CHAPTER - I

BASELINE STUDIES ON THE SUNDARBANS

1.0 INTRODUCTION

The Sundarbans is situated on the seafront of the largest delta of the world bestowed with wide range of natural resources. It has been internationally recognised for the largest concentration of mangrove and thus has become a unique and one of the most productive ecosystems in the world. The inter-tidal region of the Sundarbans delta has been designated as biosphere having biodiversity endowed with many endangered plant and animal species. It is the only Mangrove tigerland on the globe, largest nursery for fish and shell fish, mangrove reserve with largest diversity in species. It is one of the breeding ground of "ridley turtles". The local population, though considered as an integral part of this biosphere reserve are continuously exploiting various forest, aquatic and agro-resources of the Sundarbans over the years for their sustenance. This anthropogenic interference results in continuous exploitation and degradation of these resources of the Sundarbans. Consequently, being an endangered zone it now awaits longterm conservation and wise use of its resources for a sustainable development. Keeping this in view, this study attempts to seek a solution for resource management in the Sundarban region in its ecological framework.
1.0.1 SUSTAINABLE DEVELOPMENT

The Earth summit held at Rio de Janeiro, Brazil in 1992 reemphasised the need for sustainable development, a term perhaps first used at the time of Cocoyoc declaration in 1970 and gained popularity through IUCN report (1980, 1990) and WCED report (1987) – "Our Common Future". Since 1980's, particularly after the publication of the report “Our Common Future"- a good many literatures are devoted to deal with the concept of sustainable development and it's possible application. (Chattopadhyay 1998)

The Rio declaration implicitly defines sustainable development as “to equitably meet developmental and environmental needs of present and future generations". By applying the word “equitably” to both present and future generations, the Rio definition more fully reflects the ideas presented in “Our Common Future". It establishes the twin principles of inter-generational and intra-generational equity as the two fundamental pillars of sustainable development, as envisaged by Rio Conference. (Lee and Karkpatrick ,2002).

Sustainable development can not be a static concept. It is a dynamic process, to be applied by different countries in tune with their own cultural, political and economic perspectives. A broad outline of sustainable development is as follows :-

i). It has to be a long-term and continuous process.

ii). It is based on equity and justice.
iii). It's approach is balanced and integrative.

iv). It has common goals but different routes.

v). It accepts Nature not only as a resource but also as the earthly womb for survival and development of mankind.


Sustainable development demands a change in our attitude towards Nature. Nature is not just a material resource for human consumption. Man is also a part of Nature. It is not the business of the government and private companies alone. It is the business of the people in general. It involves individuals, families, communities, corporate bodies, nations and global society. It has to be a movement because it involves paradigmatic change which is difficult to bring about unless great many people get involved. Sustainable development is a comprehensive term which involves paradigm change, change in the style of development, change in our attitude towards Nature and above all it involves political, social and ethical changes. Sustainable development can be looked from a variety of perspectives, such as environmental, economic, social, political, cultural and technological. None of these perspectives can stand alone. Sustainable development is possible if all of these are taken into consideration. (Misra, 1998).

In broad terms all these cover the following aspects :-

1. Survival of human being.
2. Survival of all other life forms.

3. Satisfaction of basic human needs.

4. Maintenance of bio-physical productivity.

5. Economic efficiency and growth.

6. Preservation of environmental quality and ecosystem.

7. Inter and intra-generational equity.

8. Social justice.


10. Stabilization of human population.


1.0.2 ENVIRONMENTAL SUSTAINABILITY

The term "environmental sustainability" is very much related to the idea of sustainable development. Actually it is a follow up concept of sustainable development. Environmental sustainability aims at ensuring the protection, conservation and better management of earth's natural resources. The idea is not to debar people from using these resources. It rather aims at such a pattern of use that these resources, particularly those which are so vital for human survival, are neither exhausted nor polluted nor destroyed. This would
require a change in our attitude towards Nature and also towards what we call economic development. (Chattopadhyay, 1998).

The vast aquatic resources of the world famous biosphere reserve of the Sundarbans is being very quickly exhausted by human population in an unscientific and unplanned way during a long period. The existence of this vast resource-base is now at stake due to anthropogenic interference. The present study is thus aimed to find out a way towards the sustainable development of this environment. The study also attempts to provide a scientific Environmental Management Plan which would highlight such a pattern of use of this aquatic resources that these would neither be exhausted nor polluted nor destroyed. In this way, the study seeks a solution to maintain environmental sustainability in the ecological framework of the Sundarbans.

1.1 AREA OF STUDY

The Sundarban region covers an area of about 9518 sq. kms. approximately according to an estimate by the Sundarban Planning Region. The area comprises the districts of South and North 24 Parganas in West Bengal of India and the districts of Khulna and Bakharganj in Bangladesh. However, the study area is confined to the part of the Sundarbans in the Indian territory covering 13 police stations of the district of South 24 Parganas and 6 police stations of the district of North 24 Parganas (Table – 1).
<table>
<thead>
<tr>
<th>North 24 Parganas</th>
<th>South 24 Parganas</th>
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<tr>
<td>i. HINGALGANJ</td>
<td>i. SAGAR</td>
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<td>ii. HASNABAD</td>
<td>ii. JOYNAGAR – I</td>
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<td>iii. HAROA</td>
<td>iii. JOYNAGAR – II</td>
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<td>iv. SANDESHKHALI – I</td>
<td>iv. CANNING – I</td>
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<td>v. SANDESHKHALI – II</td>
<td>v. CANNING – II</td>
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<td>vi. MINAKHAN</td>
<td>vi. NAMKHANA</td>
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<td>vii. BASANTI</td>
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<td>viii. GOSABA</td>
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<td>ix. KAKDWIP</td>
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<td>x. KULTALI</td>
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<td>xi. PATHARPRATIMA</td>
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<td>xii. MATHURAPUR – I</td>
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<td>xiii. MATHURAPUR – II</td>
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1.2 DELINEATION OF SUNDARBAN REGION

M/s Dampier and Hodges completed a survey on the Sundarbans within the period between 1822 and 1830. By 1830 they demarcated the tract of the Sundarbans as a special forest region and delimited the northern or landward boundary of the forest area by an imaginary line known as the "Dampier & Hodges Line". According to this delineation the forest falling to the south of this line comprises an area of about 71885 sq. kms. of undivided India and an area of about 7908 sq. kms. out of 71885 sq. kms. is included in the 24 Parganas district of West Bengal within Indian territory. But as per a modified northern limit by the Sundarban Planning Region, the Sundarban region occupies an area of about 9518 sq. kms. It includes the entire police stations instead of their parts.

1.3 LOCATION

The location of the Sundarbans, both geodetic and geomorphic is itself an important determinant of its physical and social characteristics.

The geodetic location of the Indian part of the Sundarbans stretches from 21°30'N to 22°39'N latitudes and from 88°5'E to 89°9'E longitudes, further East extends the Sundarbans region of Bangladesh.

The tract of the Sundarbans lying in the southern part of West Bengal is actually a group of estuarine islands which is geographically located at the large extensive delta-face of the Ganga-Bhagirathi system. The total area of the Sundarbans of about 7908 sq. kms. is delineated by Dampier & Hodges.
1.4 GEOGRAPHICAL BACKGROUND OF THE SUNDARBANS

1.4.1 CLIMATE

The climate of the Sundarban region is characterised by Humid Tropical Monsoon climate or Aw type of climate as per the climatic classification by Trewartha. This typically monsoon type of climate is characterised by an average annual rainfall of about 180 cm., 88 per cent of which is associated with S.W. monsoon occurring between June and September.

Extreme climatic condition does not prevail in the Sundarbans because the network of creeks and rivers and the nearness of the Bay help in controlling the extreme climate. A typical and tropical monsoon climate with excess of humidity is prevalent for about 6 months with moderately warm, equitable and humid days and slow rise in night temperature. In this region, the cold weather prevails from November to February. Temperature ranges between 15°C or 16°C in January and 35°C - 36°C in April. Rainfall during winter is very negligible. The region experiences cool and dry winter. The temperature starts to rise from February. March and April are comparatively dry.
Occasional thunderstorm accompanied by rain occur from April. The incidences of cyclonic storms are common during the pre-monsoon period in April-May and also during the post-monsoon period in October-November. Cyclones cause high waves combined with high tides frequently causing devastation to the area. Rainfall is of monsoon type. The monsoon generally starts from the middle of June and continues till October. The mean temperature slowly decreases during the rainy season but humidity goes up to 96 per cent.

As the Sundarbans wholly lies on the tropics, winter is cool but never cold, summer is warm but the day temperature rarely goes beyond 31.2°C. The presence of large quantity of moisture in the air makes the weather extremely sultry in sheltered places or when there is hush in the breeze.

Humidity for this tract is very high, upto 96 per cent. Frequent cyclones and unfavourable tectonic and geodynamic problems prevail in this area. Every year 4-5 cyclonic storms are common in the lower Gangetic delta. (Naskar & Guha Bakshi, 1987).

### 1.4.2 GEOMORPHOLOGY

Being a group of estuarian islands the Sundarban has its location at the large extensive delta-face of the river Ganga-Bhagirathi. The region is entirely influenced by both riverine and marine geomorphic processes. Geologically the Sundarban region is characterised by very thick deposition of
riverine as well as marine alluvium through years, with a monotonously flat and low marshy surface featured by mudflats.

The land character of the Sundarbans derives from the natural processes of delta building as well as human intervention upon such process.

1.4.2.1 GENETIC ASPECT

The extensive estuarine tracts of the Sundarbans was built up by the continuous deposition of sediments brought down by the river Ganga from the Himalayan region. The delta building process is thought to be still going on by numerous distributaries and link channels of the Ganga-Bhagirathi system. The continuous deposition of sediments gives rise to the development of an almost flat surface built up of very thick layers of alluvium. The northern moribund deltaic region is characterised by the older alluvium whereas the southern active deltaic portions by newer alluvium. The resultant soil cover of the Sundarban is mostly a very fertile clayey or silty loam with saline nature.

1.4.2.1.1 DELTA BUILDING PROCESS

The major portion of Bengal is deltaic whereas the Sundarbans occupies the delta-face. The land of Bengal was built up and gradually raised through centuries by the silt carried by the rivers mainly from the Himalayas and partly from the Chotta-Nagpur and Santhal Parganas hills. The Ganges which is the principal delta builder, functioned in that early age and is still functioning in building the land in raising and extending it towards the sea. The process of raising and extension of the delta towards the sea will
probably continue for an indefinite period as the stock of building materials, i.e., detritus, carried with the rainfall over thousands of sq. miles of catchment area including a considerable portion of the Himalayas is almost unlimited. (Majumdar, 1942).

Millions of tons of silt are thus being transported every year by the strong current of the Ganges flood and brought down to its mouth. Here the current is checked by coming in contact with the sea and the silt in suspension drops into bed. Land was thus formed at the head of the delta and it began to approach the sea. Several diverging branches enclosing and intersecting the already built delta have helped in raising the land in the quickest possible time and extending it towards the sea in ever-increasing width. Each branch carried silt-laden flood and as both the banks were low to start with, it was inundated during floods. Consequently the silt carried in suspension dropped on the bank which was thus gradually raised. The raising was more rapid near the river.

If the task of raising the delta was left entirely to the carriers of upland floods, the process would have been exceedingly slow. Because these floods can only be expected during the monsoon months, i.e., only in four out of twelve months every year. Therefore, it is the work of Nature that the tides are also assisting this delta building process. Tides flow up these rivers with strong velocity twice daily throughout the year and as there is a vast reservoir of unconsolidated silt at these river mouths deposited by the upland floods
during monsoon months, the tides pick up such silt almost to the saturation point on their way inland. So long as the banks of these rivers within tidal limits are below high tide level and the rivers are free to spill, the silt laden tides perform exactly the same function as the upland flood carriers, i.e., raising of the delta. The difference is that while the upland flood carriers function only during the actual flood in the monsoon, the beneficial activity of the tides continues throughout the year.

The second function of the tides is to fill up the interiors of the delta lying between the upland flood carriers. The depth of the silt deposited by upland floods or by the tides is the maximum close to the river banks where the velocity determining the proportion of silt, is first checked. As the spilling proceeds away from the river banks the silt content of the water and the depth of the silt deposit is less and less. Now, if nature had to depend entirely on this agency, the area lying midway between the continuous upland flood carriers would have remained low, probably in the shape of the creeks extending from the sea, till these rivers would burst through these banks and divert along these low valleys. This would have been a slow process and to facilitate the work of delta building, here also Nature appoints the tides. The tides, picking up the silt on their way up these creeks on tidal rivers, gradually raise their beds and banks until they are raised up to high tide level and rendered fit for cultivation. The source of this silt supply is no doubt what has been carried to the sea by the upland floods for ages, but tides, by their constant movement, keep it in an unconsolidated state and distribute it all
along the delta-face between the two main estuaries, i.e. those of the Hooghly and the Raimangal.

It would be clear now that Nature has been employing both the agents, i.e. the upland flood carriers and the tides in her work of delta building. She has been assisted in her task by two favourable factors: (1) The steep slope of the Himalayas, the highest mountain of the world which has been furnishing the building material in abundance during the monsoon months and (2) the abnormally high tidal range, due to the funnel shape of the Bay of Bengal, which has been helping in distributing these materials twice daily throughout the year. But though the abnormal tidal range at the delta-face has been so helpful in raising the delta, it has stood in the way of rapid extension of the delta towards the sea. Because of high tidal range more and more of the alluvium, brought down into the sea is being dispersed along the delta-face, to be picked up by the tides travelling inland through innumerable tidal channels. As a result, less and less alluviums are deposited in a consolidated state to extend the delta. (Majumdar, 1942).

1.4.2.2. MICRO-RELIEF FEATURES

In a deltaic tract with a long coastline relief features cannot but be very gentle. The topography of the Sundarban region is not an exception to this rule, though minor topographical contrasts are noticeable throughout the district. The whole area consists of one vast plain, gently sloping seaward. It is traversed by low ridges formed either by river deposits (natural levees) or of artificially built-up road and railway embankments. The interfluve area in the
north is invariably studded with shallow lakes which are gradually silting up. The entire surface of the district including the embankments lies below 10m. contour. (Chatterjee, 1998).

Larger part of the districts of North 24 Parganas and South 24 Parganas is included within the Sundarban region, as per the Dampier Hodges Line. The entire Sundarban region may be divided into three parts based on the degree of land utilization: a) The Northern Plains of the Sundarbans, b) The reclaimed Sundarban c) Sundarban Forest. The Northern plains of the Sundarbans have been settled so long ago that they retain very few traces of reclamation, except in the east. The western part of this plain was settled much earlier than the eastern. This plain may be further divided into three parts, the Hasnabad Plain in the east, the Haroa Plain in the middle and the Bhangar-Rajarhat Plain in the west. The characteristic features of reclamation are clearly visible in the Plains of Sagar and Kakdwip in the west and those of Canning and Sandeshkhali in the east. These reclaimed plains have been cleared of forests and now under plough. (Chatterjee, 1998). A larger part of the Hasnabad plain and Haroa Plain is occupied by a number of large bills. e.g - Goabaria bill in Haroa block. Most of these bills are found to be merged with the surrounding lowlying paddy fields forming extensive bheries or wet lands. A unique relief feature of this northern plains of the Sundarban is extensive wetlands very recently converted into big saline bheries with highly profitable fish cum paddy cultivation. Moreover, hectors after hectors of low-lying bilan or paddy fields
have been transformed into huge bheries. These wetlands and bheries are mainly found in the blocks of Haroa, Minakhan, Sandeshkhali I and II and Hasnabad. This almost flat monotonous surface of the northern plain has micro-relief variations which are caused by natural levees, river meanders, ox-bow lakes and low-lying marshes enclosed by them. A large ox-bow lake is found near Dharambaria in Hasnabad block created by the river Dhansa. An important river meander is also found near Baman Pukuria in Minakhan block, created by the river Bidyadhar.

A large part of the Sundarbans, particularly in the district of South 24 Parganas has been reclaimed for cultivation. This part is characterised by the expanse of arable land with a number of patches of large swampy or marshy areas. A few important swamps are a) Patikhai-Bagmari area in Canning II block, adjacent to the river Matla, b) Ramchanderkhali Abad in Basanti Block, adjacent to river Bidya, c) near Madhabpur in Kultali block adjacent to river Thakuran etc. This reclaimed part of the Sundarbans is also featured by dispersed pattern of settlements having the locations of human habitation far away from each other with the expanse of arable land in between them.

The remaining part of the Sundarbans still awaits development which is heavily forested. The reserved and protected forests of the Sundarbans covers more than one-third of the district. This southern most part of the Sundarbans has extremely low, monotonously flat relief, gently slopping towards the Bay of Bengal, studded with innumerable tidal rivers, creeks and
estuaries. A number of islands with rather steep edges are found which represent southern extension of the delta-face and have not yet been united with the main land. They lie near the mouths of the Hooghly, Matla, Saptamukhi, Bhangaduni and other rivers of the Sundarbans. Among these islands Sagar and Lothian islands towards the west, Bulcheri, Dalhousie, Bhangaduni islands, New Moore (Purbasha) island in the extreme east are very important.

1.4.3 RIVER SYSTEMS

The Sundarban area is characterised by unstable land intersected by a network of big tidal rivers, estuaries which penetrate far inland. The watercourses of these rivers are shifting and ill-defined in nature. Here the rivers flow not in a single channel, but in a multitude of anastomozing channels which under normal conditions raise the level of the land through which they flow. Apart from the rivers along the eastward boundary like Ichhamati-Kalindi-Rajmangal, there are several other major channels flowing through the middle of the Sundarbans from North to South, covering an area of about 300 square miles. These rivers are: the Bartala Creek, Saptamukhi, Thakuran, Matla, Gosaba, Bidya, Harinbanga, Haroagang, Kultigang, Kalagachhia, etc. The Sundarbans has been built up by the delta-building process run by all these rivers.

The rivers helping in the formation of the Sundarban delta area can be grouped into three types, such as :-
a) **Primary Delta Builders** – (Group-I)- These rivers originate from the Himalayas, maintaining more or less perennial flow and navigable at least in their lower reaches, namely – 1) the Ganga and its distributaries, 2) the Bramhaputra 3) the Meghna,

b) **Primary Delta Builders** – (Group – II) - These rivers are originating from the low hills of Chhota-Nagpur and South 24 Parganas, namely :- Damodar, Ajay, More, Cossye etc.

c) **Tidal rivers** - (group – III) :- These rivers are subsidiary delta builders. Mainly the lower reaches of the rivers of group – I and group – II within tidal limits are tidal rivers. As explained earlier, their beneficient activities of raising, fertilising and draining the lower portion of the delta is found throughout the year. (Majumdar, 1942).

In lower reaches these channels of group – I and group – II are tidal. Their condition is not so bad except where free tidal flushing of their spill areas has been interfered with by premature reclamation and they are still continuing their beneficient activities. Apart from this, these rivers both the upland flood carriers and the tidal channels perform the most important function of delta building. The main volume of the Ganges used to flow down the Bhagirathi-Hooghly until about the end of the 15th century. The Jamuna which was a branch of this main stream along with its channels the Nowie, Sunti, Nonagong, Bidhydhari, Piyali and others were responsible for building up a large portion of the Sundarbans. All these rivers have now been
deprived off its upland water carrying silt except the rivers Hooghly and Ichhamati only during the rainy season to some extent. These rivers have become tidal channels and these are the only agencies now left by which the lower portion of Bengal can be raised and become fit for human habitation. Thus the new land formation is dependant wholly on the tidal action.

But this process of raising land was unfortunately disturbed by premature reclamation by the building up of marginal embankments and due to this the delta building activity by these tidal rivers has been ceased for ever. The embankments have prevented the silt-laden water at flow-tide from spilling over the land on either side. Consequently the level of the land has remained low while the silt in the water has remained confined within the riverbed. Ultimately the rivers become chocked, cease to function and most of the land remains swampy, unfit for human habitation, ready to be converted into jungles. With the rise in the riverbeds, there is a corresponding rise in the level of the flood at flow tide which seeks to find new passage and exerts increasing pressure on the embankments. These embankments are progressively weakened and frequently breached for this reason. This leads to lack of consolidation of the land surface and the shifting character of the numerous watercourses. Without the supply of upland water land formation can never proceed above the level of the high tide. Further deposits of silt could only come from spill action of silt laden headwaters and the unrestricted spread of tidal spill over embanked land.
To have an idea about the physical characteristics of tidal rivers may be out of context here. The energy which creates the tidal flow, i.e., the attraction of the Sun and the Moon in the deep sea is very limited and is manifested partly as potential energy, i.e., the rise in tide level and partly as kinetic energy i.e., the velocity of the flow. The former causes the tidal flow up the rivers and the latter determines its power of transporting silt. As the velocity of tide, when it enters the mouth of the tidal rivers, is high and as there is a vast reservoir of unconsolidated silt in suspension along the delta face, the tide is highly charged with silt while flowing up these rivers. It is generally observed that the duration of ebb tide in a tidal river is much longer than that of the flow tide. As the same quantity of water must ebb out as flowed in, it, therefore, follows that the average velocity of ‘ebb’ is less than that of the ‘flow’. Now the capacity of water to transport silt depends on its velocity. It, therefore, follows that the ebb tide is generally unable to transport back fully the silt that has been carried up these tidal rivers by the ‘flow tide’. Even a slight deposition of silt will go on accumulating as the tides function twice daily throughout the year and the channel will begin to deteriorate. The deterioration would impede the propagation of tidal wave which would cause further deterioration and the vicious cycle would continue till the channel is completely dead. Thus, to maintain the life of tidal rivers, what is necessary is an additional supply of water not saturated with silt, which has reserved the capacity to pick up more silt to supplement the tidal flow during ‘ebb’ so that it
can scour out fully the silt admitted into the river by the flood tide (Majumdar, 1942).

Before the diversion of Ganges flood through the Padma, the Jamuna constituted one of the main branches of the Ganges taking off at Tribeni, through which flood used to flow down to the sea. The Jamuna and Padma, two powerful rivers of this region used to flow southward before joining the Ichhamati. Now the Jamuna, flows sluggishly eastward into the Ichhamati and its former catchment basin completely water-logged. The Padma is also equally sluggish and its former course can be traced by connecting a number of alluvial lakes which are locally known as Padma Bills. The Bidyadhari was an important spill channel of Jamuna which performed the task of raising the delta just to the east of the areas near Calcutta. Channels connecting Bidyadhari with the Jamuna in olden days, such as Nowi, Sunti, Nonagong, etc. can still be traced reaching within a few of the present abandoned courses of the Jamuna. Silt ing up of these natural drainage channels has given rise to marshy lands in the entire northern part of the Sundarbans, particularly in a large part of North 24 Parganas and rendered them agriculturally productive. Moreover, the water -hyacinth, an obnoxious weed interferes with the proper utilisation of the sluggish streams, marshes and tanks as bheries. (Chatterjee, 1946).
Thus gradual drying up due to heavy siltation, as well as frequent shifting of water courses have ultimately made these important rivers of northern part of the Sundarbans completely sluggish. As a result northern part is at present dominated by large extensive marshy, swampy lands, already converted into big *bheries* for commercial prawn culture. The blocks of Minakhan, Hasnabad, Haroa, Sandeshkhali I and II of Northern Sundarbans are now exhibiting large scale *bheri* culture taking the benefit of poor drainage system of the local rivers.

1.4.4 LANDUSE

A broad pattern of landuse in different Police Station of the Sundarbans can be known to us mainly from the secondary source of information, i.e., Census Handbook. As per Census Handbook 1991 the landuse pattern has been noted in (Fig. – 1). (data in Annexure -1)

In the Sundarban region comparatively smaller area is found under cultivation. The irrigated areas are having the facility of production of two crops in a year, mainly "Kharif" crop during monsoon and "Rabi" crops during winter. But a larger area (48%) under cultivation is left unirrigated. Absence of irrigation facility is an important feature of agriculture in the sundarban region. The production of only one crop of paddy is found in these large areas under cultivation. Thus, paddy mono-cropping dominates the agriculture of the Sundarbans. But mono-cropping engages the large agricultural areas of the Sundarbans for only one growing season of six
PATTERN OF LAND USE IN THE SUNDARBANS, 1991

10644.39 hectares
294076.08 hectares
267490.95 hectares
25632.96 hectares
7291.69 hectares

FORREST
IRRIGATED
UNIRRIGATED
CULTURABLE WASTE (GAUCHER & GROVES)
AREA NOT AVAILABLE FOR CULTIVATION

7291.69 hectares
25632.96 hectares
294076.08 hectares
10644.39 hectares
months of "monsoon" and consequently, these fields remain fallow for the rest of the year. 44% (approximately) of the total area of the Sundarbans has been shown here in fifth category under the "area not available for cultivation".

1.4.5 SOIL

The entire coastal strip of India including the Sundarban delta contains mostly saline soil. The saline soil strip of the Sundarban delta ranges about 50 km from the Bay covering the low-lying lands, estuaries and the islands. No systematic soil survey has been undertaken in this coastal area as most of the coastal saline soil has been fallen under the mangrove vegetation along with dense impenetrable forest. Poonamperuma and Bandyopadhyay (1980) stated that the saline coastal soil is more than 3.1 million hectares as many of such mangrove soils are not mapped properly.

In this estuarine group of islands marine as well as riverine geomorphic process has given rise to the development of extremely saline clayey soil. Excessively high salinity and sticky texture of the regional alluvial soil restricts the percentage of soil air and thus hinders the entry of the roots of vegetation at the depth. Resultantly no vegetation other than mangroves with their airroots (pneumatophores) can survive in this particular soil of the Sundarbans.
Yadav et. al. (1983) have pointed out the following areas under the Sundarban saline soil like Hasnabad, Sandeshkhali I, II, Hingalganj, Gosaba, Bhanigar I, II, Canning I, II, Basanti, Joynagar I, II, Kultali, Magrahat I, II, Diamond Harbour I, II, Mandirbazar, Kulpi, Mathurapur I, II, Patharpratima, Kakdwip, Namkhana, Sagar and adjacent islands. The dense forest areas are suspected to surely possess higher salinity.

The Sundarbans saline soils are considered responsible for higher plant mortality and white salt crusts are very often visible on the surface soil. The salinity reaches maximum in the middle of May and decreases when the Monsoon starts. The electrical conductivity of the surface soil reaches upto 40 mmhos / cm and sometime more. But in the substratum the ECL values generally range between 6 and 10 mmhos / cm. (Yadav, et. al, 1981). The salt contents are mostly chlorides and sulphates of sodium, calcium and magnesium. Though bicarbonate salts are present in traces, the carbonate salts are absent there. The dominance of sodium and magnesium in the form of solution and exchange phases alongwith silty clay to clay loam make the soil sticky in water and hard with wider cracks when dry. The soil is slightly acidic to slightly alkaline (pH 5.4 to 7.8) in reaction. The soil is fairly fertile in regard to available plant nutrients. The original clays are rich in magnesium and calcium and the micronutrients are also higher in dozes which occasionally encounter toxicity during rabi cultivation (Yadav, et al, 1981).
Table - 2

SOIL COMPOSITION OF SUNDARBAN DELTA (Yadav et al, 1981)

<table>
<thead>
<tr>
<th>SOIL TEXTURE</th>
<th>Silty clay (Sand 10%, salt 51.2%, clay 38.8%)</th>
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</thead>
<tbody>
<tr>
<td>AVAILABLE POTASH</td>
<td>45.0 kg/ha</td>
</tr>
<tr>
<td>AVAILABLE PHOSPHORUS (OLSEN’S P)</td>
<td>22.5 kg / ha</td>
</tr>
<tr>
<td>ORGANIC CARBON</td>
<td>0.98 %</td>
</tr>
<tr>
<td>ZINC</td>
<td>1.0 ppm</td>
</tr>
<tr>
<td>BORON</td>
<td>0.5 ppm</td>
</tr>
</tbody>
</table>

The soil of the Sundarban proper is devoid of humus (0.98%) and supports tangled mass of tropical mangrove vegetation growing down to the water edge and flooded by high tides. The surface soils are constituted of decaying mollusces, annelids larvae and exeeviiae of insects and occasionally decomposed plant parts. These soils are found on the islands facing the Bay and many other degraded places on the surface. Sand occurs only along the sea-face when the strength of the tides and the roughness of water are more which prevent the fine particles from setting. (Naskar & Guha Bakshi, 1987).

The soil in general is deficient of nitrogen as there is no humus deposition in that soil. The nitrogen ranges from 0.02 – 0.09 %, the sulphate
0.10 – 1.15% in the riverine and flat lands and 0.06 – 1.0 % in the low lands, potash varies from 0.3 – 1.0 %, calcium oxide 1.0 – 5.0 % in the both riverine and flat land (Anonymos, 1976).

The soil of the Sundarbans delta may be grouped into the following 4 main classes a) martial soil b) dorosa or balia soil c) dhap soil d) dhal soil.

In the submergence condition and with higher salinity the decomposition rate of the organic matter is less as the bacterial population in these areas in generally very poor (Gupta & Bajpai, 1974, Chakraborty, 1984). The organic matter decomposition of these tidal zones are carried out by some facultative and obligate anaerobic bacteria (Chattopadhyay, 1984). (Chattopadhyay and Chakraborty, 1980) differentiated the brackish water fish pond soil and the corresponding fresh water pond soil and they mentioned that nitrogen and carbon contents are less in brackish water soil, where the electrical conductivity, phosphorus and calcium carbonate are much high but the pH values are almost same in these two types of soils. (Naskar & Guha Bakshi, 1987).

1.4.6. FLORA

As the only resultant feature of highly saline and clayey soils and the regional climate with heavy concentration of monsoonal rainfall and extreme humidity, the well known mangrove forest of the Sundarbans has been developed throughout the delta tract of West Bengal. The estuarine forests are ‘Halophytes’ that grow on swampy, clay, muddy and saline substratum.
Such forests in the Sundarbans have generated a fascination in the human mind. It is the largest single patch of estuarine forest, though cut up by countless rivers, creeks and waterways.

The name ‘Sundarbans’ came from the dominant species ‘Sundari’ in this forest. There is no humus on Sundarbans forest floor. The flat lands that grow higher and higher by silt deposition sometimes create large flaccid and shallow depressions known as ‘Maidan’ or blanks (saline blanks) where owing to the absence of inundation solar and aerial evaporation leads to concentration of salt. The status of such land is yet to be determined.

The mangrove forests are overgrown developed on the peculiar terrain (saline and mud and frequent inundation) which does not allow many species to flourish. The tree flora is primarily confined to Rhizophoraceae, Verbenaceae and Sonneratiaceae. Vivipary is one of the adaptations for the germination in Rhizophora, Bruquiera, Ceriops and Kandelia. Leaves are thick, coriaceous, have hydathodes, sunken stomata, aqueous tissue, mucilage-cells, long stone cells. Pneumatophores (breathing roots) are of various types and shapes. Kandelia does not have any. Ceriops have rounded, scaly, reddish one. Sonneratia apetala has small, xylocarpus has surface roots vertically flattened or have finger like projections, etc. Avicennia has asparagus like and sonneratia apetala has most well developed strong sharply pointed vertical woody dangerous breathing roots. The plant community manifest abnormal adaptations like Pneumatophores, stilt roots,
etc. These adaptations help the stems to erect against the turbulent current of streams and also help them in respiration. Classification of vegetation in the Sundarbans has been done as under:

1) Curtis in 1933 has classified the forest into 4 types:
   a) Salt water forest
   b) Mangrove forest
   c) Moderate Salt water Forest
   d) Fresh water forest

2) Champion and Seth (1958) has classified the forests into 5 types:
   a) Mangrove Scrub
   b) Mangrove forest
   c) Salt water Mixed forest (Heritiera)
   d) Brackish water Mixed forest (Heritiera)

Apart from the dominant species ‘Sundari’, this forest has many other species like garan, geona, garjan, dhundal, keora, hental, golpata, bain, tora, jadupalan, dhanigrass, nonaguri, kholsi, kankra, bakul, pasur, etc.
1.4.7 FAUNA

This forest is the natural habitat of a large number of animals like the magnificent Royal Bengal Tiger, spotted deer, wild bear in plenty with jungle cats, fishing cats, monkey, Indian fox, jackle, water monitor, monitor lizard, snakes, etc. Among aquatic fauna estuarine crocodiles, Batagur (River Terrapin), Marine turtles, tiger prawn, different types of crab, and a wide variety fish specially Hilsa, Bhātki, etc. are important.

The common birds seen in the Sundarbans are Little Egret, Open Billed Stork, Adjutant Stork, Smaller Pond, Heron, Purple Heron, Cattle Egret, Spotted Doves, Barhmini Kite, Rose Pecker, Bee Eater, Drongo, Pied Myna, Jungle Myna, Bulbul, Jailar Bird, Magpie, Robin, Sparrow, little Cormorant, etc.

Nowadays increasing human interference into the great Sundarbans mangrove forest has threatened the existence of a number of animal species. Various protective measures have been taken up by the administration for a number of endangered fauna of this forest. The International Union for Conservation of Nature and Natural Resources (IUCN) have taken up measures for the conservation of some endangered mangrove fauna like Batagur baska, Chelonia mydas, Lepidochelys olivacea, Python molurus, Bretmochelys Imbricata, Falcoperegrinus, Panthera tigris, P. Pardus, etc. Moreover, Tiger Reserve Project and Crocodile Breeding and Rearing Project have also conserved and protected the wild life of the Sundarbans specially the Royal Bengal Tiger, Chital Deer and estuarine Crocodile. These projects
are also looking after the breeding and conservation of many other endangered animal species like king crab, large sea-turtle, etc. (Naskar & Guha Bakshi, 1987).

1.4.8 POPULATION CHARACTER

The population character of the Sundarbans should be discussed not only in terms of the total population but also in terms of its spacial distribution and its occupational character.

1.4.8.1 SPATIAL DISTRIBUTION

The Sundarban region including six police stations of North 24 Parganas and Thirteen police stations of South 24 Parganas, has total population of about 2977910 in the year 1991, of which 821301 people in the areas of North 24 Parganas whereas 2156609 people in the areas of South 24 Parganas. In 1981 the total population of the Sundarbans was of about 2455370. The population of the part of the Sundarbans within North 24 Parganas was 565847 in 1981 which has become 821301 in 1991. Similarly, total population of the part of the Sundarbans within South 24 Parganas was 1889523 in the year 1981 which has become 2156609 in 1991 (Fig. No.- 2). (data in Annexure 1)

The distribution of population in different police stations of the Sundarbans is shown in Fig. No. 3 (data in Annexure 1). It depicts the highest number of population in Pathar Pratima among all police stations of the Sundarbans whereas the lowest number of population in Minakhan.
FIGURE 2

POPULATION OF THE SUNDARBANS IN 1981 & 1991

3500000
3000000
2500000
2000000
1500000
1000000
500000
0

POPULATION

1981
1991
FIGURE 3

POPULATION DISTRIBUTION IN DIFFERENT POLICE STATIONS OF THE SUNDARBANS, 1991

HAROA MINAKHAN HASNABAD HINGALGANJ
SANDESHKHALI - II JAYNAGAR - I JAYNAGAR - II KULTALI
SANDESHKHALI - I CANNING - I
SANDESHKHALI - II BASANTI SAGAR KAKDWIP
CANNING - II MATHURAPUR - I MATHURAPUR - II PATHARPATIMA NAMKHANA
MATHURAPUR - I GOSABA

35
1.4.8.2 BROAD OCCUPATIONAL PATTERN

As per 1991 census, broadly speaking, nearly 842429 persons out of 2977910 (total population) i.e. 28.28% is the total main workers of the entire Sundarban region. Among these total workers of the Sundarbans, 33703 persons are engaged into cultivation as the primary occupation. Cultivation is mainly found to be practiced in the reclaimed areas of the Sundarbans which is of mainly single crop of paddy. Besides agriculture, secondary occupation is fishing as well as Pisciculture, honey collection wood cutting, etc. These secondary occupations have absorbed 25870 persons in the entire Sundarbans. Tertiary occupation includes mainly the different types of industries which have absorbed 50687 working persons of the Sundarban region. An interesting feature of the occupational pattern of the Sundarbans is the existence of a sizable population of landless agricultural labourers, 308583 persons out of 842429 (total population) i.e. 36.63% of the total. (Fig. No.4) (data in Annexure 1).

The socio-economic status of the people of the Sundarbans is quite different from that of the other parts of West Bengal. The economy of the region is mainly agrarian which is found particularly in the reclaimed part of northern Sundarbans. The only important activity of the large reclaimed northern part is one crop agriculture which is very recently associated with highly profitable fish-cum-paddy cultivation and the most recent bheri culture. But the dominant economic activity of the larger Southern Sundarbans including the densely forested interiors is fishing, hunting and gathering.
FIGURE 4

Even in the agro-based northern part, quick thick growth of vegetation, extremely saline soil, frequent saline water intrusion into the paddy fields, availability of sweet water at an inaccessible depth, scarce irrigation facility, etc. restricts agricultural practice only within the rainy half of September-October of the year. Thus fishing, particularly the newly introduced bheri culture has become popular in the northern reclaimed areas for the other half of the year as the most important subsidiary occupation.

Another noticeable feature in the social-structure of the Sundarbans is the existence of a dominating percentage of Scheduled Cast and Scheduled Tribes. As per 1991 census, 1241367 persons constituting 41.7% of the total population of the Sundarbans belong to scheduled cast whereas 159084 persons constituting 5.34% of the total population belong to scheduled tribes (Fig. No. 5.).

As a consequence, the level of literacy as well as per capita income is much lower in the Sundarbans than in the other parts of West Bengal. As per 1991 census, 1207794 persons out of 2977910 persons of the Sundarbans are literates, constituting 40.6% of the total population. It is also reflected on the socio-economic backwardness of the Sundarbans. Thus major part of the population of the Sundarbans still remains well below the line of poverty. (Fig. No. 6).
FIGURE 5

SOCIAL STRUCTURE OF THE SUDARBAN POPULATION,
1991

GENERAL (1577459)

SCHEDULED CASTE
(1241367)

SCHEDULED TRIBE
(159084)
FIGURE 6

_PATTERN OF LITERACY IN THE SUNDARBANS 1991_

\[ 1947116 \]

\[ 1207794 \]

□ LITERATE  □ ILLITERATE
1.4.9 SUNDARBANS AS AN ECOSYSTEM

"Everywhere in this universe ecosystems exist at a wide of scales. Regardless of its scale, the ecosystem has a throughout of energy (Mather, 1986)*. Storage of solar energy through photosynthesis by the micro-plant materials and transfer of this energy through a series of organisms to reach the top position at the end of this chain occupied by man is the usual way of energy transfer.

This flow of energy through the chain of organisms is the key of survival of all global living species. Within each ecosystem many of these "FOOD CHAINS" are existing. Again a few food chains are found to be combined together to form one "FOOD WEB". However the physical life of man is sustained by this energy (Mather, 1986).

In a food chain the micro plant materials or the "primary producers" are in the first "TROPHIC LEVEL" whereas the second trophic level is formed by vegetarian animals and the higher trophic levels are occupied by non-vegetarian animals. Man belongs to the fag-end of the food-chain because he consumes both vegetables and animal matters. He can obtain energy from an animal that eats grass which hires energy from the sun or he may directly consume the crops or vegetables.

At each stage of food-chain, at each transfer of energy from one organism to another, there is a large loss of potential energy of about 80% to 90%. So in order to get more energy at the last stage occupied by man,
either the length of the food-chain must be shortened or more energy must be added to the base level of the food pyramid by increasing the number of micro plant and animal organisms as the primary producers. It means the broader the base of the food pyramid the more the energy at the top level consumer as man.

In fact, different types of eco-systems associated with different types of landuses supply varying amount of energy to the land in form of “net primary production” or NPP. Tropical rainforests have the highest NPP (2200 g/m²/yr. Dry matter) and desert and tundra the lowest (140 g/m²/yr. Dry matter). (Mather, 1986).

The mangrove in the Sundarbans signifies the special ecological effect due to the tidal ingress of the sea undeterred by upstream flow and plant community manifests abnormal adoption like pneumatophores, stilt roots, etc. It is an unique bio-climatic zone in a type of geographical situation along the coastal region of Bay of Bengal. This vast natural resources is internationally recognised for its wide bio-diversity of both mangrove flora and fauna as well as characteristic adoptability of their species.

The Sundarban is the only tigerland on the earth where tiger occupies pinnacle of the aquatic as well as forest foodwebs. The existence of mangrove eco-system on the land as well as in the water entitles 64 mangrove species in the Sundarbans whereas the other geographical provinces do not bear more than 20 species naturally. In this mangrove
ecosystem this extremely diverse plant and animal community depend on their symbiotic relationship. A diagram of this mangrove eco-system prevailing in the Sundarbans has been shown here to have an idea about the system. In the aquatic foodchain microscopic phytoplanktons are at the base of the food-pyramid as the primary producers or energy-fixers. From them the energy is to be transferred to mollusces, crustacea (shrimp, prawn, crab, seedlings of prawn) and various insects, viz, zooplanktons. In the next trophic level, birds, predator fish, large fish are surviving on mollusces, crustacea and insects. Snakes and water monitors are surviving on birds, and crocodiles are again surviving on watermonitors, predator fish and even on crustacea (shrimp, prawn, etc.), being at the top of the aquatic foodchain.

On the other hand, in the mangrove forest, forest foodchain is found where mangrove vegetation and detritus is the energy fixer at the base of the food-pyramid. From this primary producer, the energy is transferred to herbivores (deer, monkey, pig) through Chelonids found in the next-trophic level. Tigers occupying the top position of the pyramid are surviving on herbivores and chelonids.

But tigers are also surviving on crustacea, small and, large fish and water monitors from the aquatic foodweb. Again, lesser cats of the forest are taking predator fish, water monitor, etc. from water. Chelonids are eaten by water monitors. Even crocodiles are eating herbivores (deer, monkey, etc.) as an important food. Forest detritus is an important food item for crustacea,
FIGURE 7

MANGROVE FOOD WEB IN THE SUNDARBANS
mollusces and zoo planktons. In this way aquatic and forest foodwebs are closely related and co-existing in the Sundarban biosphere by the name of most complex form of "Mangrove Food web". If any component of this ecosystem is found missing by any means, the entire system would be collapsed in the long run. Indiscriminate destruction of mangrove vegetation and minute organisms like prawn seedlings, shrimp, etc. means gradual shortening of the base of this food pyramid. Due to this an increasingly less amount of energy would reach the top level consumers which would ensure an ultimate abolition of the ecosystem as a whole in the long run. Thus any interference by human being into this biosphere in form of woodcutting, seedling collection, etc. would evitably cause severe damage to our existence at the penultimate stage.

1.4.10 SUNDARBAN AS A BIOSPHERE RESERVE

Estuaries are special bio-type in littoral zone. They are the most dynamic, complex and rich ecosystems in the world. Here the opposite currents meet, oscillatory tidal currents are formed and sedimentation system is complicated. Estuaries are complex biological environment which also provide aesthetic enjoyment and recreational sites. They are priceless natural assets and are dynamic ecological system, nursing grounds, sheltering place, source of nutrients for the marine life.(Chowdhury & Chakrarbarty, 1989).

Of all the estuaries of the world the Sundarbans estuary is the most complex and one of the largest. The Sundarbans stand supreme in the
habitat maps of the world. Very few areas exist in the world with such diversities in animal species living in a complex physical, chemical, mechanical and animate environment. The plants and animals are in perfect balance in a rich biomass by their stress and strains, thrusts and counter thrusts. Sundarbans offer a perfect example where different societies of living organisms live in hostile and complex biosphere known as biogeocoenosis. It develops various adaptations like Osmo-regulatory mechanism, self sustaining Oscillation, Pneumatophores, etc. This is a peculiar terrain having vast assemblages of vertebrates and invertebrates with Royal Bengal Tiger at the apex of animal pyramid. Even people operating in the hostile estuarine tract develop peculiar habits and the influence of myths, legends and the fisher-folk of the Sundarbans make the habitat one of the most difficult but interesting for any biological study. In this ecosystem a scientist is to determine:-

i) Salinity in soil and water

ii) P.H. value of soil

iii) Various mineral nutrients in water

iv) Oscillating water currents.

v) The effect of Moon Tides on plant and animal behaviour and reproduction.

vi) Various temperature ranges in water, salinity and osmoregulation.
vii) Wind velocity

viii) Sandy clay and rocky shore and annual dispersion of micro animals.

ix) Inter tidal mudflat and animal association.

x) Effect of salinity and other factors on the behaviour of animals, especially on tigers.

xi) Density and pressure of water.

xii) The cause and effect of bioluminescense.

xiii) Various plant and animal zones.

xiv) Wide fluctuations of tidal level.

Salinity of water and soil is of prime consideration as on it depends the variety of plants and animals and their physical, physiological and chemical adjustments. Not only the plant species are specific and limited, animals also in such areas have to develop various physiological adjustments. A special chemical environment is produced owing to mixing up of various concentration of salts. In Summer, salinity increases. There is steep vertical salinity gradient (high at surface and low towards bottom).

The dynamic estuarine regions widely differ among themselves. In the estuaries of "Sundarbans", wide difference in low and high tide level is an important feature. It is possible to isolate specific areas having diverse plants and animals and having wide characteristics. Such estuaries are facing
destruction and pollution owing to human ignorance and apathy. In order to solve problem involving physical, chemical and animate environment in the estuary multidisciplinary approach is imperative (Chaudhuri and Chakraborty, 1989).

The International union for conservation of Nature and Natural Resources (IUCN) has taken various measures for conservation of some endangered mangrove fauna. ‘The Tiger Reserve Project’ and ‘Crocodile Breeding and Rearing Project’ have also been taken up in the Sundarbans. After imposing these strict rules and regulations, the wild life specially the Royal Bengal Tiger, Chital Deer and estuarine crocodiles are now conserved and protected. Because tigers on land and crocodiles in water are the two top consumers of mangrove ecosystem of the Sundarbans. These projects are also looking after the breeding and conservation of many other endangered animals species like large sea-turtle, king crabe, etc. Conservation of these top consumers of the Sundarbans delta forest is necessary to keep the ecosystem in balance. Because the food webs follow some definite pattern and any disturbance in the intermediate stage can trip the entire ecosystem.