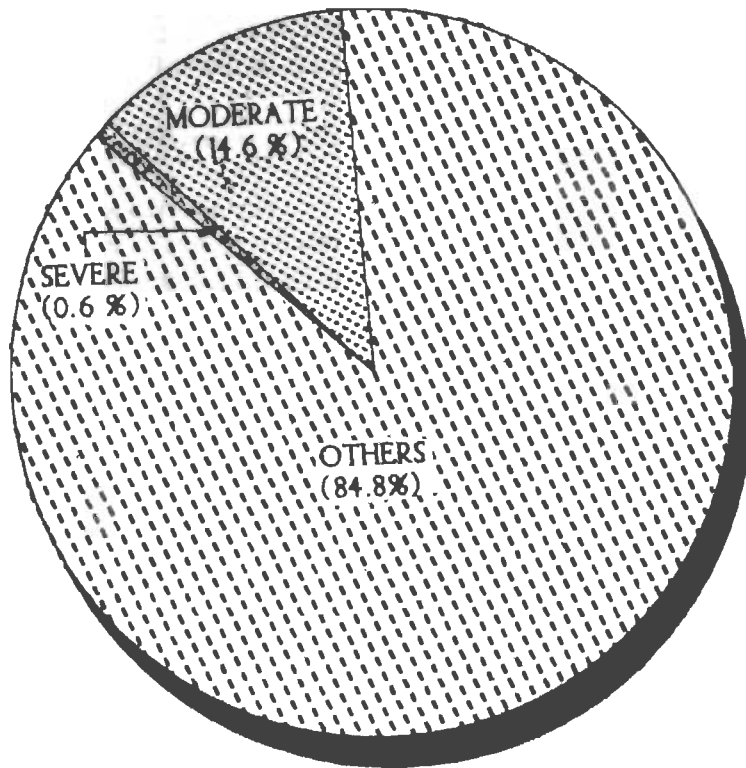


Fig. 5.3 Soils under limiting erosion classes

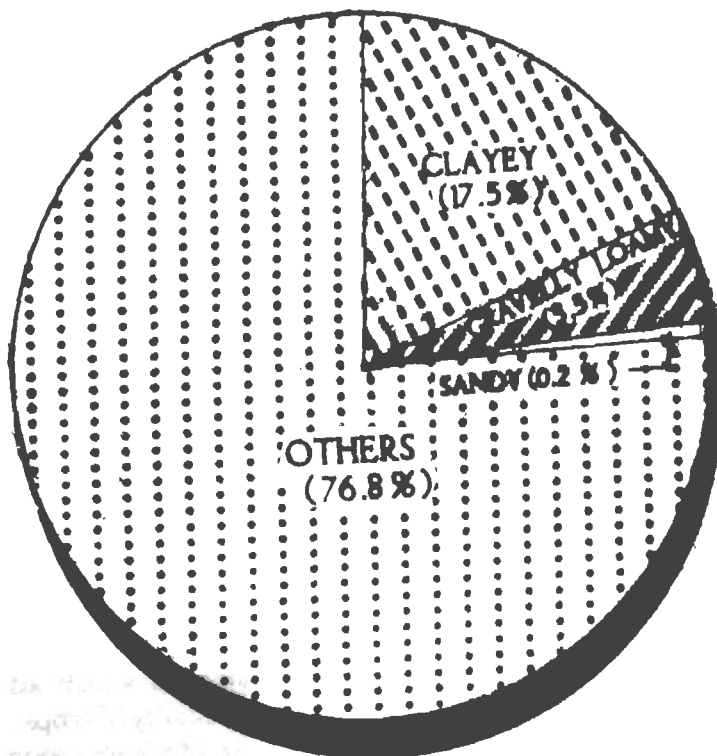


Fig. 5.4 Soils under limiting textural classes (surface)

5.5. SALINITY

Soil salinity in West Bengal is mainly due to the inundation of tidal water in deltaic zone. The reclamation of these soils by removing soluble salts is a major management aspect. Of the five soil salinity classes, three classes, viz. very strong, strong and moderate salinity hazards affect the crop growth severely. The area affected by salinity limitation are given in Table 5.5 and shown in Fig. 5.5. For management of salinity either the soils need drainage fol-

lowed by leading to maintain formerly salt balance in the soil profile.

5.6 FLOODING

Surface flooding is considered a serious limitation for crop production in the Indo-gangetic plains of West Bengal. Among the several flood limitations only those which cause great damage to crops are described. The area affected by moderate and severe flooding are given in Table 5.6 and shown in Fig. 5.6.

Table 5.4. Soils under limiting textural classes (surface)

Class	Location		Affected Soil Map Units	Area affected	
	Agro-eco subregion	Distribution (District)		(,000 ha)	Per cent of mapped area (% of TGA)
Sandy	Hot Subhumid	Coastal part of Medinipur	W073, W074, W075, W076	13.7	0.16 (0.2)
Gravelly loam	Hot Subhumid/ Warm Perhumid	Part of Darjiling Medinipur, Bankura, Purulia	W001, W002, W003, W004, W092, W093, W096, W105, W108, W115	488.4	5.6 (5.5)
Clayey	Hot Subhumid	24-Parganas(S) Medinipur, Barddhaman, Murshidabad, Nadia	W021, W036, W037, W038, W039, W042, W044, W045, W046, W047, W048, W049, W052, W054, W055, W056, W058, W072, W075, W076, W077, W078, W080, W081, W083, W084, W085, W087, W088, W089	1550.7	18.0 (17.5)

5.7 WATERLOGGING

Waterlogging is defined as the stage whereby the soil become saturated by water within the depth of root zone for a significant period. It is considered as a

serious limitation which adversely affect the yield and quality of crops. Waterlogging may be caused by high ground water table or submergence by rain water or both. The areas affected by waterlogging in West Bengal is given in Table 5.7 and figure 5.7.

Table 5.5. Soils under limiting salinity classes

Class	Location		Affected Soil Map Units	Area affected	
	Agro-eco subregion	Distribution (District)		(,000 ha)	Per cent of mapped area (% of TGA)
Very strong	Hot Subhumid	South 24-Parganas & Medinipur	W090	241.0	2.8 (2.7)
Strong	---do---	----do----	W073,W087	5.7	0.06 (0.06)
Moderate	---do---	----do----	W075,W076,W077 W078,W079,W080, W088,W089	131.0	1.5 (1.5)

Table 5.6 Soils under limiting flooding classes

Class	Location		Affected Soil Map Units	Area affected	
	Agro-eco subregion	Distribution (District)		(,000 ha)	Per cent of mapped area (% of TGA)
Moderate	Hot Humid	Part of Jalpaiguri, Kochbihar, North Dinajpur	W008,W009,W010, W013	112.0	1.3 (1.3)
	Hot Subhumid	Part of North Dinajpur, Malda, Murshidabad, Nadia, Barddhaman, 24-Parganas, Medinipur	W011,W012 W013,W014 W019,W021,W022, W025,W035,W044, W045,W046,W055-55, W057,W061, W063-65,W075,W076, W077,W078 W086	931.2	10.8 (10.5)
Severe	Hot Subhumid	Part of Hooghly Medinipur, Murshidabad, Nadia and 24-Parganas	W047,W049 W056,W058, W079,W080, W082 W084,W085, W087,W088, W089,W090	907.2	10.5 (10.2)

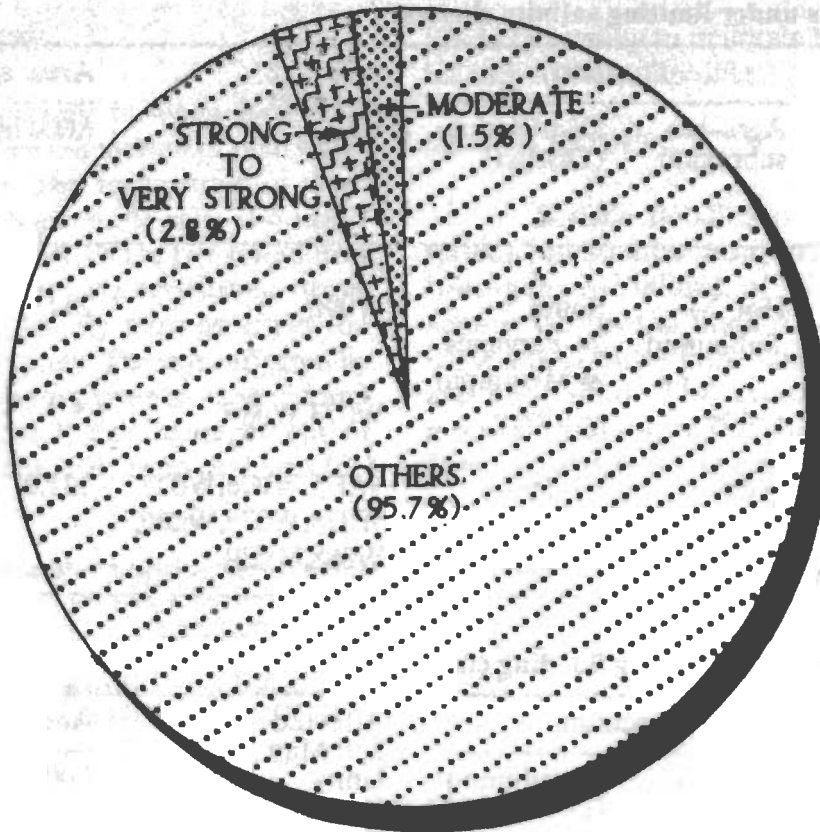


Fig. 5.5 Soils under limiting salinity classes

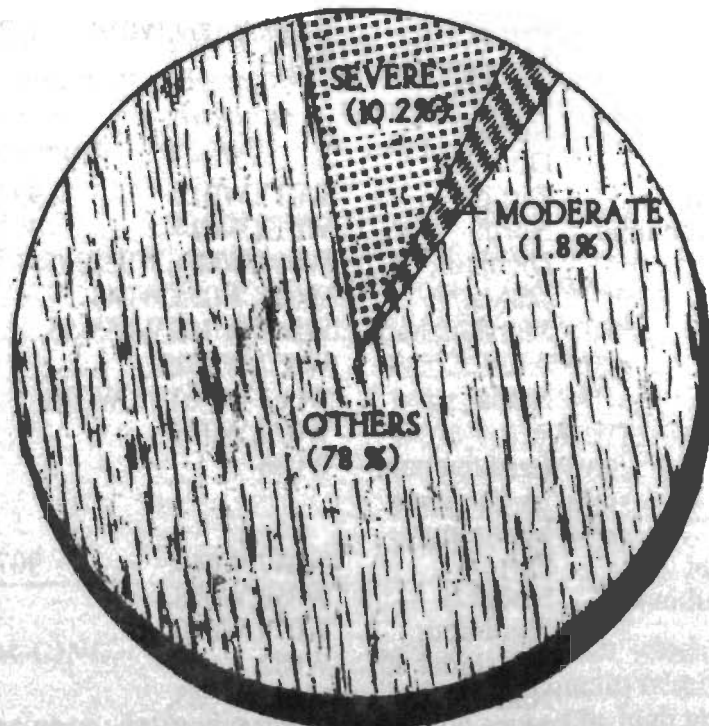


Fig. 5.6 Soils under limiting flooding classes

Table 5.7 Soils under limiting waterlogging classes

Class	Location		Affected Soil Map Units	Area affected	
	Agro-eco subregion	Distribution (District)		(,000 ha)	Per cent of mapped area (% of TGA)
Moderate	Hot, Perhumid	Coochbihar, Jalpaiguri	W026*, W028	111.3	1.3 (1.2)
	Hot, moist Subhumid (Bengal Basin)	W.Dinajpur, Medinipur, Bardhaman, Birbhum, Murshidabad	W029*, W038, W041, W042, W043, W048	337.5	3.9 (3.8)
	Hot, Perhumid	Darjling, Jalpaiguri, Coochbihar	W008*, W018*	189.8	2.2 (2.1)
	Hot, moist Subhumid (Bengal Basin)	W.Dinajpur, Maldah, Murshidabad, Birbhum, Medinipur, Hooghly, Bardhaman, Nadia, Howrah	W015*, W017*, W020, W024*, W027*, W031*, W032, W033, W034, W036, W037, W039, W060, W062, W066, W071, W072, W081, W083	618.5	7.1 (6.9)

* Area affected for less than 3 months.

SOIL DEGRADATION

The major soil problems in West Bengal, discussed in the preceding chapter cause soil degradation resulting in appreciable losses in soil productivity. **Soil degradation can be defined as the rate of adverse changes in soil quality resulting in declined in productive capacity of land due to processes induced mainly by human intervention (UNEP, 1992).** Two categories of soil degradation processes have been identified in West Bengal. The first category deals with soil degradation by displacement of soil material and includes mainly water erosion. The second category of soil degradation deals with internal soil physical and chemical deterioration and includes mainly waterlogging, flooding (under physical deterioration) and salinization (under chemical deterioration) (Sehgal and Abrol., 1994).

The data (Table 6.1), show that as much as 30.9 per cent of total geographical area in the state is degraded due to the above mentioned problems. Of this, 19.7 per cent of the area occurring mainly in districts of Purulia, Bankura and Darjiling is degraded due to loss of top soil by water erosion; 3.2 per cent of the area occurring mainly in the districts of 24-Parganas (South) and Medinipur is degraded due to salinization, whereas waterlogging has resulted in the soil degradation of 6.9 per cent of area occurring mainly in the districts of 24-Parganas (North and South), Medinipur, Hugli, Nadia, and Maldah. A detailed account of status of soil degradation in the state is given in Table 6.1 whereas the severity of soil degradation is detailed in Table 6.2.

Table 6.2 Severity of soil degradation in West Bengal

Soil Degradation Type	Severity class				Total area (%)
	Low	Medium	High	Very high	
	(,000 Ha)				
Water erosion	458.0 (5.2)	667.5 (7.5)	627.2 (7.0)	-	1752.7 (19.7)
Physical deterioration	324.3 (3.6)	370.8 (4.2)	14.5 (0.2)	-	709.6 (8.0)
Chemical deterioration					
a) Salinization + Waterlogging (Cs + Pw)	-	130.5 (1.5)	39.0 (0.4)	-	169.5 (1.9)
b) Salinization + Flooding (Cs + Ps)	-	-	113.0 (1.3)	-	113.0 (1.3)
c) Wind Erosion + Salinization (Et + Cs)	-	-	-	6.5 (0.01)	6.5 (0.01)
Total area (Percent)	782.3 (8.8)	1168.8 (13.2)	793.7 (8.9)	6.5 (0.01)	2751.3 (30.9)

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APPENDICES

Climatic data (1931-60) of some important stations

A. Station: DARJILING (27°03' N, 88°16' E); altitude: 2127 m; climate: Per-humid (Hilly ecosystem)

Month	Mean Air temperature °C		Humidity (%)		Rainfall		Potential Evapotranspiration (P.E) (mm)	Mean Wind speed (Km.hr ⁻¹)
	Daily Max.	Daily Min.	Relative Humidity	Vapour Pressure	Total (mm)	No. of rainy days		
Jan.	9.3	3.0	69	7.0	31.7	1.3	31.4	2.1
Feb.	11.1	4.3	74	7.8	26.7	2.7	41.3	3.7
March	14.8	7.7	68	9.5	52.4	4.3	68.9	3.9
April	18.0	10.8	68	10.9	109.0	8.2	87.0	5.1
May	18.6	12.9	82	15.6	187.1	14.2	83.4	3.9
June	19.3	14.7	89	18.5	522.3	20.6	71.4	3.7
July	19.8	15.4	91	19.2	712.9	25.8	70.5	2.9
August	19.8	15.4	87	18.3	572.5	23.8	70.7	3.3
Sept.	19.9	14.6	86	17.6	418.5	17.4	63.0	2.7
October	18.6	11.5	75	13.5	116.1	5.2	60.8	2.3
November	15.3	7.4	68	9.1	14.2	1.0	42.2	1.9
December	11.9	4.4	72	7.4	5.0	0.6	31.4	1.8
Annual	16.4	10.2	77	12.9	2758.4	125.1	722.7	3.1
Total/ Mean								

B. Station: JALPAIGURI (26°32' N, 88°43' E); altitude: 83 m; climate: Per-humid (Plain ecosystem)

Jan.	23.4	10.8	87	13.3	9.2	0.9	55.2	3.3
Feb.	25.2	12.7	82	14.5	13.5	1.4	74.3	4.1
March	29.6	16.4	69	16.8	30.0	2.3	125.7	6.1
April	31.6	20.4	68	21.1	115.2	5.3	151.8	7.9
May	30.9	22.9	80	27.0	339.7	14.0	144.9	8.4
June	30.6	24.3	87	30.3	710.0	20.7	123.7	7.2
July	30.6	25.0	88	31.7	776.1	21.5	117.5	6.5
August	30.8	24.9	87	31.6	662.8	19.9	118.2	5.7
Sept.	30.7	24.4	87	30.3	536.9	15.9	105.2	5.1
October	30.0	21.4	72	25.4	143.1	5.9	105.2	5.1
November	27.7	16.2	66	20.1	13.5	0.7	73.7	3.2
December	25.0	22.1	86	14.5	2.7	0.2	53.9	2.9
Annual	28.8	19.3	82	22.9	3352.7	108.7	1250.0	5.4
Total/ Mean								

C. Station: BAHARAMPUR (24°08'N, 88°16' E); altitude: 19 m; climate: Moist Subhumid

Month	Mean Air Temperature °C		Humidity (%)		Rainfall		Potential Evapotranspiration (P.E) (mm)	Mean Wind speed (Km.hr ⁻¹)
	Daily Max.	Daily Min.	Relative Humidity	Vapour Pressure	Total (mm)	No. of rainy days		
Jan.	25.7	11.8	74	13.7	12.8	1.0	64.7	1.4
Feb.	28.4	13.7	67	14.5	19.1	1.6	82.3	1.9
March	34.1	18.4	57	17.6	17.6	1.7	133.5	3.1
April	37.6	23.1	61	24.3	37.3	2.7	164.7	4.9
May	37.1	24.7	72	30.4	114.6	6.6	185.5	6.9
June	34.5	26.0	80	33.2	218.7	12.2	126.9	5.9
July	32.5	26.0	84	33.5	294.5	17.5	110.6	5.6
August	32.3	26.1	84	33.4	301.6	15.7	108.3	4.5
Sept.	32.8	25.8	81	32.9	226.4	12.2	104.2	3.7
October	32.8	23.3	76	28.2	126.6	5.8	109.5	2.0
November	29.4	17.4	72	19.3	15.8	1.0	81.6	1.3
December	26.4	13.1	74	14.8	3.9	0.3	61.8	1.3
Annual Total/ Mean	31.9	20.8	73	24.7	1388.9	78.3	1333.0	3.5

D. Station: ASANSOL (23°41'N, 86°59' E); altitude: 126 m; climate: Dry subhumid

Jan.	25.7	12.2	67	12.3	16.6	1.3	77.4	5.3
Feb.	28.3	14.7	62	13.6	24.3	2.2	98.2	6.2
March	34.2	19.6	47	15.3	17.3	1.8	155.2	7.2
April	38.5	23.8	48	19.8	23.9	1.3	187.5	8.2
May	39.1	26.3	62	27.7	73.0	4.8	207.6	8.9
June	36.1	26.4	74	31.6	192.4	7.3	146.6	8.6
July	32.0	25.6	84	32.5	344.4	18.2	111.7	8.1
August	31.6	25.5	86	32.6	335.3	17.6	104.2	7.3
Sept.	31.9	25.3	83	32.1	234.8	11.4	105.3	6.2
October	31.4	22.2	77	26.2	112.9	3.4	112.8	4.8
November	29.0	16.1	69	17.2	14.8	1.0	88.5	4.8
December	26.2	12.4	67	13.1	2.5	0.2	72.5	5.3
Annual Total/ Mean	32.0	20.8	69	22.8	1392.2	72.5	1468.2	6.7

Source: Meteorological Dept. (GOI).

Distribution of soils under dominant phases

Sl. No.	MAPPING UNIT (SOIL ASSOCIATION NO.)*	DESCRIPTION	AREA (HA)	PERCENT-AGE OF MAPPED AREA	REMARKS*
SLOPE CLASS:-					
1.	W008, W009, W010, W011, W012, W013, W014, W017, W018, W019, W020, W021, W022, W023, W025, W026, W027, W028, W029, W030, W031, W033, W034, W035, W036, W037, W038, W039, W040, W041, W042, W044, W045, W047, W048, W049, W050, W051, W052, W053, W054, W055, W056, W057, W058, W059, W060, W061, W062, W066, W070, W075, W076, W077, W078, W079, W080, W081, W082, W083, W084, W085, W086, W087, W088, W089, W090	Level-nearly level	5271822	59.4	SLOPE (Column 16) Code Class a Level to nearly level (0-1%) b Very gently sloping (1-3%) c Gently sloping (3-8%)
2.	W006, W007, W015, W016, W024, W032, W072, W091, W094, W096, W097, W098, W099, W101, W102, W103, W115	Very gently sloping	1697354	19.1	d Moderately sloping (8-15%)
3.	W073, W092, W093, W095, W100, W104, W108, W109, W110, W114	Gently sloping	300354	3.4	e Moderately steep sloping (15-30%)
4.	W005, W071	Gently sloping-very gently sloping	34823	0.4	f Steeply sloping (30-50%)
5.	W043, W046, W063, W064, W065, W067, W068, W069	Very gently sloping-level-Nearly level	1115208	12.6	g Very steeply sloping (>50%)
6.	W074	Mod. sloping	4357	0.1	
7.	W002, W003	Steeply sloping-mod. steeply sloping	131346	1.5	
8.	W004	Steeply sloping	40985	0.5	
9.	W001	Very steeply sloping	20493	0.2	

Sl. No.	MAPPING UNIT (SOIL ASSOCIATION NO.)*	DESCRIPTION	AREA (HA)	PERCENT-AGE OF MAPPED AREA	REMARKS*
SURFACE TEXTURE CLASS:					
					SURFACE TEXTURE (Column 15) <u>Code</u> <u>Class</u>
1.	W037, W042, W049, W077, W080, W083, W084, W085, W089	Clayey	621580	7.0	C Clayey
2.	W021, W036, W038, W039, W044, W045, W047, W048, W052, W054, W056, W058, W072, W078, W081, W088	Clayey-Loamy	1513214	17.0	L Loamy GL Gravelly loamy
3.	W075	Clayey-Sandy	3015	0.03	S Sandy
4.	W006, W007, W008, W009, W010, W011, W012, W013, W014, W015, W016, W017, W018, W019, W020, W022, W023, W024, W025, W026, W027, W028, W029, W030, W031, W032, W033, W034, W035, W040, W041, W043, W046, W050, W051, W053, W055, W057, W059, W060, W061, W062, W063, W064, W066, W067, W068, W069, W070, W071, W079, W082, W086, W087, W090, W091, W094, W098, W100, W101, W102, W103, W104, W109, W110, W111, W112, W113, W114, W115	Loamy	5638215	64.0	
5.	W002, W003, W004, W005, W092, W093, W095, W096, W099, W108, W113, W114, W115	Gravelly Loamy-Loamy	629205	7.0	
6.	W001, W105, W109	Gravelly loamy	45503	0.5	
7.	W065, W076	Loamy-sandy	157295	1.7	
8.	W073, W074	Sandy	8713	0.1	

Sl. No.	MAPPING UNIT (SOIL ASSOCIATION NO.)*	DESCRIPTION	AREA (HA)	PERCENT-AGE OF MAPPED AREA	REMARKS*
SOIL SALINITY CLASS:					
					SALINITY (Column 18) $\frac{EC_e}{\text{Class}}$ (dS m^{-1})
1.	W090	Very strong-strong (S4e-S31)	302225	3.4	
2.	W073, W087	Strong (S3m)	6970	0.1	S1 Slight (2-4)
3.	W088	Moderate (S2m-S21)	78178	0.9	S2 Moderate (4-8)
4.	W077, W078	Moderate-Slight (S2m-S11)	165342	1.9	S3 Strong (8-15)
5.	W079, W080	Moderate-Slight (S21-S11)	265161	3.0	S4 Very strong (15-25)
6.	W075, W076, W089	Moderate (S21)	36043	0.4	Extent:
7.	W074	Slight (S11)	4357	0.1	l limited (< 1/3 area covered) m moderate (1/3-2/3 area covered) e extensive (>2/3 area covered)

Sl. No.	MAPPING UNIT (SOIL ASSOCIATION NO.)*	DESCRIPTION	AREA (HA)	PERCENT-AGE OF MAPPED AREA	REMARKS*
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SURFACE FLOODING CLASS:

FLOODING (Column 20)

Code Class

1.	W010, W011, W012, W014, W016, W019, W021, W022, W025, W035, W044, W045, W046, W050, W051, W052, W053, W054, W055, W057, W059, W060, W061, W062, W063, W064, W065, W066, W075, W076, W077, W078, W081, W086	Moderate	2261039	26.2	1 Moderate 2 Severe
2.	W047, W049, W056, W058, W079, W080, W082, W083, W084, W085, W087, W088, W089, W090	Severe	1382540	16.0	

EROSION CLASS:

EROSION (Column 17)

Code Class

1.	W069, W111	Slight	299431	3.4	1 Slight
2.	W005, W028, W067, W068	Moderate-slight	546248	6.1	2 Moderate
3.	W004, W006, W007, W016, W024, W033, W064, W065, W071, W072, W094, W095, W096, W097, W098, W098, W099, W101, W102, W103, W105, W106, W107, W108, W112, W113, W114, W115	Moderate	1906308	21.5	3 Severe
4.	W003	Moderate-severe	20896	0.3	
5.	W002, W091	Severe-moderate	147897	1.7	
6.	W001, W073, W074, W092, W093, W104, W109, W110	Severe	123378	1.4	

(* "Field Manual, NBSS Publ., Sehgal et al. 1987)

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- o Agro-ecological Zones - Statewise
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