

**Case Study on the Present Status of Beel Fisheries
in three Districts of West Bengal with a
Suggestive Note for its Overall Development**

**A Thesis
Submitted to the
West Bengal University of Animal and Fishery Sciences
In partial fulfillment of the requirements for the Degree of
Master of Fishery Science
In**

AQUACULTURE



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2010**



**Dedicated to My Sir,
Sri Amulya Bhattacharjee.**



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CERTIFICATE

This is to certify that the work embodied in the thesis entitled "**Case Study on the Present Status of Beel Fisheries in three Districts of West Bengal with a Suggestive Note for its Overall Development**" submitted by **Mr. Swagata Sarbadhikary** in partial fulfillment of the requirements for the Degree of **Master of Fishery Science (Aquaculture)** in the Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences, is the faithful and bonafide research work carried out under my supervision and guidance. The results of the investigation reported in this thesis have not so far been submitted for any other degree or diploma. The assistance and help received during the course of investigation have been duly acknowledged.

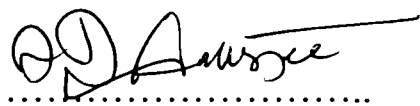
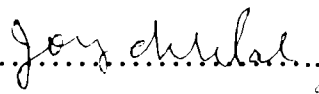

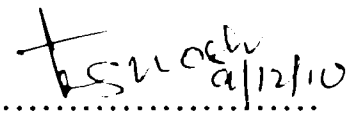
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CHAPTER -1

INTRODUCTION

INTRODUCTION

India is naturally endowed with wonderful wetlands primarily associated with the Brahmaputra & the Ganga river basins. These wetlands together encompass an area of 0.2 million hectares in the states of Arunachal Pradesh, Assam, Bihar, Manipur, Meghalaya, Tripura & West Bengal (Sugunan *et al.*, 2000). These wetlands have found their origin due to the fluvial activities of rivers, a characteristic of the floodplain, as the rivers use to change their course frequently resulting into the creation of many meanders which have ultimately assumed the shape of lakes after getting cut-off from rivers as a result of piling of silt. The state of West Bengal occupies an important place in the map of India due to its aquatic wealth in the form of natural lakes bearing rich potential for inland fish production. The widely distributed lakes with high potentialities of fish production have attracted the attention of scientists of several disciplines. These natural lakes are known by different names in different places, viz. 'beel' in West Bengal & Assam, 'maun' in Bihar, 'tal' in Uttar Pradesh.

Wetland is a broad term, which encompasses a wide range of inland, coastal & marine habitats sharing the common features of temporary or permanent freshwater or shallow coastal waters. The Ramsar Convention (1971) defined wetlands as 'areas of marsh, fen, peat, land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tides does not exceed six meters.' Maltby (1991) gave a more precise definition & according to him 'wetlands occupy the transitional zone between permanently wet & generally dry environments. They share characteristics of both environments, yet cannot be classified exclusively as either aquatic or terrestrial.' Since the wetlands of India are mostly situated on floodplains of major rivers, which form rich & varied inland fishery resources, they are better designated as floodplain wetlands or floodplain lakes (Sugunan, 1997).

The lands along both sides of a river channel formed by layers of river alluvium, containing the meanders or braided reaches of a river & periodically inundated at times of high river discharge, constitute its floodplain (ICLARM, 1999). The beels by virtue of their unique position, location & carrying capacity are the lifeline in respective areas of their existence & are highly significant from fisheries point of view. They have an important role on the socio economic conditions of the area, being one of the major sources of livelihood for thousands of fishermen living in their vicinity.

Physiographically beels are of two types, open & closed. Open beels are wide, shallow with irregular contours & are connected to rivers through channels, either throughout the year or at least during monsoon. They are also termed as 'live beels'. Closed beels, also known as 'dead beels', are totally disconnected from the rivers. They mainly receive water from the catchment area. Floodplains can be classified in several ways, e.g., permanently or seasonally flooded ones (ICLARM, 1999). Based on the flow of water, these can be divided into two groups; the plains & the standing waters (Welcomme, 1979).

In the state of West Bengal, the beels cover an estimated area of 46,000 ha contributing 22% to the total freshwater area (Vass, 1989). Districts of North 24 Parganas & Nadia are potentially important for beel fishery of this state.

Unfortunately, these resources have suffered utter neglect in the past in spite of their varied uses in general & fish yielding potentialities in particular. In fact, rather than conservation, consistent efforts have been made to convert the wetlands for intensive agriculture or fill them to create land for industrial or urban development. Hazardous & toxic substances are carried to the beel ecosystem through sewage or through run-off from the vast agricultural lands. Many of such lakes are gradually changing into swamps & are in the process of becoming grasslands.

The present study includes the beels of the districts of North 24 Parganas, Nadia & Hooghly. These beels though do not contribute significantly to the total fish production of the state, but their vast unutilized areas & lack of proper management practices offer a scope for increased production with scientific approach of programme.

The beels act as breeding grounds for a number of riverine fishes including Indian Minor Carps, as well as nursery ground for Indian Major Carps (IMC). Besides IMC, *Labeo calbasu*, *L. goni*, *L. bata*, *Chela sp.*, *Eutropichthys vacha*, *Gudusia chapra*, *Colisa sp.*, *Notopterus notopterus*, *N. chitala*, *Barilius sp.*, *Mystus sp.*, *Aorichthys seenghala*, *A. aor*, & *Wallago attu* constitute an important fishery of the beel.

Therefore, the present study has been undertaken to study the recent status of the ecology & fisheries of the primarily unmanaged beels. The problems in increasing the productivity of the beels is to be identified so as to formulate effective management strategies towards optimum utilization of these valuable water resources.

The objectives of this study is to –

1. study the present status & potency of the beel fisheries in some districts of West Bengal.
2. study the possibilities of increased production with the application of improved technological approaches.

CHAPTER -2

*REVIEW
OF
LITERATURE*

REVIEW OF LITERATURE

Concepts of Beels

Definitions

Beels are a particular category of wet-lands naturally formed due to meandering of rivers. A precise definition of wet-land is diffusive as various authors have defined it in different ways as per the nature of formation, water retention characteristics, hydrological features & ecological characteristics etc.

The first generalized definition of wet-lands as 'areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters' has been mentioned in the Ramsar Convention (1971). However, the wet-lands of India are mostly situated on flood plains of major rivers, which form a rich & varied inland fishery resource & are better designated as flood plain wet-lands or flood plain lakes (Sugunan, 1997). Flood plains are the flat land bordering rivers that are subject to periodic flooding, which tend to be most expansive along the lower reaches of rivers (Maltby 1991). This view is also stated by Bhattacharyya et al. (2003) in general.

Pandian (2000) defined beels as either permanent or temporary water bodies associated with rivers that constantly shift their beds especially in the potaman regimes. He further stated that the beels usually represent the lentic component of flood plains. In addition, tectonic depressions located in river basins are also included under beels. Srivastava (2000) stated that the beels are shallow water bodies which are formed when a river changes its course, their connection with the river being snapped or sometimes retained particularly during the rainy season. Thus, the beels are fresh water wet-lands (Barbier 1989).

Beels are saucer-shaped depression of marshy characters usually formed by changed river system. It represents the transitional phase between the terrestrial & aquatic systems with water level at or near the surface or the land is covered with shallow depth of water. Soil & water of beels are very productive. They serve as natural habitats, breeding, feeding & spawning ground of large & small indigenous fishes of different food habits (Jha, 1989). A large portion of rural families is engaged in part time fishing from the beels (Hughes et al. 1994).

Characteristics

Pandian (2000) discussed in detail about the beels, their importance & characteristics. The beels are very large in size & shape with an extent of riverine connection & offer a very good scope for both culture & capture fisheries. Beels are rich in plant nutrients. So, they have high biological productivity.

The high fluctuation in water level & the seasonal riverine connections are the main characters of the beel ecosystem. The organisms inhabiting the system comprise a complex mixing of lentic & lotic communities.

According to Leopold et al. (1964) flood plains typically include the following features :-

- i) the river channel.
- ii) oxbows or oxbow lakes representing the cut-off portion of meander bends.
- iii) point bars-loci of deposition on the convex side of curves in the river channel.
- iv) meander scrolls – depressions & rises on the convex side of bends formed as the channel migrates laterally down the valley by erosion of concave banks.
- v) sloughs – areas of dead water formed both in meander scroll depressions & along the valley walls as flood water moves down the valley.
- vi) back swamp deposits – finer sediments are deposited in slack water ponded between the natural leaves & the wall.
- vii) natural leaves – raised berms or crests above the flood plain surface adjacent to the channel, usually containing coarser materials deposited as floods flow over the banks.
- viii) sand play – deposits of flood debris usually of coarser & sand particles in the form of splays or scattered debris.

Classifications

In India, Central Inland Fisheries Research Institute (CIFRI) (2000) classified beels as follows :-

Based on water retentivity

- i) Seasonal beels – Periodically water is replenished by monsoon rains & completely dry up during summer months.
- ii) Perennial beels – Permanent beels which retain water round the year.

Based on depth beels are classified as

- i) Shallow beels – having maximum depth upto 5 meters.
- ii) Medium deep beels – Maximum depth between 5 to 10 meters.
- iii) Deep beels – having maximum depth over 10 meters.

On the basis of size

- i) Small beels – effective area less than 100 ha.
- ii) Medium beels – effective area 100 to 500 ha.
- iii) Large beels – effective area more than 500 ha.

On the basis of riverine connection

- i) Open beels – these beels retain continuity with the parent rivers for the whole year or at least during rainy season.

- ii) Closed beels – these beels are cut – off from the nearby rivers & receive water from their catchments area.

Based on the extent of macrophyte infestation

- i) Weed choked beels – more than 50% of the total area is covered with aquatic macrophytes.
- ii) Moderately weed infested beels – less than 50% of the total area is covered with aquatic macrophytes.

And on the basis of shape –

Ox – bow shaped, crescent shaped, serpentine, oval, irregular braided channels etc.

Beel Fisheries

Beels are considered a significant resource for the development of culture & capture fisheries in West Bengal as well as several other states of North Eastern part of India. Several authors presented the status of beel fisheries.

Kurup et al. (1995) estimated the exploited fishery resources of Vembanad lake. Kalita & Kalita (1996) carried out an investigation to assess the fishery of the Tekera beel in Assam with reference to the special fishing technique known as Katal. Chakraborty (1997) worked on the fish species & their diversity in the flood plain lakes & the need for their conservation. Jha (1997) studied the fish yield of Mukhapur lake. Chandra & Jha (1997) discussed the status of fisheries development in North Bihar. Mukhopadhyaya (1997) presented a detailed account on present status of fish production in the beels of West Bengal with suggestions for fish yield optimization. He advocated that weed choked shallow beels are not suitable for multispecies culture practices.

Ecology & fisheries of ox-bow lakes of North-Bihar was studied by Sinha & Jha (1997). The fish & fisheries, biodiversity & management of the lake had also been discussed. Acharjee et al. (1998) worked on the productivity & fish yield in the lower Brahmaputra basin. Sugunan (1998) studied the fishery resources of the north eastern region & scope for their development. He also mentioned scope for pen culture in beels, pen materials & selection of species, pen culture of prawns & its management. A detailed & exhaustive survey on management of fisheries in open water system & extension method was carried out by Jha (1998). Similar study had been reported by Bhaumik (1998). Sinha (1998) discussed about flood plain resources of India, their distribution & their significance of fisheries. Jha (1999) described the classification, management & fish production in different beels. Katiha (1999) worked on economics of inland open water fisheries in India Vinci & Hassan (1999) has given a brief account of advantages & disadvantages of pen & cage culture in beels. Acharjee et al. (1999) showed that the fish production from Dighali beel of Assam was only 4.4 Kg/ha/yrs & thus only 2.2% of the potential is harvested.

According to recent data near about 42,000 ha area in West Bengal is under beel fisheries out of total 88,75,000 ha areas of the state.

Distributions of Lakes

Dehadral (2006) estimated 2,02,213 ha of flood plain lakes is available in India where fish & fisheries remain a traditional economic activity with tremendous socio-economic impact in the rural sector. The wet lands in India are mainly associated with the Ganga & Brahmaputra river basins. (Srivastava et al. 2003 ; Chauhan, 2006).

State	Distribution (by district)	River Basin	Local Name	Area (ha)
Arunachal Pradesh	East Kameng, Lower Subansiri, East Siang, Dibang Valley, Lohit, Changlang & Tirap	Kameng, Subansiri, Dibang, Lohit, Dihing & Tirap	Beel	2,500
Assam	Brahmaputra & Barrak Valley Districts	Brahmaputra & Barak	Beel	100,000
Bihar	Saran, Champaran, Saharsa, Muzaffarpur, Darbhanga, Monghyr, Turnea	Gandak & Kosi	Maun, Chaur & Dhar	40,000
Manipur	Imphal, Thoubal & Bishnupur	Iral, Imphal & Thoubal	Pat	16,500
Meghalaya	West Khasi hills & West Garo hills	Someshwari & Jinjiram	Beel	213
Tripura	North, South & West Tripura districts	Gumti	Beel	500
West Bengal	24-Parganas North & South, Hooghly, Nadia, Murshidabad, Maldah, Cooch Bihar, Burdwan, North & South Dinajpur & Midnapore	Hooghly, Ichamoti, Bhagirathi, Churni, Kalindi, Dharub, Dharala, Pagla, Jalangi, Behula, Torsa, Mahananda	Beel, Charha & Boar	42,500
Total				202,213

Species Diversity

The recent survey of fish bio-diversity in the beels of West Bengal shows these species.

Cirrhinus mrigala (Mrigal), *Catla Catla* (Catla), *Labeo rohita* (Rui) & introduced exotic carp species *Cyprinus carpio* (American Rui), *Ctenopharyngodon idella* (Grass carp) & *Hypophthalmichthys molitrix* (Silver carp) are extensively used in the state. In addition, two exotic species, namely *Oreochromis mossambica* & *T. nilotica* (commonly

known as Tilapia) have also been extensively cultured in the beels. Besides the fin fishes, crustaceans (prawns, shrimps & crabs) also form an important component of fisheries resources.

Fish species commonly found in the beels of West Bengal

1. <i>Anabas testudineus</i>	36. <i>Danio devario</i>
2. <i>Amphipnous cuchia</i>	37. <i>Eutropichthys vacha</i>
3. <i>Amblypharyngodon mola</i>	38. <i>Glossogobius giuris</i>
4. <i>Ailia coilia</i>	39. <i>Gudusia chapra</i>
5. <i>Ailia punctata</i>	40. <i>Heteropneustes fossilis</i>
6. <i>Barilius bola</i>	41. <i>Hypophthalmichthys molitrix</i>
7. <i>Barilius barila</i>	42. <i>Labeo rohita</i>
8. <i>Barilius barna</i>	43. <i>Labeo calbasu</i>
9. <i>Barilius shacra</i>	44. <i>Labeo bata</i>
10. <i>Barilius bendelisis</i>	45. <i>Labeo gonius</i>
11. <i>Botia dario</i>	46. <i>Labeo dyocheilus</i>
12. <i>Batasio sp</i>	47. <i>Labeo nandesa</i>
13. <i>Bagarius bagarius</i>	48. <i>Mystus aor</i>
14. <i>Badis badis</i>	49. <i>Mystus seenghala</i>
15. <i>Chela laubuca</i>	50. <i>Mystus vittatus</i>
16. <i>Chela atpar</i>	51. <i>Mystus cavasius</i>
17. <i>Cyprinus carpio var. Communis</i>	52. <i>Mastacembalus armatus</i>
18. <i>Cyprinus carpio var. Specularis</i>	53. <i>Mastacembalus pancalus</i>
19. <i>Cirrhinus mrigala</i>	54. <i>Notopterus notopterus</i>
20. <i>Cirrhinus reba</i>	55. <i>Notopterus chitala</i>
21. <i>Catla catla</i>	56. <i>Nandus nandus</i>
22. <i>Crossocheilus latius latius</i>	57. <i>Ompok pabda</i>
23. <i>Clupisoma garua</i>	58. <i>Ompok pabo</i>
24. <i>Channa marulius</i>	59. <i>Ompok bimaculatus</i>
25. <i>Channa punctatas</i>	60. <i>Pangasius pangasius</i>
26. <i>Channa gachua</i>	61. <i>Puntius ticto</i>
27. <i>Channa striatus</i>	62. <i>Puntius conchoniis</i>
28. <i>Channa stewartii</i>	63. <i>Puntius sarana</i>
29. <i>Chanda nama</i>	64. <i>Rasbora rasbora</i>
30. <i>Chanda ranga</i>	65. <i>Rasbora elonga</i>
31. <i>Colisa fasciata</i>	66. <i>Rhinomugil corsula</i>
32. <i>Colisa latius</i>	67. <i>Setipinna phasa</i>
33. <i>Colisa chuna</i>	68. <i>Tor tor</i>
34. <i>Colisa baculis</i>	69. <i>Tor putitora</i>
35. <i>Ctenopharyngodon idella</i>	70. <i>Xenontodon cancila</i>

Management Protocols

Weed Clearance

Almost all the beels have a rich growth of macrophytic vegetation like hyacinth (*Eichornia sp.*), *Hydrilla sp.*, *Vallisneria sp.* etc. (Srivastava, 2000). & as such macrophyte-detritus cycle is the over-riding energy flow system subducing the plankton cycle. So, removal of the macrophytes is essential for profitable fish culture depending on the micro-plankton cycle. Control of macrophytes is the most important measure to be followed in the closed beels. Clearance of macrophytes creates congenial atmosphere for rich plankton growth. In closed beels as there is little chance of getting flooded, grass carp fingerlings @ 10% of the total stocking density may be released to control submerged macrophytes like *Hydrilla sp.* (Sugunan et al, 2000).

Liming

Liming is expected to augment release of essential plant nutrients from the soil phase. Liming during post-monsoon or winter season will also help prevent occurrence of Epizootic Ulcerative Syndrome (EUS), a common cause of loss of fish stocks. However, this measure way not be cost effective in beels larger than 20 ha (Bhattacharyya et al. 2000).

Fertilization

Since most beels receive a lot of nutrients from the catchments & have large organic reserves, external fertilization (application of inorganic/organic fertilizers) is usually not required. However, fertilization may be required to increase the fish yield of a beel on regular basis in case of small closed beels. Wherever possible, the beel should be fertilized through discharge of nutrient-rich waste waters from agriculture or animal husbandry to reduce the cost (Sugunan et al., 2000; Choudhury et al.; 2003).

Stocking

Stocking with fish seed is the one & only meaningful conversion of accumulated organic matter of beel into highly valued fish flesh. To develop this system of fish production, availability of required size, number & species of fish seed would be a major concern for beel managers. For achieving the estimated potential of 1000-1500 kg/ha/yr, stocking of advanced fingerlings (10-15 cm) is advocated & stocking density should be 1500-2000 nos/ha/yr.

Open beels connected with river receive recruitment to stock from the river which may be merely manipulated for selective stocking. The closed beels, which are heavily infested with weed, need periodical stocking. Stocking of the beels with quality fingerlings of economically important & fast-growing species would, therefore be an important step towards the rational management of beel fishery. Selective stock enhancement of commercially important, fast-growing fish species is necessary to

prevent small, less valuable fishes like *Puntius sp.* from flourishing in the beel by utilizing the available food sources. In managed beels, the IMCs are regularly stocked to increase their fish yield.

Stocking size

As mortality of fish is size-dependent, it is important of stock fish of proper size to ensure a good survival/recovery of stocked fingerlings. In the beels having large carnivorous population like *Wallago attu*, *Notopterus chitala*; the minimum stocking size should be at least 10 cm in length. However, the suggested size at stocking for fingerlings should be 10 cm or 10 gm (Suresh et al., 2006). At present, it will be difficult to get a steady supply of large sized fingerlings in adequate number & at the right time to stock the beels. It is difficult task to transport a large number of advanced fingerlings (>10cm in size) to the beels, having remote location & poor road connections. Lapse in stocking (in the right size & in adequate number & in time) is mainly responsible for low yield obtained from culture-based fisheries in beels of India.

Disease Management

Important fish diseases of the beels are gill rot, fin & tail rot, fish lice infestation, ulcer, dropsy mainly during the winter season. Hence, prophylactic measures should be an important criteria for proper management practice. (Bhaumik et al, 2004).

Problems of the Beels

Wetlands in general are among the most threatened habitats. It is due to accelerated drainage, pollution, land reclamation & over-exploitation of wet land species (Jhingran, 1991). Threats to met lands are from –

- a) Deforestation for timber, fuel & fodder.
- b) siltation
- c) Land reclamation for industrial, agricultural & residential purposes.
- d) Dumping of untreated effluents & sewage disposal.
- e) Jute retting etc.

Some of the important trends are -

- i) Massive growth of aquatic macrophytes (submerged, floating, emergent) in most of the beels.
- ii) Inadequate population of plankton communities.
- iii) Dominance of mollusks at the benthic niche.
- iv) Greater dominance of forage fish & those of less economic value & poor market acceptability.
- v) Sizeable presence of exotic species exerting pressure on the native species.
- vi) Water quality deterioration.

These environmental stresses are result of various activities which are broadly grouped as under –

Utilization –

- i) Over-cultivation of marginal lands leading to excess silt load & turbidity.
- ii) Over exploitation.
- iii) Destruction for recreational purposes.
- iv) Habitat degradation through change in fishing practices.

Development –

- i) Degradation through large scale river valley modifications.
- ii) Introduction of exotic fishes.
- iii) Uncontrolled human settlement.
- iv) Planned or unplanned expansion of urban infrastructure.
- v) Natural & anthropogenic calamities.

Disposal –

- i) Dumping of wastes.
- ii) Pollutants.

CHAPTER -3

*MATERIALS
AND
METHODOLOGY*

MATERIALS AND METHODOLOGY

The study was conducted in the state of West Bengal as this state is naturally enriched with a considerable amount of riverine wetlands in the form of beels. Moreover, the distribution of unmanaged beels in this state is concentrated in three districts namely Hooghly, North 24 Parganas & Nadia. Therefore, representative samples of beels from these three districts have been investigated presently. The geographical & political information of West Bengal along with the three districts where the study was conducted are depicted below.

West Bengal at a Glance

Location: East India

Area: 88,752 sq km (34,267 sq mi)

West Bengal is a state situated in the eastern part of India, which shares its international border with Bangladesh, apart from Nepal & Bhutan. The state also shares ethno-linguistic similarity with Bangladesh. It stretches from Himalayas in the north to the Bay of Bengal in the south. West Bengal stands surrounded by Assam & Sikkim in the northeast, Orissa in the southwest and the states of Jharkhand & Bihar in the west. The exact co-ordinate location of the state is 27°13'15" & 21°25'24" north latitudes & 85°48'20" & 89°53'04" east longitudes.

West Bengal has the Rajmahal hills on its northwestern side & the Shillong Plateau on its northeastern border. The state stands bounded by the Indian peninsular. The geography of West Bengal is spread from the Himalayas in the north to the Bay of Bengal in the south. It is sprawled across 88,752 square kilometres, & it is the thirteenth largest state in the country.

With Himalayas to the north and the Bay of Bengal to the south, the geography of West Bengal has a wonderful mix of diverse terrains. The highest peak of the state is Sandkfu, which is almost 12,000 feet in height. The Terai region demarcates the mountainous region from the plains. The plains in turn transition into the Ganges delta, in the south.

The Ganges is the main river of the state, which splits near the centre of the state, with one fork flowing towards Bangladesh as the river Padma, & the other through West Bengal as Bhagirathi & Hooghly. Other rivers in the state are the Mahananda, Teesta, Jaldhaka & Torsa rivers, which rinse through the northern hilly region of the state. In the west, the plateau region includes the rivers Kangsabati, Damodar & Ajay. There are also numerous rivers & creeks in the Ganges delta as well as in the Sundarbans.

The climate of the state varies considerably, being savannah like in the southern portions, to being humid-subtropical in the north. The state experiences four main seasons of summer, monsoon, autumn & winter. Summer in this region is excessively humid, although the western highlands experience a dry summer like that of northern India. In summer, the temperature ranges from 38⁰ to 45⁰ Celsius. Night is cooler because of the southerly breeze carrying the moisture from the Bay of Bengal. The early summers in West Bengal experiences brief thunderstorms known as Kalbaishaki.

Monsoon season lasts from June to September, & drenches the entire state. The state experiences mild winter over the plains & harsh cold in the Darjeeling Himalayan hill region. Over the plains, the average minimum temperature reaches 15⁰ Celsius, whereas the hill ranges experience occasional snowfall at places. In winter, a cold & dry northern wind blows which lowers the humidity level.

Because of the variations in climate over the state, West Bengal is enriched with diverse flora & fauna, where forests make up 14 percent of the geographical area of the state.

Geographically, the state is quite diverse, consisting of high peaks of Himalaya in the northern extremes & coastal regions in the southern parts, with plateaus & Ganges delta coming in between. West Bengal is also the only state in India where Himalayas are in the north & Sea is at the south.

West Bengal spreads over an area of about 34,267 square miles i.e. 88,752 square kilometers. Area wise it is one of the smallest states of India. But, in terms of population it is the largest among the states of India. The diversity in the state is such that depending on soil and climate variations, it can be divided into six broad divisions - hill region (north); terai and Teesta alluvial region (north); laterectic, red & gravely undulating region (west); coastal alluvial region (south); gangetic alluvial region (west); Vindhya alluvial region (centre).

District of Hooghly at a Glance

Hooghly is one of the 19 districts of West Bengal. It can alternatively be spelt *Hoogli* or *Hugli*. The name of the town of Hooghly is derived from the River, about 40 km north of Kolkata. Hooghly district comes under Burdwan Division with its headquarter located at Chinsurah town. The name "Hooghly" is derived probably from the 'HOGLA', a tall reed, which grows in abundance on the riverbanks & in the marshy low lands below them.

The district is a completely flat land with no place having more than an elevation of 200 meters. The River Hooghly borders it to the east. Another major river is 'Damodar'. The district is bordered by Howrah District to the south, Bardhaman District to the north, & to the east by the River Hooghly. Bankura District lies to the north-west, with Medinipur District to the south-west.

Hooghly is the one of the most economically developed districts in West Bengal. It is also the main center of jute cultivation, jute industry, & jute trade hub in the state. There are also a number of industrial complexes including one of the largest car manufacturing plants in India, the 'Hindustan Motors' plant located in Uttarpara. The jute mills are located along the banks of the river Hooghly in Tribeni, Bhadreswar, Champdani & Sreerampur.

The district comprises four subdivisions: Chinsurah, Chandannagore, Sreerampore & Arambagh. Chinsurah subdivision consists of two municipalities (Hooghly-Chuchura & Bansberia) & five community development blocks: Balagarh, Chinsurah–Mogra, Dhaniakhali, Pandua & Polba–Dadpur. Chandannagore subdivision consists of Chandannagore municipal corporation & three municipalities (Bhadreswar, Champdani & Tarakeswar) & three community development blocks: Haripal, Singur and Tarakeswar. Sreerampore subdivision consists of five municipalities (Sreerampore, Uttarpara Kotrung, Konnagar, Rishra & Baidyabati) & four community development blocks: Chanditala–I, Chanditala–II, Jangipara and Sreerampur Uttarpara. Arambagh subdivision consists of Arambagh municipality & six community development blocks: Arambagh, Khanakul–I, Khanakul–II, Goghat–I, Goghat–II & Pursurah.

Hooghly-Chuchura is the district headquarters. There are 23 police stations, 18 development blocks, 12 municipalities & 210 gram panchayats in this district.

Area	3,145 sq. km
Latitude	23 ⁰ 01' 20" to 22 ⁰ 39' 32"N
Longitude	88 ⁰ 30' 20" to 87 ⁰ 30' 15"E
Population (2001)	5040047
Males	2588322
Females	2451725
Population density	1601 per sq. km
Sex Ratio	947 females per 1000 males
No. of Sub-Division	4
No. of Blocks	18
Average rainfall	1500 mm
Temperature	Max.: 38 0C; Min.: 11 0C
Postal Code	712101

District of North 24 Parganas at a Glance

North 24 Parganas is an administrative district of West Bengal with its headquarters located at Barasat. The district is also written as 24 Parganas (North). It is located within the Ganges-Brahmaputra delta. The river Ganges flows along the entire western border of the district.

North 24 Parganas district is a district in southern West Bengal & is bordered by Nadia at north, to Bangladesh (Khulna Division) by north and east, to South 24 Parganas & Kolkata by south & to Kolkata, Howrah & Hoogly by west. North 24 Parganas is the most populous district after Kolkata. It is also the tenth largest district in the State by area & second most densely populated district (3,781/km² as of 2007 census).

The climate is tropical, like the rest of the Gangetic West Bengal. The hallmark is the Monsoon, which lasts from early June to mid September. The weather remains dry during the winter (mid November to mid February) & humid during summer.

People are mainly engaged in farming, fishing & other agricultural activities. The average size of agricultural landholdings is 3.2 Bighas. Hindu "Refugees" from Bangladesh form a major part of the industrial workforce. North 24 Parganas is one of the economically backward District of West Bengal.

The district comprises five subdivisions: Barrackpore, Barasat Sadar, Basirhat, Bangaon & Bidhannagar. Barrackpore subdivision consists of sixteen municipalities (Kanchrapara, Halisahar, Naihati, Bhatpara, Garulia, Barrackpore, North Barrackpur, New Barrackpur, Titagarh, Khardaha, Panihati, Kamarhati, Baranagar, Dum Dum, North Dumdum & South Dumdum) & two community development blocks: Barrackpore-I & Barrackpore-II. Barasat Sadar subdivision consists of six municipalities (Barasat, Habra, Rajarhat Gopalpur, Ashoknagar Kalyangarh, Madhyamgram & Gobardanga) & seven community development blocks: Barasat-I, Barasat-II, Amdanga, Deganga, Habra-I, Habra-II & Rajarhat. Bangaon subdivision consists of Bangaon municipality & three community development blocks: Bagda, Bangaon & Gaighata. Basirhat subdivision consists of three municipalities (Basirhat, Baduria & Taki) & ten community development blocks: Baduria, Basirhat-I, Basirhat-II, Haroa, Hasnabad, Hingaljanj, Minakhan, Sandeshkhali-I, Sandeshkhali-II & Swarupnagar. Bidhannagar subdivision consists of only Bidhannagar municipality. Barasat is the district headquarters. There are 35 police stations, 22 development blocks, 27 municipalities, 200 gram panchayats & 1599 villages in this district.

Area	4094 sq. km
Forest Land	4,221 Hectares
Latitude	23 ⁰ 15'2" & 22 ⁰ 11'6" North
Longitude	89 ⁰ 5' & 88 ⁰ 20' East
Population(2001)	90, 25,832
Males	4684860
Females	4340972
No.of Sub-Division	05
No. of Blocks	22
No.of Villages	1606
Averagerainfall	1,579 mm
Temperature	Max.: 40 0C; Min.: 10 0C
STDCode	033

District of Nadia at a Glance

Nadia is one of the 19 districts of West Bengal & it is present in the more or less middle position of the state. The district is recognized for its rich culture & heritage from time immemorial. Nabaddip, which is the birth place of Sri Chaitanya Dev is a holy place for Hindus. Apart from that Krishnanagar, Krishnagange, Palashi, Phulia, Santipur are other historically famous places of Nadia district. This district is very densely populated & majority of population is directly or indirectly dependent on agriculture & allied activities. Apart from that a number of people are directly dependent on hand looms & “Tant” is famous all over the world. Kalyani is another town with the memories of Dr. Bidhan Chandra Roy. There are two universities in the district namely Kalyani university & Bidhan Chandra Krishi Viswavidyalaya.

This district is situated between 22° 53' N - 24° 12' N latitude & 88° 01' E – 88° 48' E longitude. The Tropic of Cancer passes through the middle of this district. The average height of the district is 46 ft (MSL). The boundary of the district is demarcated by the Murshidabad district in the northern side, Bangladesh on the eastern side, 24-Parganas (N) in the eastern & southern and Bhagirathi River in western side. Total area of the district is 3927 sq km & majority of the land comes under cultivated area.

This district has got a network of rivers & rivulets. Bhagirathi is the main river of the district & it indicates the western boundary of the district. Among the other major water bodies' rivulets of Bhagirathi like Jalangi, Bhairab, Mathavanga, Ichamati & Churni are important. These water bodies are one of the major sources of irrigation water & also used in domestic purposes.

This district has been sub divided into four subdivisions for the administrative purpose, namely Krishnagar, Ranaghat, Kalyani & Tehatta. Krishnanagar is the district town of this district. Again for the agricultural extension work this district has been sub divided into three subdivisions namely Krishnagar, Ranaghat & Tehatta & are further divided into blocks. For administrative purposes Nadia district has been sub divided into seventeen blocks, where as for agricultural extension work this district has been subdivided into sixteen agricultural blocks. This district has been consists of seventeen Panchayat Samity one in each administrative blocks. Total 187 Gram Panchayat present in this district & a total 2639 Gram Sansad is there. Total number of Mauza is 1406.

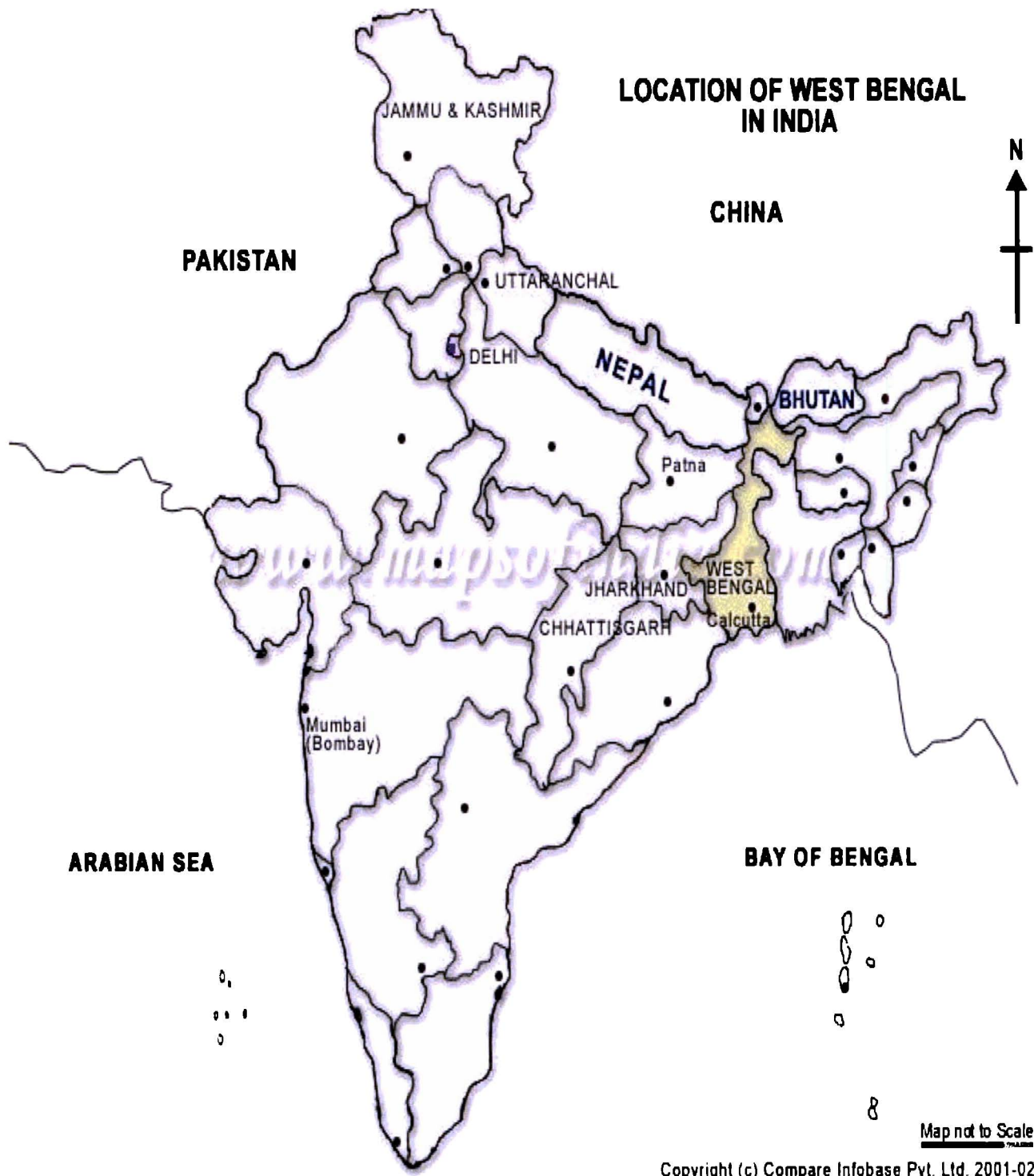
Area	3927Sq.Kms.
Population(2001)	46,03,756
Males	23,65,054
Females	22,38,702
Populationdensity	1172 Per Sq. K.M.
SexRatio	947 females per 1000 males
LiteracyRate	66.14%
No.ofSub-Division	04
No.ofBlocks	17
No.ofVillages	1406
STDCode	03472

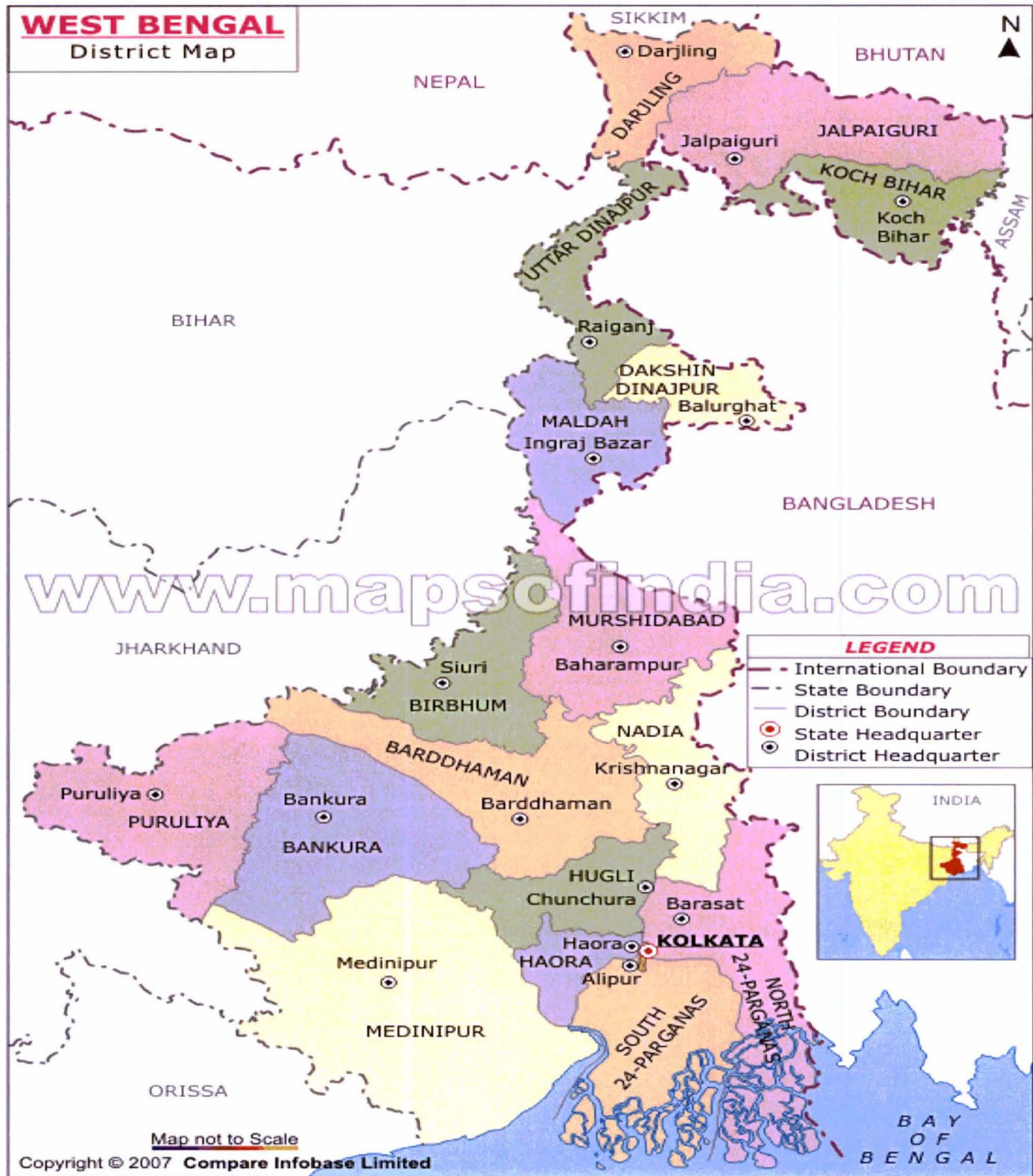
Selection of Beels

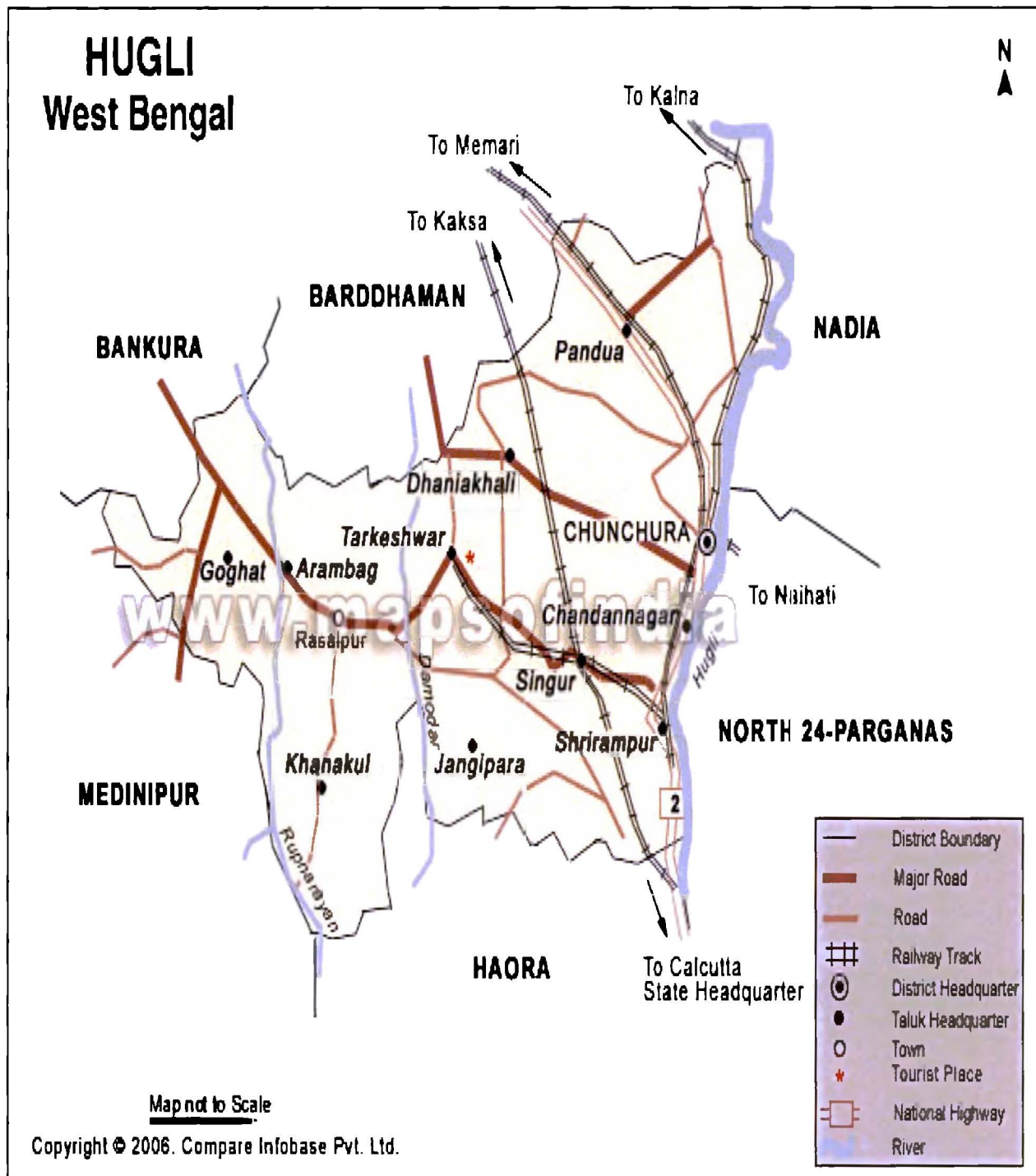
All together, 30 nos. of beels, (20 from Hooghly, 8 from North 24 Parganas & 2 from Nadia) have been selected at random. The transect map of the beels is given at the next pages.

A survey schedule encompassing the morphometry, biological properties, fishery components, managements & the problems of the beels is prepared for collection of primary & secondary data directly from the spot as well as from the Government & Non-Government organizations. A sample survey schedule is attached as annexure of the present thesis.

The data are collected during 02.02.2010. to 02.08.2010. & are analyzed for statistical interpretation towards pointing out the present status, problems & potentialities in terms of fish production following appropriate methods & softwares.











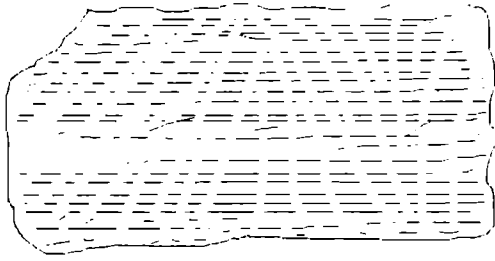


Fig 1. A Line Sketch of the View of the Banerjee Beel

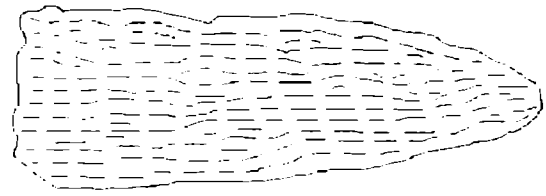


Fig 2. A Line Sketch of the View of the Bhagabati Beel

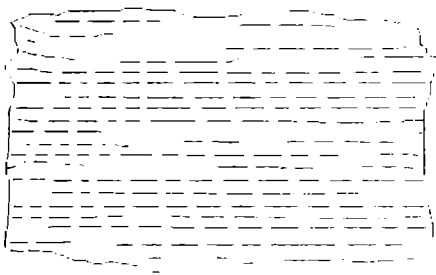


Fig 3. A Line Sketch of the View of the Block Beel



Fig 4. A Line Sketch of the View of the Borpukur Beel

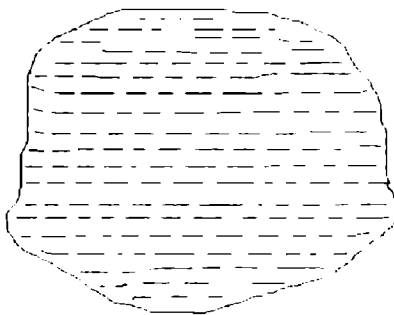


Fig 5. A Line Sketch of the View of the Chakraborty Beel

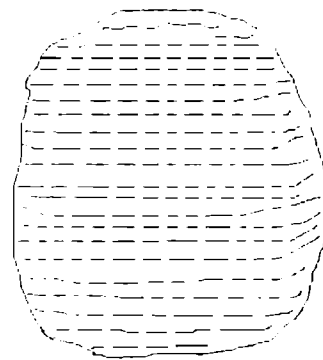


Fig 6. A Line Sketch of the View of the Chakrapur Beel

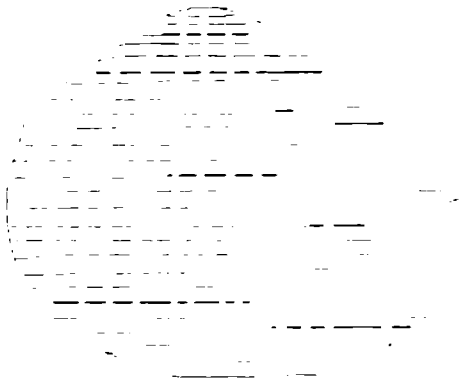


Fig 7. A Line Sketch of the View of the Dighi



Fig 8. A Line Sketch of the View of the Jhamp Pukur Beel

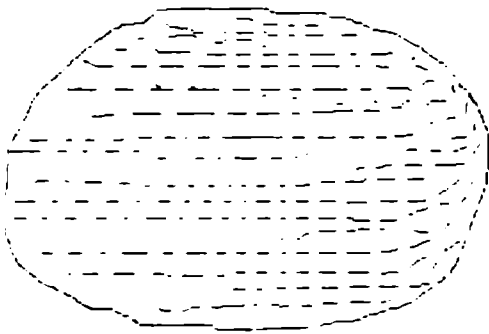


Fig 9. A Line Sketch of the View of the Katapukur Beel

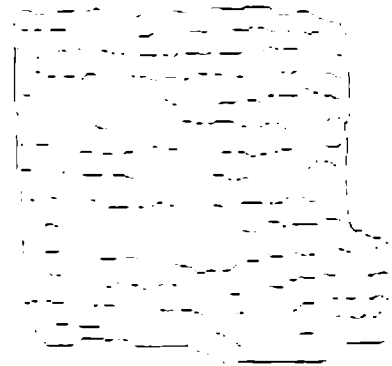


Fig 10. A Line Sketch of the View of the Keshar Beel

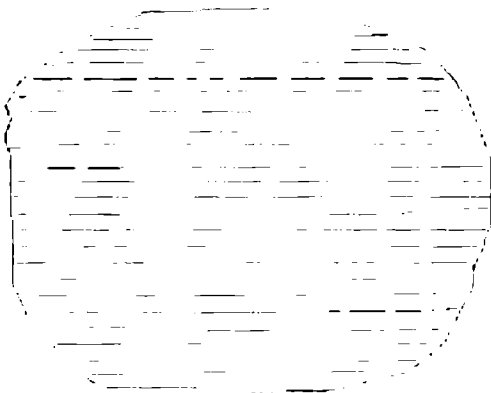


Fig 11. A Line Sketch of the View of the Khirkir Beel

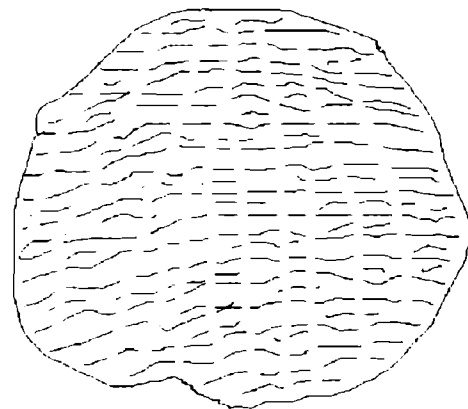


Fig 12. A Line Sketch of the View of the Kolupukur Beel

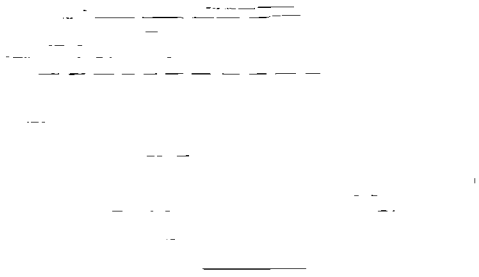


Fig 13. A Line Sketch of the View of the Kumorhat Beel

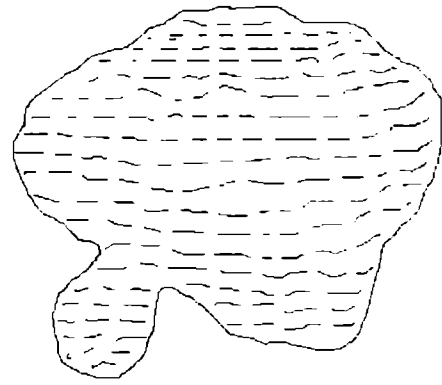


Fig 14. A Line Sketch of the View of the Labasan Beel

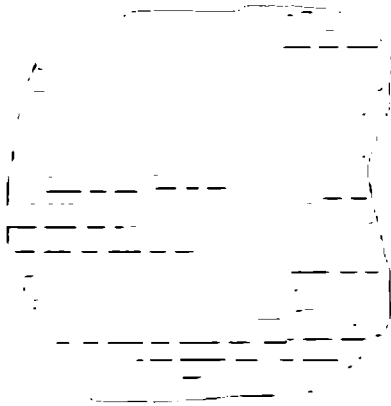


Fig 15. A Line Sketch of the View of the Matiara Beel

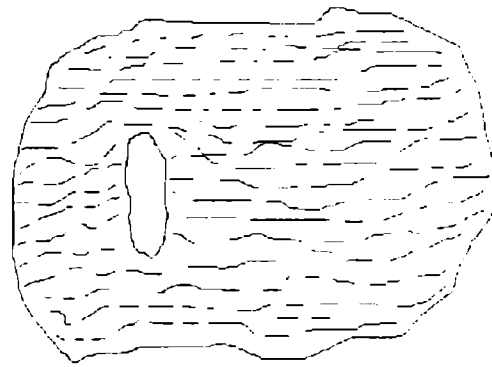


Fig 16. A Line Sketch of the View of the Moyla Beel

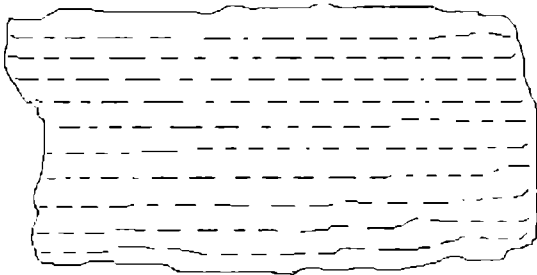


Fig 17. A Line Sketch of the View of the Pannam Beel



Fig 18. A Line Sketch of the View of the Rajhati Beel

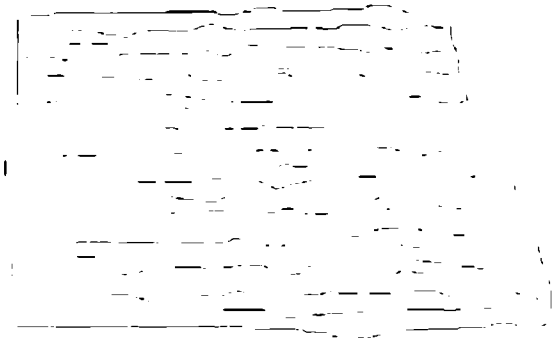


Fig 19. A Line Sketch of the View of the Ram Dighi



Fig 20. A Line Sketch of the View of the Ramnagar Beel

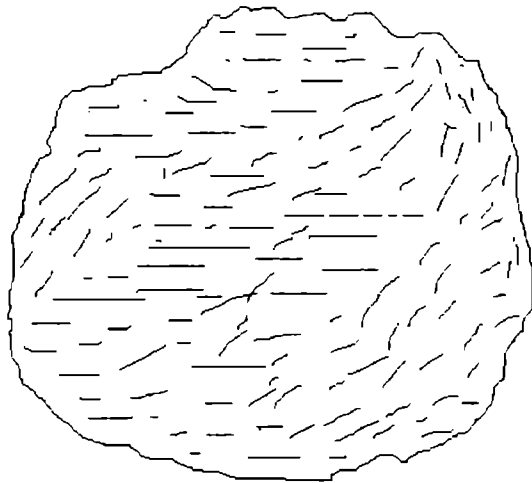


Fig 21. A Line Sketch of the View of the Kumli Beel

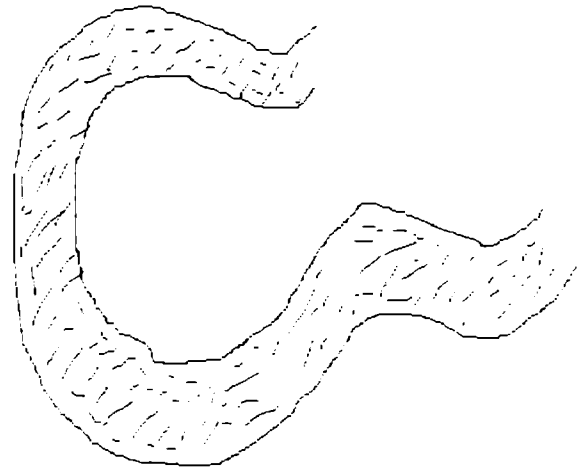


Fig 22. A Line Sketch of the View of the Sonakhali Beel

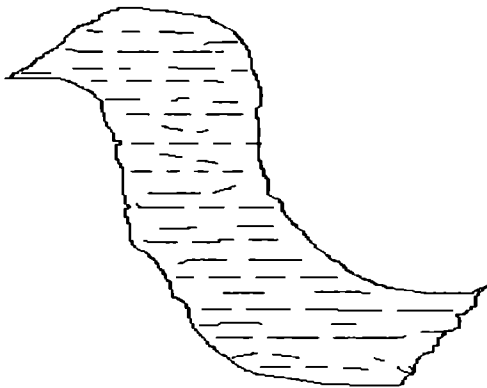


Fig 23. A Line Sketch of the View of the Bharat Housing Beel

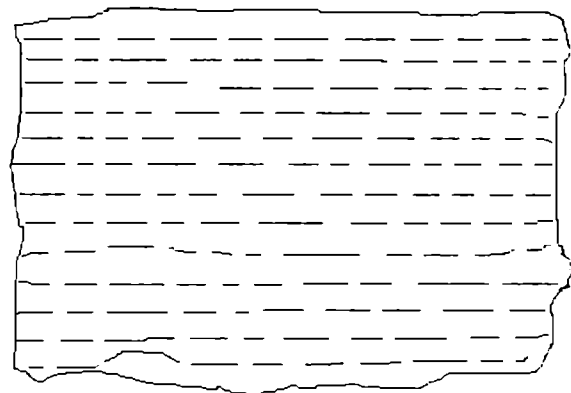


Fig 24. A Line Sketch of the View of the Pritinagar Beel I

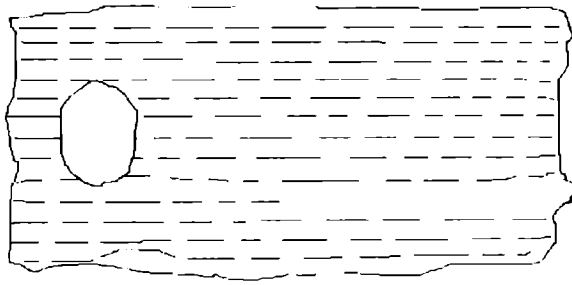


Fig 25. A Line Sketch of the View of the Pritinagar Beel 2

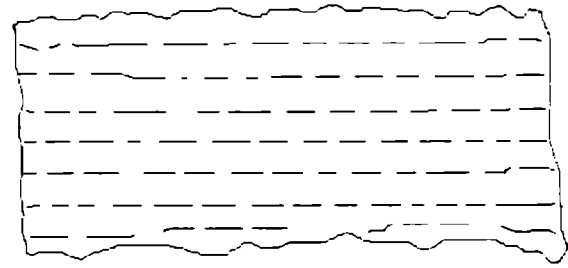


Fig 26. A Line Sketch of the View of the Jagaddal Beel 1

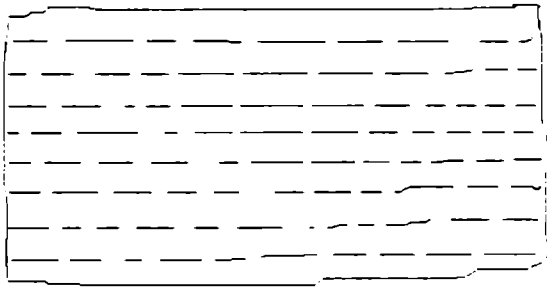


Fig 27. A Line Sketch of the View of the Jagaddal Beel 2



Fig 28. A Line Sketch of the View of the Sodla Beel

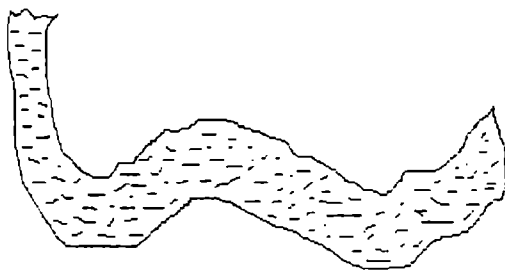


Fig 29. A Line Sketch of the View of the Annapurna Beel



Fig 30. A Line Sketch of the View of the Ichhapur Beel

CHAPTER -4

RESULTS

RESULTS

Physical Morphology & General Features of the Beels

All the 30 beels are surveyed in the present study covering two blocks in the Hooghly district, one block in North 24 Parganas & one block in Nadia district fall under the floodplain wetlands category. Of all the beels studied only one beel in Nadia district is an open type, whereas, all the other beels are closed.

The general shape of the beels in the Hooghly district is dominated by rectangular, circular & oval shapes. In North 24 Parganas the beels are either rectangular or serpentine in shape. These features are completely different in the beels of Nadia district. With regards to the water retention characteristics, all the 30 beels under study are more or less perineal type, except a seasonal type of beel in the Hooghly district in Block Khanakul 1.

The soil types in all the beels of the three districts studied under the present investigation are alluvial in nature. But, in few cases, it is mixed with loam particularly in the North 24 Parganas district. The fertility status of the beels is dominated by medium fertile category followed by less fertile & fertile beels. (Table 1)

With regards to the administrative status, all the beels under the present investigation falls under the unregistered category & all the beels of Hooghly & North 24 Parganas are properly leased out for farming. In contrast, the beels studied in Nadia are not leased out, but culture is practiced on co-operative basis.

Hydrological Characteristics

The average water depth of the beels of Hooghly ranges from 6.23-6.50 ft with maximum & minimum depth ranges between 6.80-7.00 ft & 5.65-5.70 ft respectively. The average water depth of the beels of North 24 Parganas ranges from 7.72-7.80 ft with maximum & minimum depth ranges between 8.44-9.00 ft & 7.00-7.50 ft respectively. The average water depth of the beels of Nadia ranges from 7.75-8.00 ft with maximum & minimum depth ranges between 8.50-9.50 ft & 7.00-7.65 ft respectively. Among the three districts the depth of the beels of Nadia district is found to be higher than the other two districts.

The average water spread area during the monsoon months is ranged from 5.65-6.83 acre in Hooghly; whereas, it is ranged from 4.16-5.00 acre in North 24 Parganas & 4.00-5.00 acre in Nadia respectively. The post monsoon size of the beels with regards to the water spread area is 5.58 acre in Hooghly, 4.58 acre in North 24 Parganas & 4.25 acre in Nadia district. (Table 2)

Macrophyte diversity & infestation

The beels of all the districts are more or less infested with all categories of macrophytes. However, the diversity of macrophytes is more in Nadia districts. The beels of the other two districts are found to be substantially covered by macrophytes. Large bodied macrophytes principally dominated by *Eichhornia sp.* are responsible for covering the surface area in most of the beels. (Table 3)

Plankton Population

Phytoplankton - Phytoplankton population of the beels in all the three districts are mainly represented by *Chlorophyceae*, *Bacillariophyceae* & *Myxophyceae*.

Zooplankton - Zooplankton population in general is represented by *Copepods*, *Cladocerans* & *Rotifers*. (Table 4)

Other Aquatic Biota

Aquatic insect population of the beels in all the districts are mainly represented by *Back Swimmers (Notonecta)*, *Water Stick Insects (Ranatra)*, *Pond Skaters (Gerris)*, *Water Scorpions (Nepa)*, *Diving Beetles (Cybister)* etc. Frogs, snakes & turtles are also encountered in some cases. (Table 5)

Fish Abundance & Yield

Beels of all the three districts are found to be very rich in the diversity of fish population. Indian Major Carps (*Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Labeo calbasu* etc) are encountered in the beels along with some exotic carps (*Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *Cyprinus carpio* etc). Minor fishes like *Labeo gonius*, *Labeo bata*, *Cirrhinus reba*, *Puntius sarana*, *Gudusia chapra*, *Eutropichthys vacha* etc are also encountered. The diversity of weed fishes like *Puntius ticto*, *Chanda nama*, *Colisa latius*, *Rasbora rasbora*, *Mystus vittatus*, *Mystus gulio*, *Botia dario*, *Chela atpar* & air breathing catfishes like *Wallago attu*, *Ompok bimaculatus*, *Ompok pabda*, *Mystus aor*, *Notopterus notopterus*, *Notopterus chitala*, *Channa striatus*, *Anabas testudineus*, *Heteropneustes fossilis*, *Clarius batrachus* etc are also found in the beels of Nadia district mainly. Some important ornamental fishes comprised mainly of smaller varieties like *Puntius sp.*, *Chanda sp.*, *Rasbora sp.*, *Botia sp.*, *Nandus nandus*, *Ailia coilia* etc are found to be abundant in the beels of Nadia. Among shellfishes, presence of *Macrobrachium sp.* is conspicuous in Nadia & North 24 Parganas districts. (Table 6)

A large variation is observed in the annual yield of fish while comparing the beels of the three districts namely Hooghly, North 24 Parganas & Nadia. The average yield of the beels is 78.2 quintal/year, 73.1 quintal/year & 179.9 quintal/year in Hooghly, North 24 Parganas & Nadia respectively. While comparing the Blocks, the highest yield is

observed in Haringhata Block of Nadia district & the lowest yield is observed in Block Barrackpore Sub-div 1 of North 24 Parganas district. (Table 7 & 8)

Management Practices

Eradication of aquatic weed in all the beels studied covering all the three districts are done manually mainly during the harvesting period. However, the herbivorous fishes present in the beels also help in controlling the macrophytes through biological means. Controlling of predatory fishes is done manually in all the beels by repeated netting (gill nets, cast nets etc).

None of the beels are properly managed in terms of application of lime, fertilizers & manures & prophylactic measures. Regarding feeding, most of the beels adopted supplementary feeding composed of rice bran, mustard oil cake & ground nut oil cake etc without maintaining any recommended dose & frequency. 80% of the beels stock Rohu, Catla, Mrigal, Silver Carp & Common Carp without maintaining any species composition. The stocking size ranges 10-15 cm in length or 10-15 g in weight. The stocking density ranges from 1000-2000 nos./ha as fingerlings. (Table 9)

Harvesting Practices

In all the beels, harvesting is partially done throughout the year but the peak is from September to January. Different types of fishing gears are used, for example gill net, cast net, lift net, scoop net, drag net, along with spears, hooks & lines etc. An indigenous fishing method, traditionally known as Chetki Jal, is used to catch smaller fishes, trash fishes & small prawns. Similarly, different types of fishing crafts are also used which include small plank boats, dinghi, wooden country made boats (1-2m x 5-6m) etc. (Table 10)

Marketing

The harvested fishes are sold to the nearby wholesale market through auction while only a few kgs find their way to domestic consumption.

Disease Occurance

Mainly carps like *C. Mrigala*, *C. Catla* etc are reported to be infected in adult stage. Diseases like fin rot, tail rot, scale rot etc are encountered in winter & as treatment KmnO_4 @1.5-2kg/total area & 500g/bigha, Clear @50g/bigha, a mixture of Kerosin, Salt & Qrien (50 litre each) @500g/bigha are used. For surfacing & gasping behaviour during high stocking density, KNR & NOVAN @33ml/bigha are used.

Problems

The major problems faced by the farmers include lack of institutional support & finance, management related problems, ecological problems & anthropogenic problems. Again, most of the farmers emphasized the lack of institutional support & finance to be the major problems. Next to that, management related problems are also encountered as a major problem by 70-75% respondents. Among the ecological problems, heavy macrophyte infestation is cited as the most common problem in North 24 Parganas. Anthropogenic problems mainly in the form of encroachment of the peripheral region of the beels for paddy cultivation & over-exploitation is the main impediments as suggested by the farmers of Hooghly & Nadia district. (Table 11)

Table 1. Physical morphometry and salient features of the beels.

P A R A M E T E R S	Name of the Beel															
	Keshar	Chakrapur	Ramnagar	Matiara	Pannam	Labasan	Bhagabati	Kolu Pukur	Jhamp Pukur	Banerjee	Chakraborty	Katapukur	Moyla	Block	Kajhail	Borpukur
Nature of the beel	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain	Flood-plain
Nature of riverine connection	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
Shape of the beel	Square	Circular	Rectangular	Nearly Circular	Rectangular	Irregular	Triangular	Circular	Circular	Rectangular	Newly Circular	Oval	Oval	Rectangular	Oval	Irregular
Nature of water retention	Perennial	Perennial	Seasonal	Seasonal	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Soil type	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial
Fertility	Fertile	Medium Fertile	Fertile	Less Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Medium Fertile
Registered / unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered	Unregistered
Leased / Not Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased

P A R A M E T E R S	Name of the Beel													
	Hooghly				North 24 Parganas				Nadia					
	Ram Dighi Beel	Kumorhat Beel	Khirkir Beel	Dighi Beel	Bharat Housing Beel	Annapurna Beel	Ichhpur Beel	Sodia Beel	Pritinagar Beel 1	Pritinagar Beel 2	Jagaddal Beel 1	Jagaddal Beel 2	Sonakhali Beel	Kumil
Nature of the beel	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain	Flood- plain
Nature of rive- rine conn ection	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Season- ally open	Closed
Shape of the beel	Trapez oid	Nearly Oval	Circular	Oval	Serpentine	Oval	Oval	Rectan- gular	Rectan- gular	Rectan- gular	Rectan- gular	Rectan- gular	Cscescent	Circular
Nature of water reten- tion	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial	Peren- nial
Soil type	Alluvi al	Alluvial	Alluvial	Alluvial	Loamy	Loamy	Alluvial	Loam y	Alluvial	Alluvial	Alluvial	Alluvial	Alluvial + Loamy	Alluvial
Ferti- lity	Mediu m Fertile	Less Fertile	Less Fertile	Fertile	Medium Fertile	Medium Fertile	Fertile	Mediu m Fertile	Fertile	Medium Fertile	Medium Fertile	Medium Fertile	Fertile	Fertile
Regis- tered / unregi- stered	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred	Unregi- stred
Leased / Not Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Leased	Not Leased	Not Leased

Table 2. Hydrology of the beels.

Parameters	Name of the Beels							
	Hooghly							
	Keshar	Chakrapur	Ramnagar	Matiara	Pannam	Labasan	Bhagabati	Beel
Water Depth (ft)								
Max.	5.0	7.0	6.0	4.0	6.5	7.0	6.0	6.0
Min.	3.0	6.0	5.0	3.0	5.0	6.0	5.0	5.0
Av.	4.0	6.5	5.5	3.5	5.5	6.5	5.5	5.5
Area (acre)								
Max. (Monsoon season)	14.0	5.0	12.0	9.0	8.0	9.0	5.0	5.0
Min. (Leaned season)	12.0	4.0	10.0	8.0	6.0	8.0	4.0	4.0
Actual (Post season)	10.5	3.0	9.0	7.5	7.0	8.5	3.5	3.5

Parameters	Name of the Beels							
	Hooghly							
	Kolupukur	Jhamp Pukur	Banerjee	Chakraborty	Katapukur	Moyla	Block	Beel
Water Depth (ft)								
Max.	7.0	9.0	7.0	7.0	7.0	6.0	5.0	5.0
Min.	6.0	8.0	6.0	6.0	6.0	5.0	4.0	4.0
Av.	6.5	8.5	6.5	6.5	6.5	5.5	4.5	4.5
Area (acre)								
Max. (Monsoon season)	5.0	6.0	7.0	5.0	6.0	5.0	7.0	7.0
Min. (Leaned season)	4.0	5.0	6.0	4.0	5.0	4.0	6.0	6.0
Actual (Post season)	3.5	5.0	6.5	4.0	5.5	4.5	6.0	6.0

Parameters	Name of the Beels						
	Hooghly						
	Rajhati Beel	Borpukur Beel	Ram Dighi	Kumorhat Beel	Khirkir Beel	Dighi	Mean
Water Depth (ft)							
Max.	10.0	4.0	7.0	10.0	7.0	9.0	6.80
Min.	8.0	3.0	6.0	8.0	6.0	8.0	5.65
Av.	9.0	3.5	6.5	9.0	6.5	8.5	6.23
Area (acre)							
Max. (Monsoon season)	7.0	7.0	5.0	5.0	4.5	5.0	6.83
Min. (Leaned season)	5.0	6.0	4.0	4.0	4.0	4.0	5.65
Actual (Post season)	4.5	6.0	4.5	4.0	4.0	4.5	5.58

Parameters	Name of the Beels						
	North 24 Parganas						
	Bharat Hpusing Beel	Annapura Beel	Ichhapur Beel	Sodla Beel	Pritinagar Beel 1	Pritinagar Beel 2	Jagaddal Beel 1
Water Depth (ft)							
Max.	10.0	7.0	9.0	8.0	9.0	9.0	9.5
Min.	9.0	6.0	7.0	7.0	7.0	7.5	7.5
Av.	9.5	6.5	8.0	7.5	8.0	8.2	8.5
Area (acre)							
Max. (Monsoon season)	5.0	8.0	5.0	5.0	4.5	4.0	4.5
Min. (Leaned season)	4.0	6.0	4.0	4.5	4.0	3.8	3.5
Actual (Post season)	4.0	6.5	4.5	4.8	4.0	3.5	3.0

Parameters	Name of the Beels				
	North 24 Parganas		Nadia		
	Jagaddal Beel 2		Sonakhali Beel	Kumli Beel	
Water Depth (ft)		Mean			Mean
Max.	6.0	8.44	7.0	10.0	8.50
Min.	5.0	7.00	6.0	8.0	7.00
Av.	5.5	7.72	6.5	9.0	7.75
Area (acre)					
Max. (Monsoon season)	4.0	5.00	5.0	5.0	5.00
Min. (Leaned season)	3.5	4.16	4.0	4.0	4.00
Actual (Post season)	3.5	4.58	4.5	4.0	4.25

Table 3. Macrophytes present in the beels of Hooghly, North 24 Parganas & Nadia District.

Macrophytes	Hooghly	North 24 Parganas	Nadia
Floating	<i>Eichhornia</i> <i>Pistia</i> <i>Lemna</i> <i>Salvinia</i> <i>Azolla</i> <i>Myriophyllum</i> <i>Spirodela</i>	<i>Eichhornia</i> <i>Salvinia</i> <i>Lemna</i> <i>Myriophyllum</i> <i>Spirodela</i> <i>Pistia</i>	<i>Eichhornia</i> <i>Salvinia</i> <i>Spirodela</i> <i>Myriophyllum</i> <i>Pistia</i> <i>Lemna</i> <i>Azolla</i>
Submerged	<i>Hydrilla</i> <i>Vallisneria</i> <i>Ceratophyllum</i> <i>Potamogeton</i> <i>Chara</i>	<i>Vallisneria</i> <i>Chara</i> <i>Hydrilla</i> <i>Ceratophyllum</i> <i>Potamogeton</i>	<i>Hydrilla</i> <i>Vallisneria</i> <i>Chara</i> <i>Ceratophyllum</i> <i>Potamogeton</i>
Marginal	<i>Ipomea</i> <i>Typha</i> <i>Trapa</i> <i>Leersia</i> <i>Cyperus</i>	<i>Ipomea</i> <i>Leersia</i> <i>Trapa</i> <i>Typha</i>	<i>Ipomea</i> <i>Leersia</i> <i>Trapa</i> <i>Typha</i>
Rooted emergent	<i>Nymphaoides</i> <i>Nelumbo</i> <i>Nymphaea</i>	<i>Nymphaea</i> <i>Nelumbo</i> <i>Nymphaoides</i>	<i>Nymphaea</i> <i>Nelumbo</i> <i>Nymphaoides</i>

Table 4. Planktons present in the beels of Hooghly, North 24 Parganas & Nadia District.

Plankton	Hooghly	North 24 Parganas	Nadia
Phytoplankton	<i>Chlorophyceae</i> – <i>Spirogyra</i> <i>Botryococcus</i> <i>Eudorina</i> <i>Pediastrum</i> <i>Bacillariophyceae</i> – <i>Cyclotella</i> <i>Nitzschia</i> <i>Melosira</i> <i>Navicula</i> <i>Myxophyceae</i> – <i>Spirulina</i> <i>Microcystis</i> <i>Anabaena</i>	<i>Chlorophyceae</i> – <i>Botryococcus</i> <i>Spirogyra</i> <i>Bacillariophyceae</i> – <i>Nitzschia</i> <i>Cyclotella</i> <i>Navicula</i> <i>Myxophyceae</i> – <i>Spirulina</i> <i>Microcystis</i> <i>Anabaena</i>	<i>Bacillariophyceae</i> – <i>Nitzschia</i> <i>Navicula</i> <i>Myxophyceae</i> – <i>Microcystis</i> <i>Oscillatoria</i> <i>Spirulina</i> <i>Nodularia</i>
Zooplankton	<i>Copepoda</i> – <i>Nauplii</i> <i>Mesocyclops</i> <i>Eucyclops</i> <i>Cladocera</i> – <i>Bosmina</i> <i>Moina</i> <i>Rotifera</i> – <i>Trichocera</i> <i>Euclinis</i> <i>Brachionus</i>	<i>Copepoda</i> – <i>Nauplii</i> <i>Cladocera</i> – <i>Bosmina</i> <i>Moina</i> <i>Rotifera</i> – <i>Trichocera</i> <i>Euclinis</i> <i>Brachionus</i>	<i>Copepoda</i> – <i>Eucyclops</i> <i>Nauplii</i> <i>Cladocera</i> – <i>Bosmina</i> <i>Moina</i> <i>Rotifera</i> – <i>Trichocera</i> <i>Euclinis</i> <i>Brachionus</i>

Table 5. Aquatic insects, ornamental fishes, shell fishes and other aquatic organism present in the beels of Hooghly, North 24 Parganas & Nadia district.

Aquatic insects	Back swimmers (<i>Notonecta</i>), Water stick insects (<i>Ranatra</i>), Pond skaters (<i>Gerris</i>), Water scorpions (<i>Nepa</i>), Diving beetles (<i>Cybister</i>), etc.
Ornamental fishes	<i>Puntius spp.</i> , <i>Chanda spp.</i> , <i>Rasbora spp.</i> , <i>Mystus vittatus</i> , <i>Amblypharyngodon mola</i> , <i>Colisa spp.</i> , <i>Botia spp.</i> , <i>Nandus nandus</i> , <i>Ambassis spp.</i> etc.
Shell fishes	<i>Macrobrachium rosenberghii</i>
Other aquatic organisms	Frogs, snakes, turtles etc.

Table 6. Fish species present in the beels of Hooghly, North 24 Parganas & Nadia District.

Fish Species	Hooghly		North 24 Parganas	Nadia
	Khanakul 1	Khanakul 2	Barrackpore Sub-division 1	Haringhata
Major Species	<i>Labeo rohita</i> <i>Catla catla</i> <i>Cirrhinus mrigala</i> <i>Ctenopharyngodon idella</i> <i>Hypophthalmichthys molitrix</i> <i>Cyprinus carpio</i> (less abundance)	<i>Labeo rohita</i> <i>Catla catla</i> <i>Cirrhinus mrigala</i> (less abundance)	<i>Labeo rohita</i> <i>Catla catla</i> <i>Cirrhinus mrigala</i> <i>Ctenopharyngodon idella</i> <i>Hypophthalmichthys molitrix</i> <i>Cyprinus carpio</i> (less abundance)	<i>Labeo rohita</i> <i>Catla catla</i> <i>Cirrhinus mrigala</i>
Minor Species	<i>Labeo bata</i> <i>Labeo calbasu</i> <i>Puntius sarana</i> <i>Eutropichthys vacha</i> (less abundance)	<i>Labeo calbasu</i> (less abundance)	<i>Labeo gonius</i> <i>Labeo bata</i> <i>Labeo calbasu</i> <i>Puntius sarana</i> (less abundance)	<i>Labeo bata</i> <i>Labeo gonius</i> <i>Labeo calbasu</i> <i>Puntius sarana</i>
Weed Fishes	<i>Chanda spp.</i> <i>Puntius spp.</i>	<i>Puntius spp.</i> <i>Chanda spp.</i> <i>Colisa spp.</i>	<i>Puntius spp.</i> <i>Chanda spp.</i> <i>Amblypharyngodon mola</i> <i>Colisa spp.</i> <i>Mystus spp.</i>	<i>Puntius spp.</i> <i>Amblypharyngodon mola</i> <i>Xenentodon cancila</i> <i>Chanda spp.</i> <i>Colisa spp.</i> <i>Mystus vittatus</i> <i>Mastacembelus panaculus</i>
Catfishes And Air-breathing Fishes	<i>Notopterus notopterus</i> <i>Channa spp.</i> <i>Heteropneustes fossilis</i> <i>Notopterus chitala</i> <i>Anabas testdineus</i>	<i>Channa spp.</i> <i>Heteropneustes fossilis</i> <i>Notopterus chitala</i> <i>Anabas testdineus</i>	<i>Mystus spp.</i> <i>Anabas testudineus</i> <i>Channa spp.</i> <i>Wallago attu</i> <i>Notopterus notopterus</i> <i>Notopterus</i> <i>Clarias batrachus</i> <i>Heteropneute fossilis</i>	<i>Mystus spp.</i> <i>Wallago attu</i> <i>Notopterus chitala</i> <i>Notopterus notopterus</i> <i>Anabas testudineus</i> <i>Ompok bimaculatus</i> <i>Heteropneute fossilis</i> <i>Clarias batrachus</i> <i>Ompok pabda</i> <i>Channa spp.</i>

Table 7. Yield of Fish (Q/yr) in the beels of Hooghly, North 24 Parganas & Nadia District during 2009-10.

Hooghly		
Block	Name of the beel	Yield (Q/yr)
Khnakul 1	1. Keshar	198.7
	2. Chakrapur Beel	80.0
	3. Ramnagar Beel	131.5
	4. Matiara Beel	20.7
	5. Pannam	80.0
	6. Labasan Beel	120.0
	7. Bhagabati Beel	70.2
	8. Kolupukur Beel	60.0
	9. Jhamp Pukur Beel	80.0
	10. Banerjee Beel	55.6
	11. Chakraborty Beel	66.7
	12. Katapukur Beel	55.7
	13. Moyla	60.8
Khnakul 2	14. Block Beel	60.2
	15. Rajhati Beel	110.0
	16. Borpukur Beel	49.7
	17. Ram Dighi	70.2
	18. Kumorhat Beel	35.0
	19. Khirkir Beel	39.8
	20. Dighi	120.0
Mean	78.2	

North 24 Parganas		
Block	Name of the beel	Yield (Q/yr)
Barrack-pore Sub-div 1	1. Bharat Housing Beel	31.0
	2. Annapurna Beel	102.3
	3. Ichhapur Beel	110.3
	4. Sodla Beel	65.3
	5. Pritinagar Beel 1	97.3
	6. Pritinagar Beel 2	77.3
	7. Jagaddal Beel 1	55.8
	8. Jagaddal Beel 2	45.6
	Mean	73.1

Nadia		
Block	Name of the beel	Yield (Q/yr)
Harin-ghata	1. Magra (Sonakhali) Beel	212.7
	2. Kumli Beel	147.0
	Mean	179.9

Table 8. Year wise production from the studied beels in Quintal/Year.

Production / Year	Name of the Beels										
	Keshar Beel	Chakrapur Beel	Ramnagar Beel	Matiara Beel	Pannam Beel	Labasan Beel	Bhagabati Beel	Kolupukur Beel	Jhamp Pukur Beel	Banerjee Beel	
2005-06	183.9	77.2	132.5	21.2	91.3	119.2	60.7	57.3	81.0	58.9	
2006-07	203.1	77.5	133.7	20.3	83.9	116.7	62.8	55.9	82.5	57.5	
2007-08	177.3	79.3	129.0	19.3	81.7	117.6	63.0	56.2	79.3	57.2	
2008-09	190.1	78.2	130.0	19.5	83.0	118.7	69.0	58.7	79.7	56.0	
2009-10	198.7	80.0	131.5	20.7	80.0	120.0	70.2	60.0	80.0	55.6	

Production / Year	Name of the Beels										
	Chakraborty Beel	Katapur Beel	Moyla Beel	Block Beel	Rajhati Beel	Borpukur Beel	Ram Dighi Beel	Kumorhat Beel	Khirkir Beel	Dighi Beel	
2005-06	70.0	54.0	68.3	60.1	99.7	50.2	70.0	32.5	38.2	119.8	
2006-07	69.2	53.0	64.9	61.3	98.3	46.9	67.3	34.8	39.2	117.3	
2007-08	68.3	53.2	61.2	59.9	107.0	45.2	69.8	33.4	38.3	115.8	
2008-09	65.2	54.9	62.3	59.7	109.1	44.3	71.0	33.7	37.2	105.3	
2009-10	66.7	55.7	60.8	60.2	110.0	49.7	70.2	35.0	39.8	120.0	

Production / Year	Name of the Beels										
	Bharat Housing Beel	Annapurna Beel	Ichhpur Beel	Sodla Beel	Pritinagar Beel 1	Pritinagar Beel 2	Jagaddal Beel 1	Jagaddal Beel 2	Sonakhali (Magra) Beel	Kumli Beel	
2005-06	30.0	98.1	99.4	65.5	99.4	75.5	55.2	45.2	185.0	149.0	
2006-07	35.0	94.7	105.9	64.0	103.6	79.4	53.6	43.2	191.0	152.0	
2007-08	29.5	95.6	120.0	67.2	101.2	81.6	55.7	47.9	197.8	135.0	
2008-09	32.0	90.8	107.8	66.8	95.8	75.5	53.4	46.0	209.8	143.0	
2009-10	31.0	102.3	110.3	65.3	97.3	77.3	55.8	45.6	212.7	147.0	

Fig. Fish Production from Keshar Beel during the years (in Q)

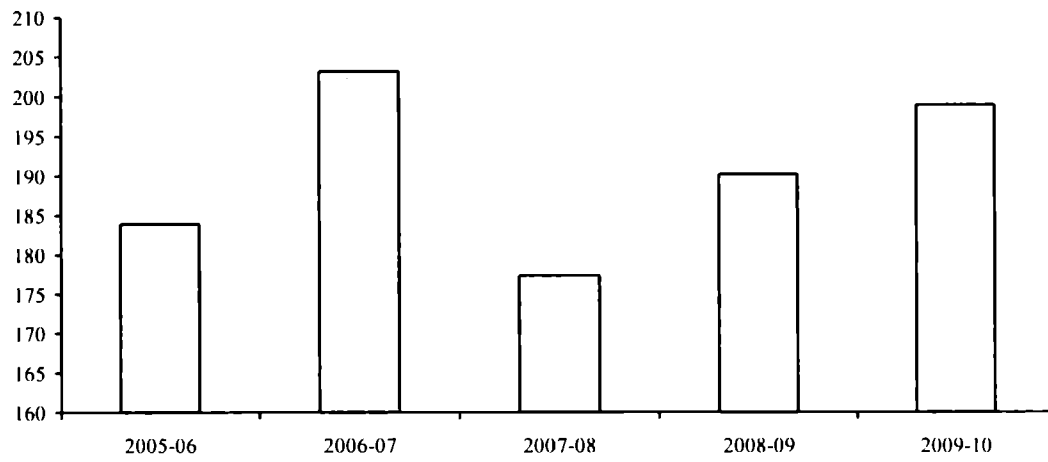


Fig. Fish Production from Chakrapur Beel during the years (in Q)

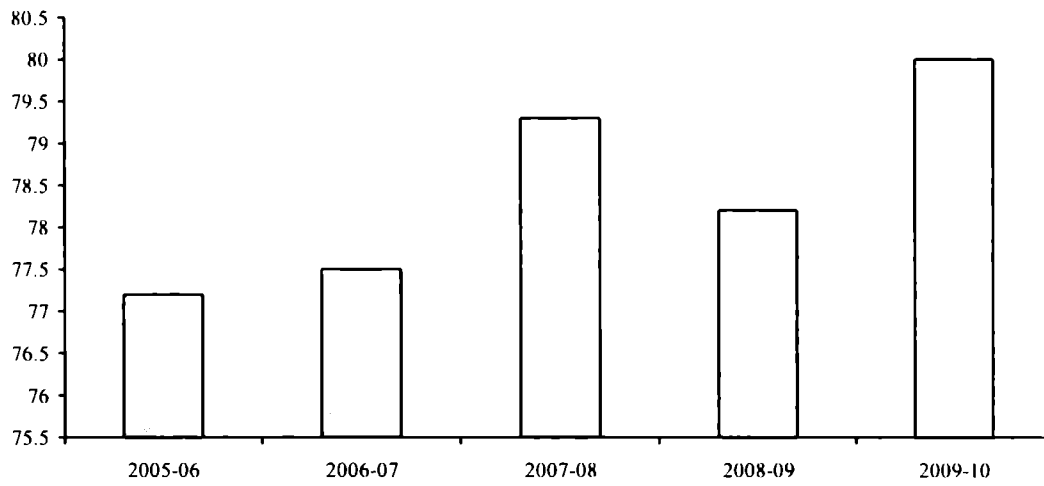


Fig. Fish Production from Ramnagar Beel during the years (in Q)

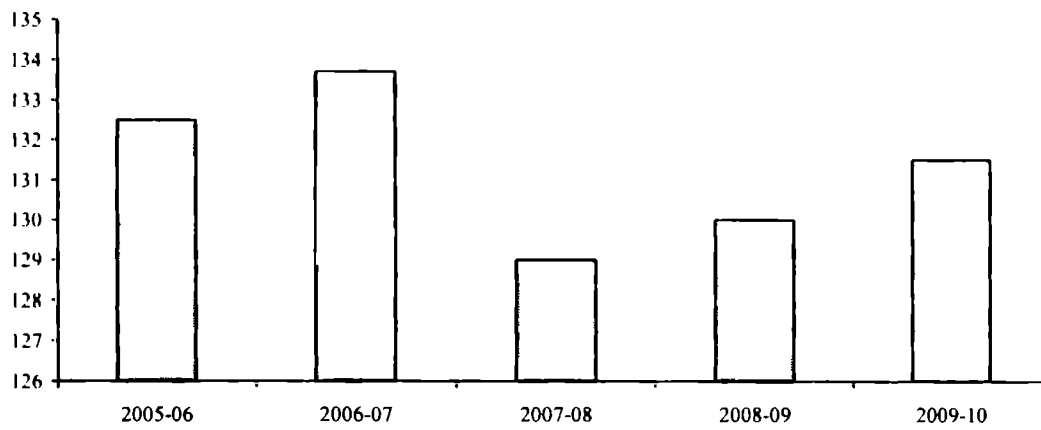


Fig. Fish Production from Matiara Beel during the years (in Q)

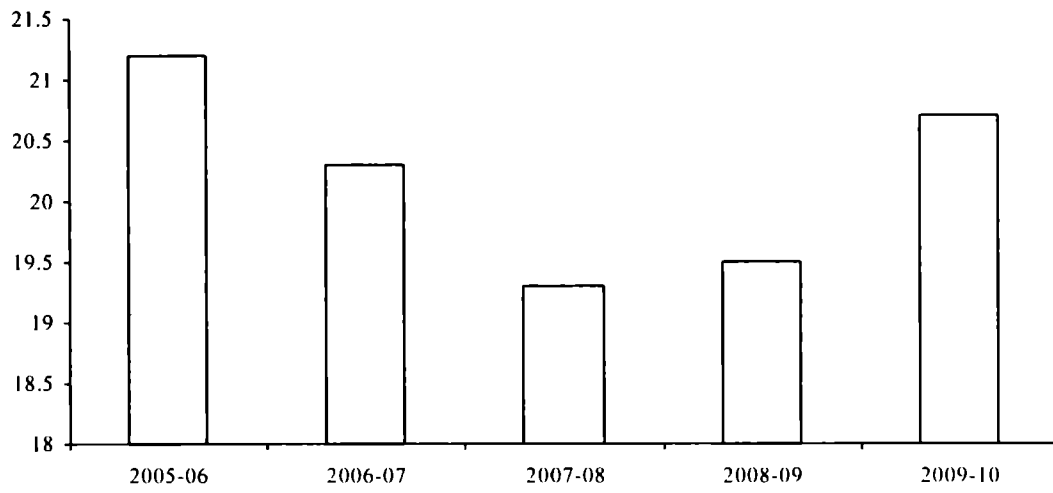


Fig. Fish Production from Pannam Beel during the years (in Q)

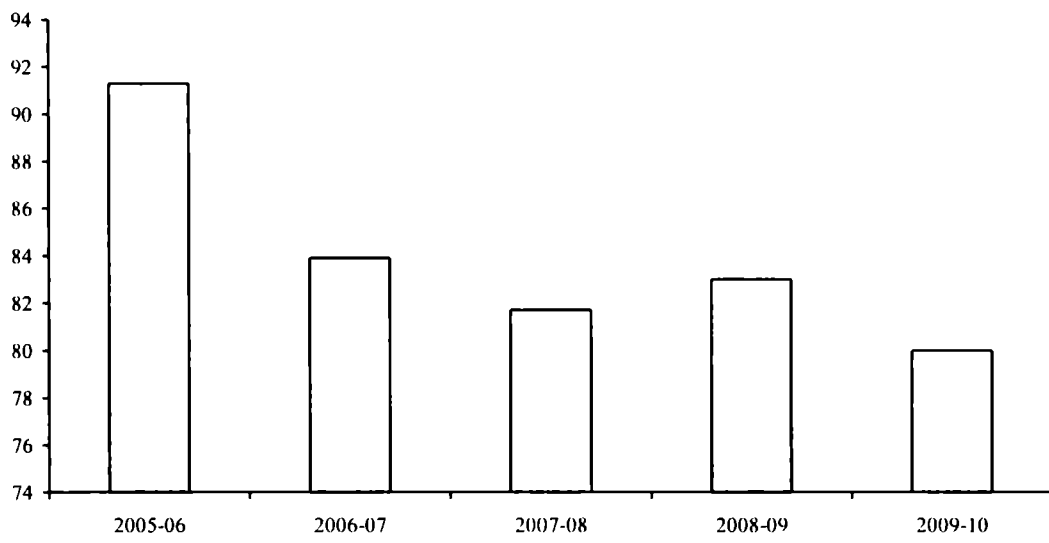


Fig. Fish Production from Labasan Beel during the years (in Q)

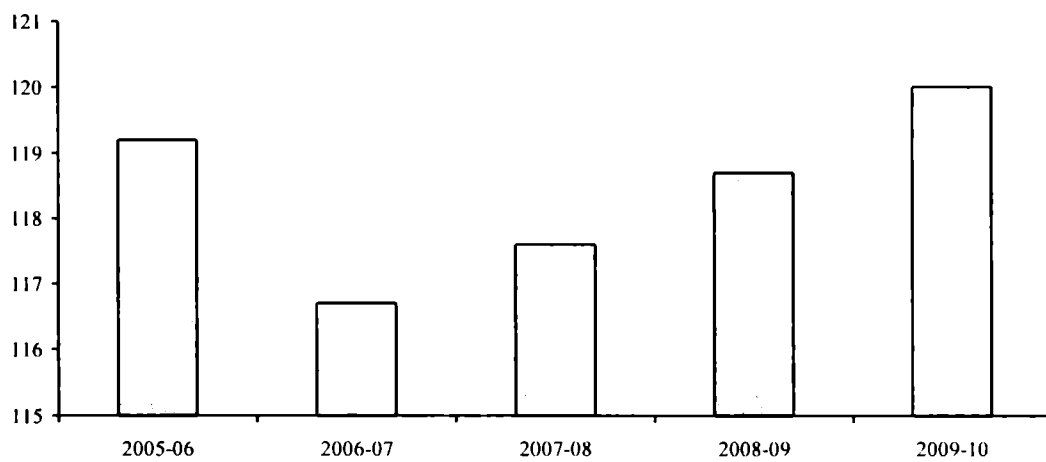


Fig. Fish Production from Bhagabati Beel during the years (in Q)

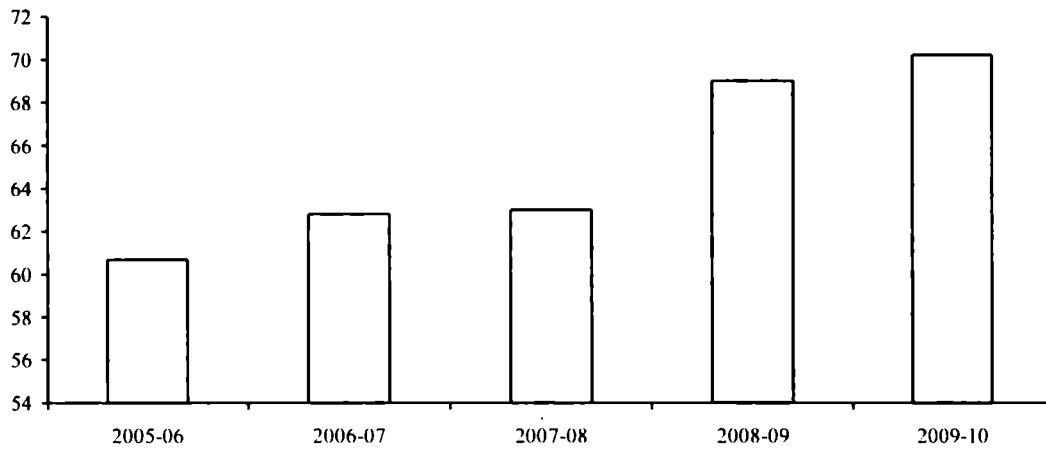


Fig. Fish Production from Kolupukur Beel during the years (in Q)

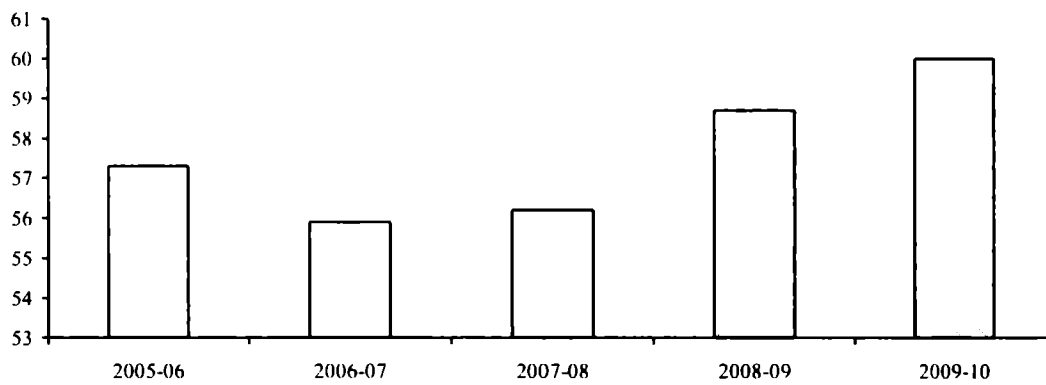


Fig. Fish Production from Jhamp Pukur Beel during the years (in Q)

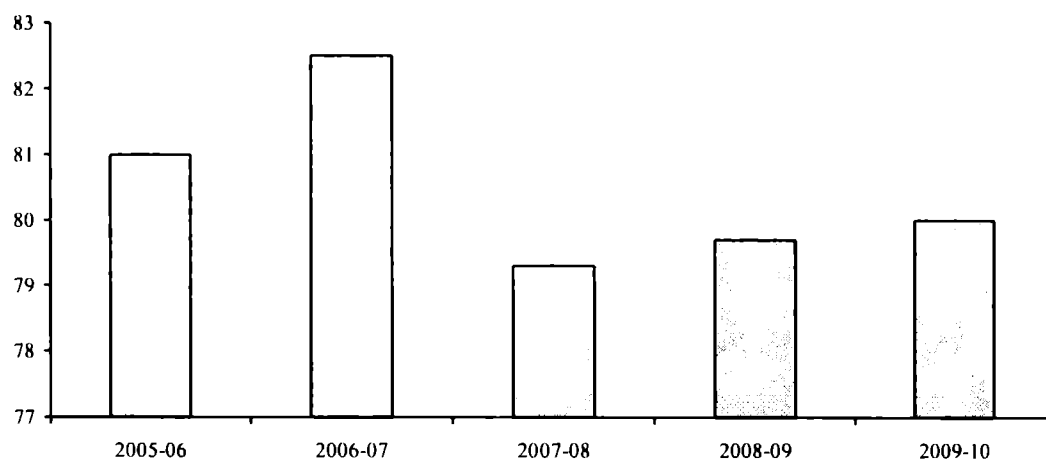


Fig. Fish Production from Banerjee Beel during the years (in Q)

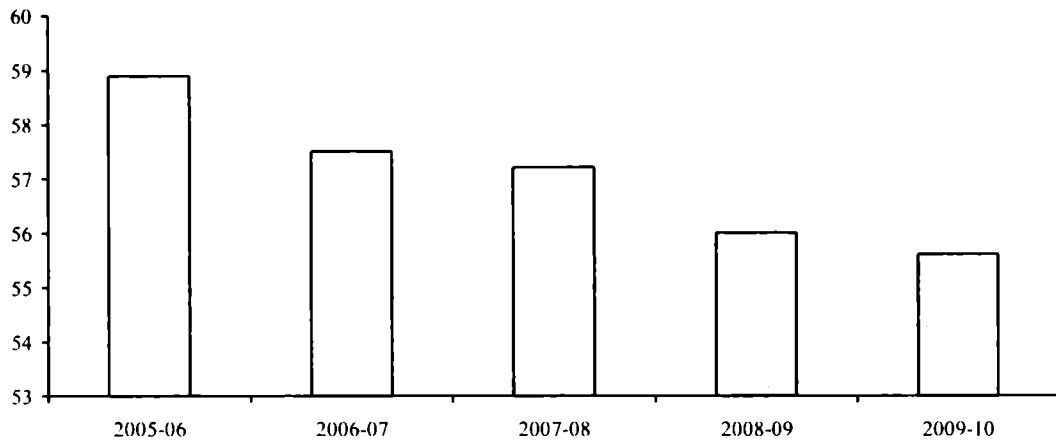


Fig. Fish Production from Chakraborty Beel during the years (in Q)

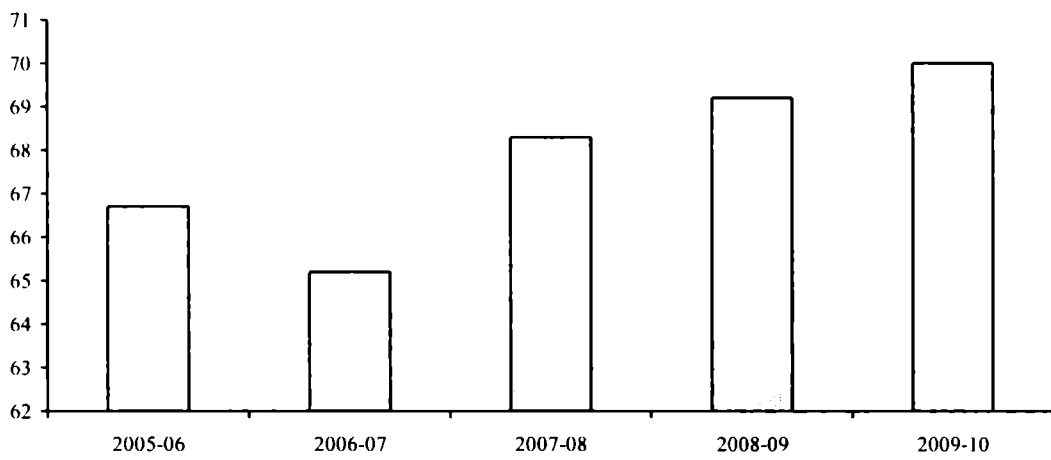


Fig. Fish Production from Katapukur Beel during the years (in Q)

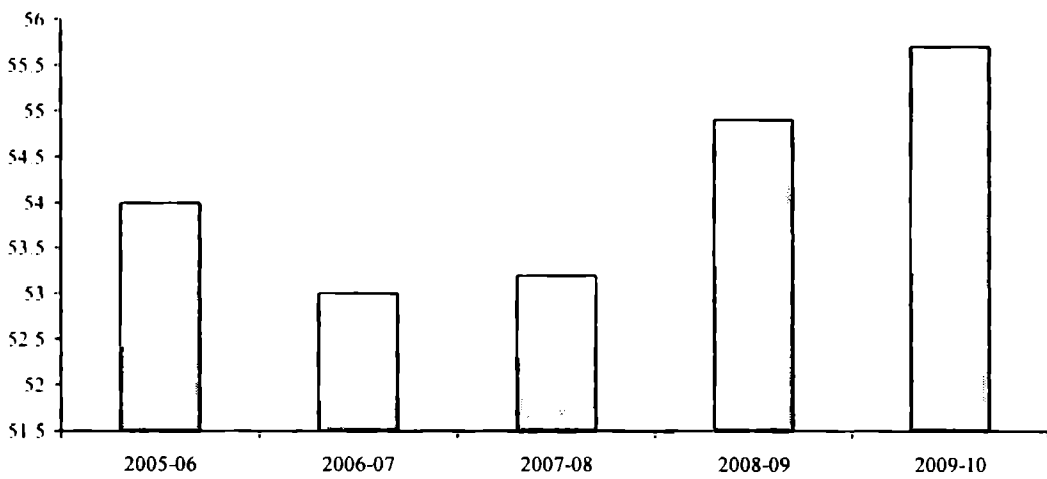


Fig. Fish Production from Moyla Beel during the years (in Q)

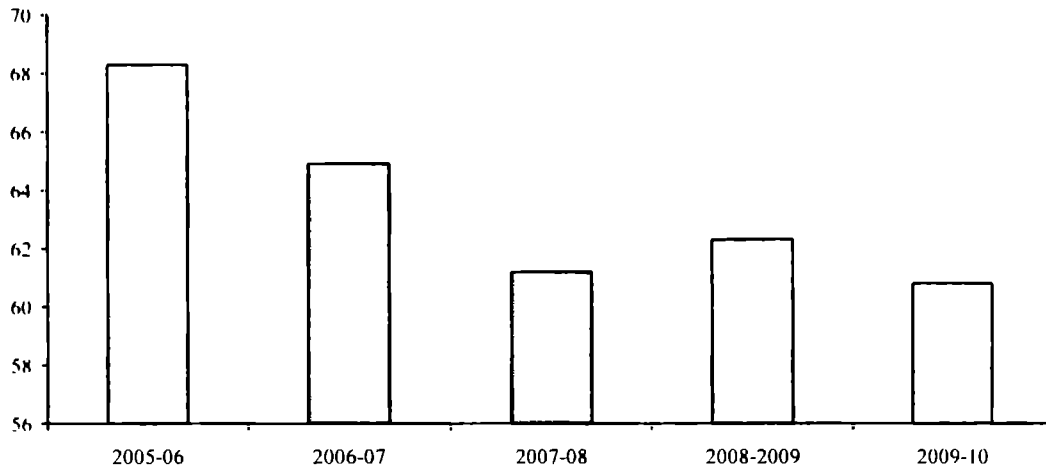


Fig. Fish Production from Block Beel during the years (in Q)

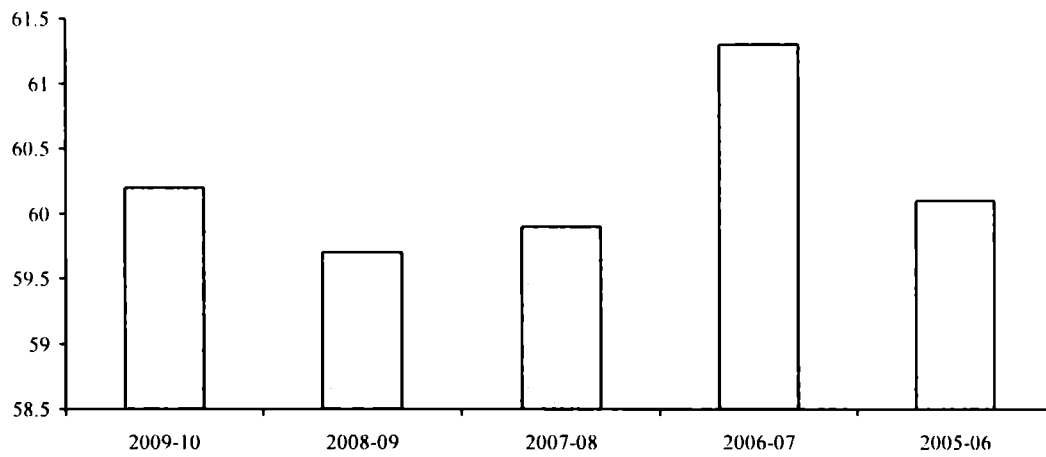


Fig. Fish Production from Rajhati Beel during the years (in Q)

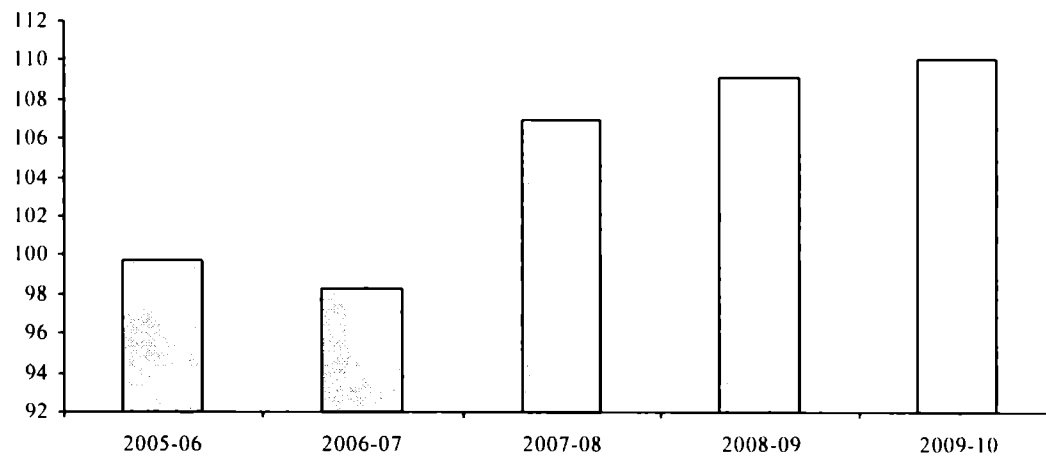


Fig. Fish Production from Borpukur Beel during the years (in Q)

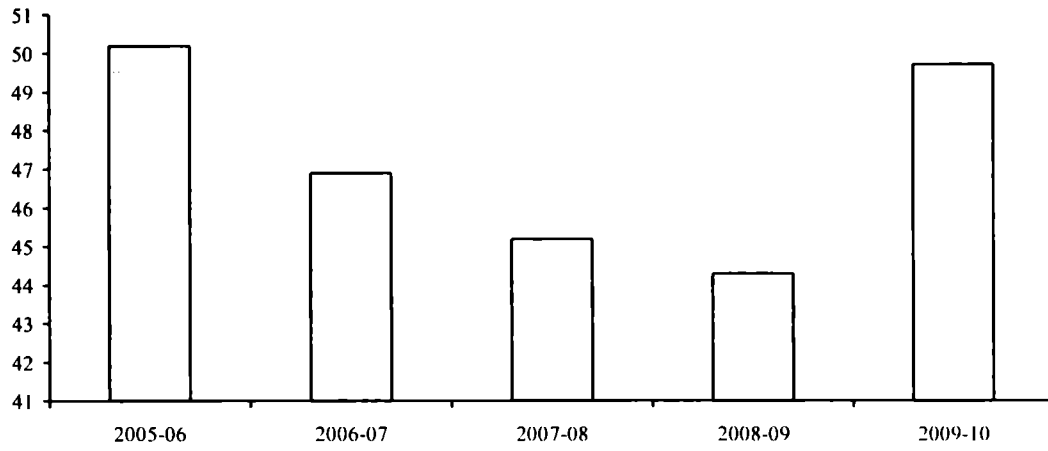


Fig. Fish Production from Ram Dighi during the years (in Q)

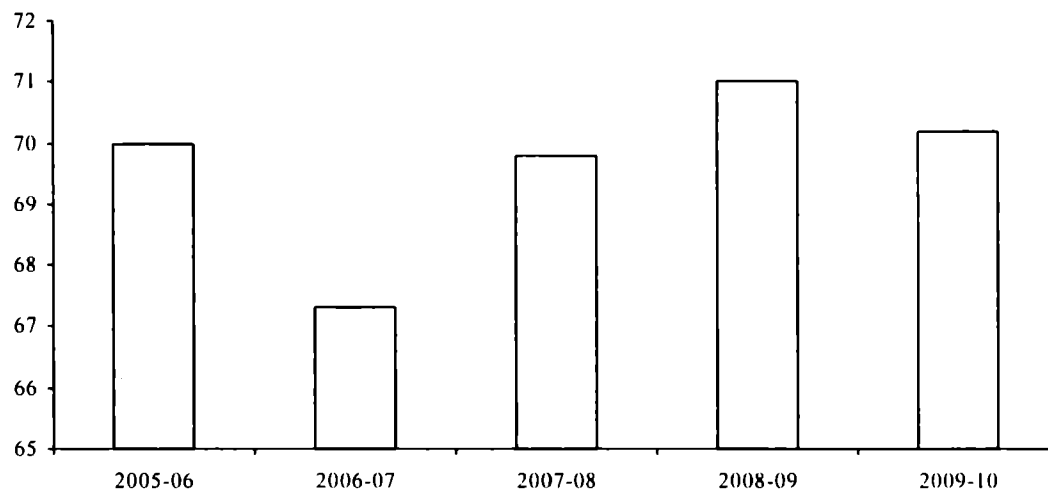


Fig. Fish Production from Kumorhat Beel during the years (in Q)

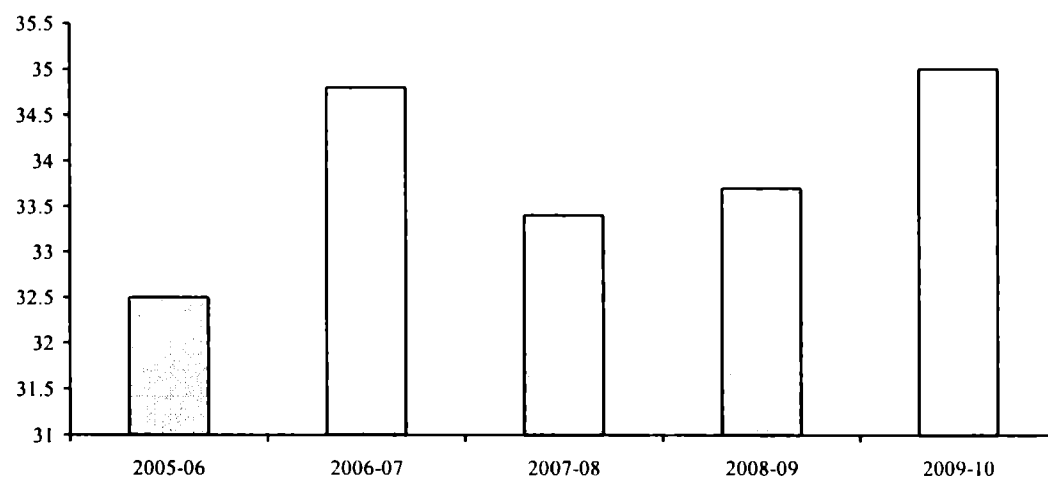


Fig. Fish Production from Khirkir Beel during the years (in Q)

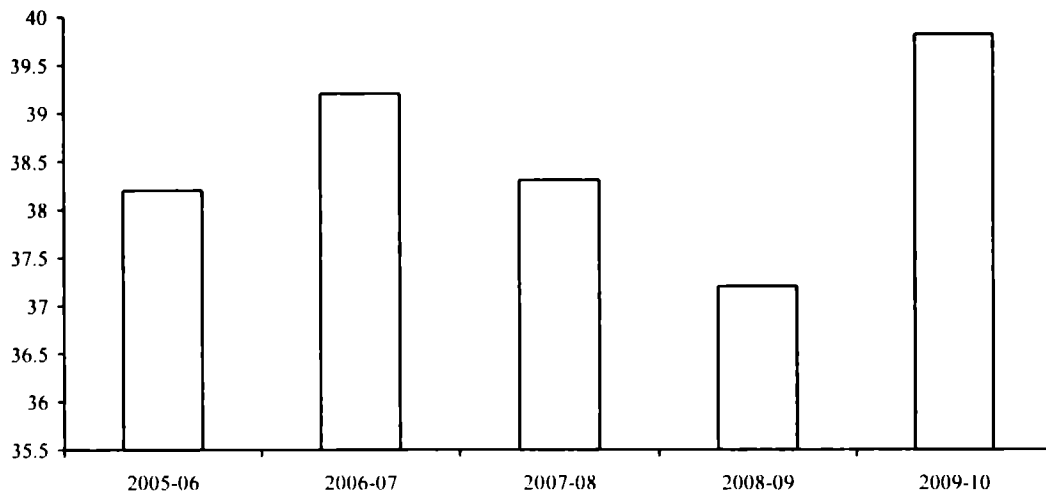


Fig. Fish Production from Dighi during the years (in Q)

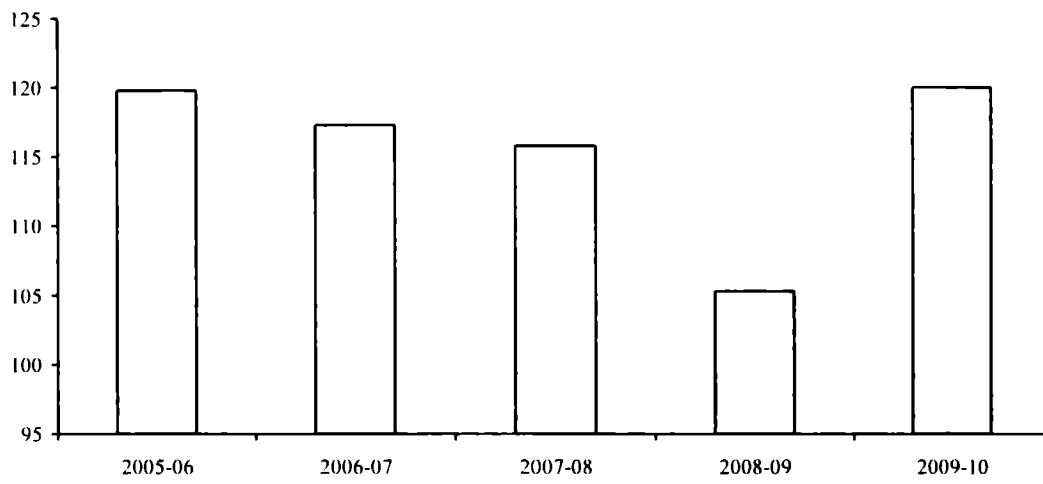


Fig. Fish Production from Bharat Housing Beel during the years (in Q)

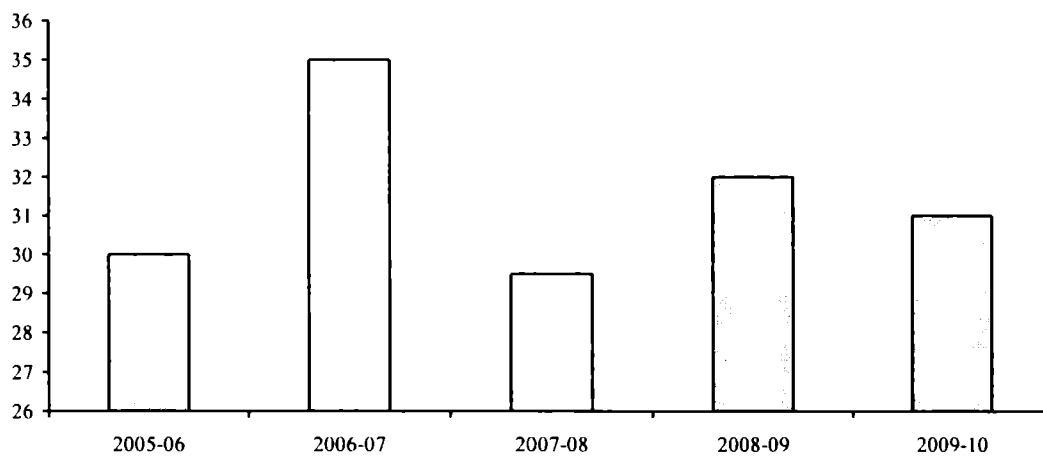


Fig. Fish Production from Annapurna Beel during the years (in Q)

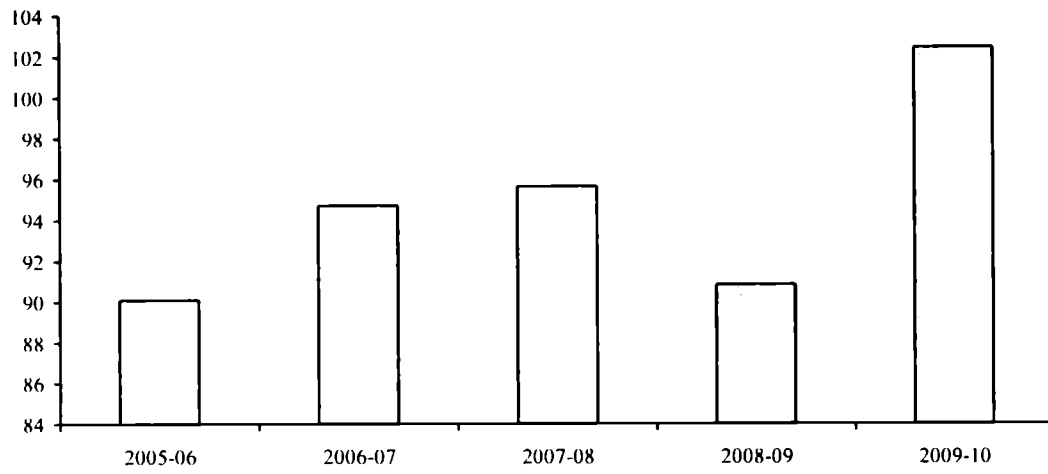


Fig. Fish Production from Ichhapur Beel during the years (in Q)

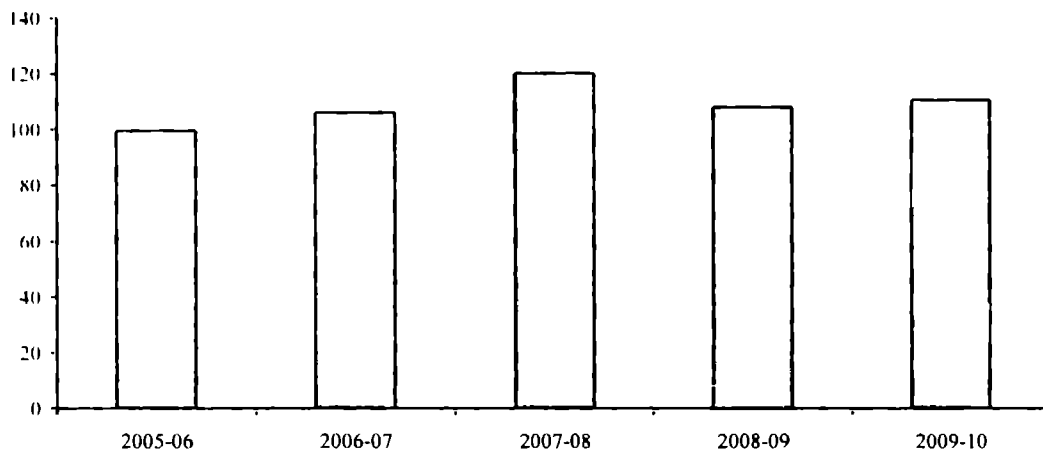


Fig. Fish Production from Sodla Beel during the years (in Q)

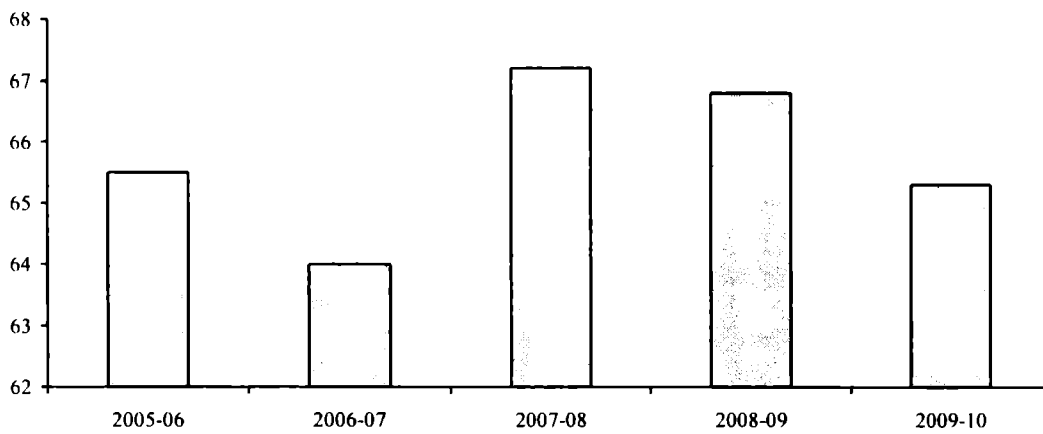


Fig. Fish Production from Pritinagar Beel 1 during the years (in Q)

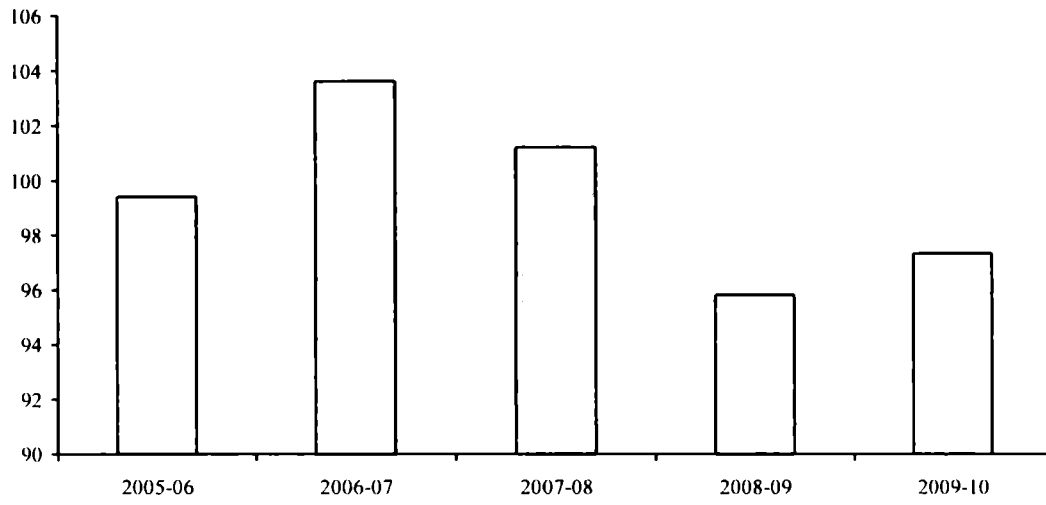


Fig. Fish Production from Pritinagar Beel 2 during the years (in Q)

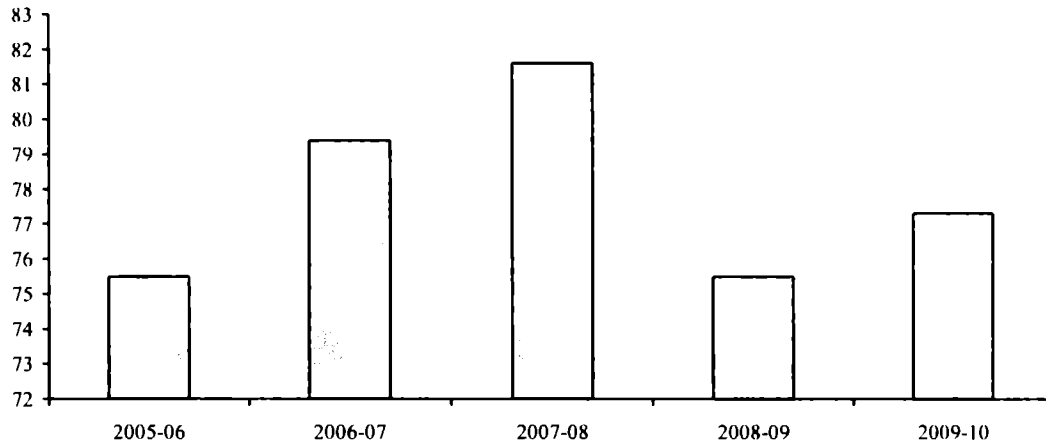


Fig. Fish Production from Jagaddal Beel I during the years (in Q)

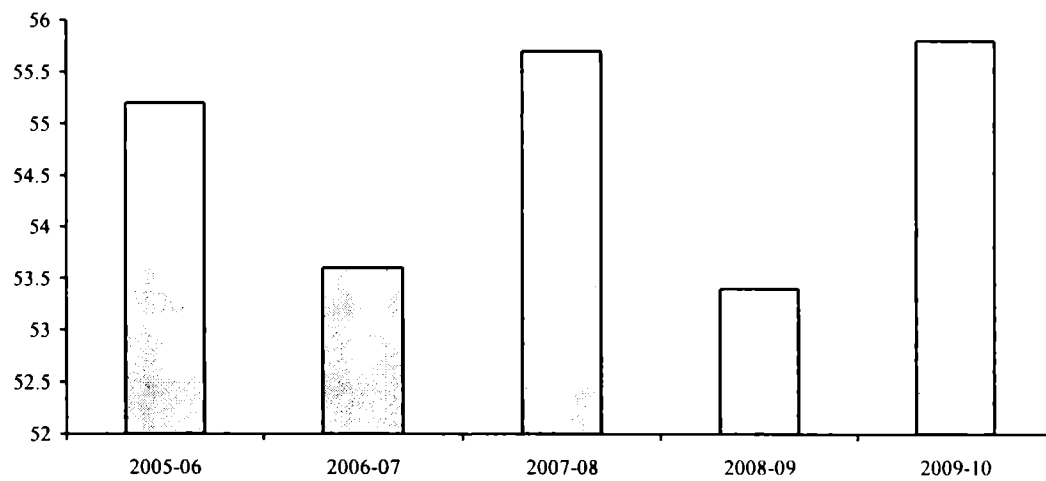


Fig. Fish Production from Jagaddal Beel 2 during the years (in Q)

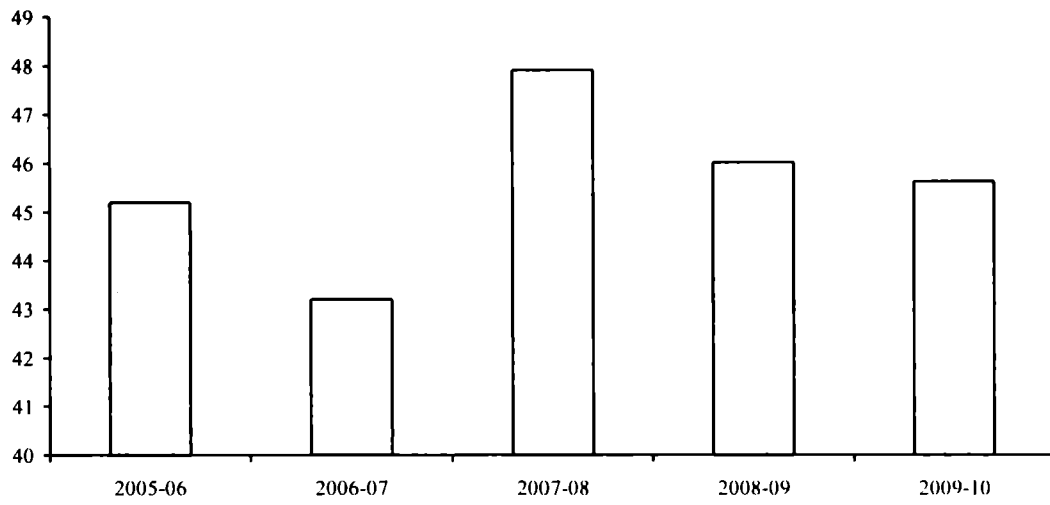


Fig. Fish Production from Sonakhali Beel during the years (in Q)

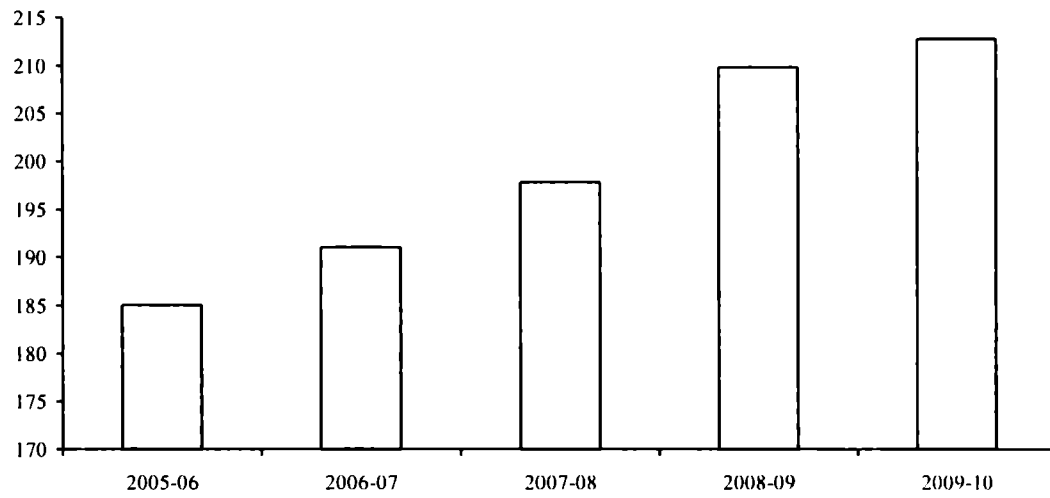


Fig. Fish Production from Kumli Beel during the years (in Q)

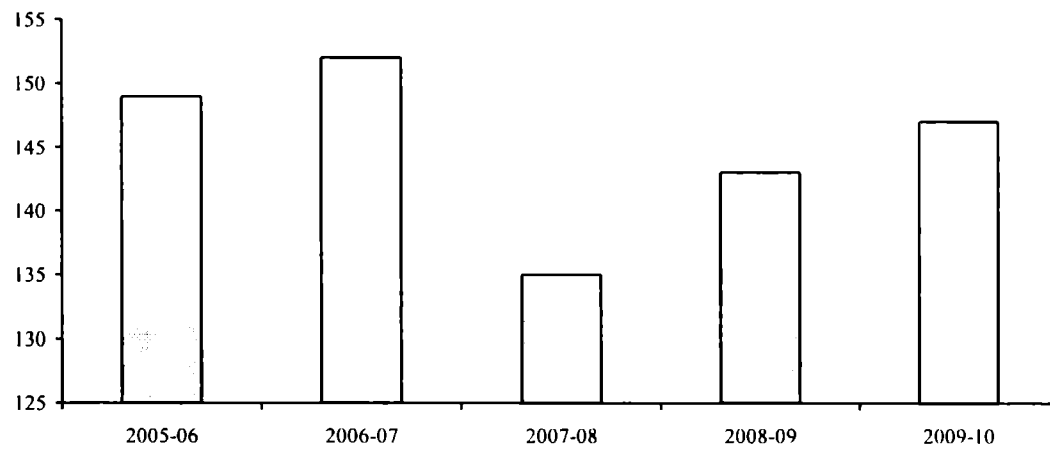


Table 9. Management practices followed in the beels of Hooghly, North 24 Parganas & Nadia District.

Management Practices		Hooghly, North 24 Parganas & Nadia District						No Management (0%)
1) Eradication of:		Management practiced (100%)						
		Type of management practices						
Manual	Methods	Chemical	Methods	Biological	Methods	Herbivorous fishes also helps in controlling	No Management (0%)	
100%	Manually during harvesting Period	0%	---	100%	---	Methods		No Management (0%)
100%	Repeated netting using gill Nets, cast net, traps etc & Dewatering.	0%	---	0%	---	Methods		
100%	Repeated netting using gill Nets, pole and line etc & Dewatering.	0%	---	0%	---	Methods	No Liming (50%)	
		Liming practiced (50%)						
		Type	Dose			Frequency	No Fertilization (100%)	
		Agricultural lime	12-18 bags in total area			2 weeks before stocking		
		Type	Dose			Frequency	No Manuring (100%)	
		---	---			---		
		Type	Dose			Frequency	No Prophylaxis (100%)	
		---	---			---		
		Type	Dose			Frequency	No Feeding (80%)	
		---	---			---		
		Artificial feeding (0%)		Supplementary feeding (20%)				
		Feed composition		Feed ratio		Feeding schedule		
		---		---		---		
		Feed composition		Feed ratio		Feeding schedule		
		Rice bran, Mustard oil cake, Ground nut oil cake etc.		---		Irregular		
		Stocking practiced (80%)						No Stocking (20%)
		Species stocked	Species ratio	Stocking size	Stocking density	Stocking frequency		
		Labeo rohita, Catla catla, Cirrhinus mrigala, Hypophthalmichthys molitrix, Cyprinus carpio etc.	---	10-15 cm Or 10-15 gm fingerling	1000-2000 nos./acre of advanced fingerling	Occasional		

Table 10. Nets & Gears operated in the beels of Hooghly, North 24 Parganas & Nadia District

Name	Mesh Size	Fish commonly tapped
A. Nets		
1. Drag Net	2.0 cm	Small sized carps, trash fishes.
2. Gill Net		
i)With foot rope	6.0 cm	<i>Channa marulius</i> , <i>Channa striatus</i> etc.
ii)Without foot rope	2.4 cm	Small fishes of all kinds.
3. Cast Net	1.0-3.0 cm	Small major carps, <i>Puntius sp.</i>
4. Scoop Net	1.0-1.5 cm 0.8-1.0 cm	Minor carps, trash fishes & smaller catfishes. All kinds of small fishes including juveniles & prawns.
5. Purse-Seine(Belt jal)	4.0 cm	Indian major carps & silver carps.
6. Chetki Jal	0.5-1.0 cm	Smaller fishes, trash fishes & small prawns.
B. Crafts		
1. Wooden country made boats, 1-2 m X 5-6 m are generally used.		
2. Dinghi		

Table 11. Problems encountered in the beels of Hooghly, North 24 Parganas & Nadia District.

PROBLEMS	Hooghly			North 24 Parganas	Nadia	Total Mean (%)
	Khanakul 1 (%)	Khanakul 2 (%)	Mean (%)			
Institutional support and Finance Problems						
Lack of Govt. support	80	80	80.0	80	60	73.3
Lack of finance	80	75	77.5	80	60	72.5
Lack of advance harvesting equipments	90	90	90.0	70	70	76.6
Lack of technical know-how	70	70	70.0	60	60	63.3
Lack of extension/transfer of technology	70	70	70.0	70	70	70.0
Management Problems						
Non-application of mesh size regulation	80	80	80.0	70	40	63.3
Fishing during breeding season	80	80	80.0	70	40	63.3
Lack of quality seeds	70	70	70.0	60	70	66.6
Ecological Problems						
Pollution/ Discharge	10	10	10.0	75	50	45.0
Situation	30	60	45.0	30	70	48.3
Heavy macrophyte infestation	50	70	60.0	65	90	71.6
Disease	20	25	22.5	20	40	27.5
Anthropogenic Problems						
Land reclamation	10	10	10.0	10	10	10.0
Encroachment	60	60	60.0	55	20	45.0
Poaching	10	20	15.0	70	15	33.3
Anti-social element	25	35	30.0	55	35	40.0
Over-exploitation	10	10	10.0	40	40	30.0

Picture 1. A View of a Beel in Hooghly



Picture 2. A View of a Beel in North 24 Parganas



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Picture 3. A view of a weed (Eichornia) choked Beel in Nadia.



Picture 4. A floating macrophyte (Pistia) in a Beel in North 24 Parganas.



Picture 5. A typical view of a Pond Skater.



Picture 6. A typical view of a Back Swimmer.



CHAPTER -5



DISCUSSION

DISCUSSIONS

The result of the present study indicates that most of the unmanaged floodplain lakes in the Hooghly, North 24 Parganas & Nadia districts of West Bengal are basically dead beels with regards to their connectivity with the parent rivers. Because of this, most of the beels are devoid of any introduction of riverine species. Jhingran (1991) & Sugunan et al. (2000) mentioned that since majority of beels remains cut-off from the rivers due to natural causes or construction of riverine embankments, there was absence of significant recruitments from rivers. As a result, these closed beels are inhabited by fishes that can spawn in stagnant waters like murrels, *W. attu*, *N. notopterus*, barbs, rasboras etc. large riverine catfishes *Bagarius bagarius*, *Pangasius pangasius*, *Notopterus chitala*, *Ompok* sp. are likely to be absent there. The beels are subjected to infestation of macrophytes as there is no flushing from the rivers. However, the average water depth (6.23 ft in Hooghly, 7.72 ft in North 24 Parganas & 7.75 ft in Nadia) is considered to be congenial for fish culture activities as Rath (2000) observed that the optimal water depth for fish culture should be 2-3 m. Jhingran (1991) also mentioned that a depth of about 2 m was considered congenial from the point of view of biological productivity of a water body.

So far the management practices are concerned, most of the beels are yet to get modern scientific practices. Therefore, the average productivity of the beels studied in all the districts (Hooghly, North 24 Parganas & Nadia) is very less with respect to their potentials. Regarding the stocking size & density, it is found that the stocking rate is comparatively high (1000-2000 nos./ha) though, the beels are not subjected to proper eradication of wide range of predatory & unwanted fishes. It might be suggested here that stocking density should be reduced to some extent & the stocking size should be higher (15-30 cm in length & 50-100 g in weight) in comparison to the present practices (10-15 cm in length & 10-15 g in weight). This will be helpful for the desired species to compete with the unwanted & large sized predatory fishes.

Plankton

Phytoplankton – Phytoplankton are primary producers which form the base for an autotrophic food chain. Phytoplankton belonging to Chlorophyceae, Myxophyceae & Bacillariophyceae is recorded during the study period.

Rana et al. (1996) observed Cyanophyceae to be a dominant component of the phytoplanktonic population in an unmanaged beel, whereas Sugunan & Bhattachariya (2000) found Chlorophyceae as dominant in the beels of Assam. Presence of pollution tolerant species of phytoplankton like *Euglena* has also being considered indicative of enriched waters (Khan et al., 1998). Presence of most pollution tolerant species of phytoplankton *Oscillatoria*, *Scenedesmus* & *Euglena* indicates high degree of organic pollution (Nandan & Patel, 1992). Vasisht & Sra (1979) had recorded the dominance & regular presence of *Microcystis* sp as an indicative of of pollution & eutrophication of waterbody. Saify et al. (1986) had attributed the Chlorophyceae dominance to the eutrophic condition of water bodies.

Zooplankton – A total of three zooplankton species are recorded in the studied beels of study area. In the present investigation, the zooplanktons are mainly constituted by Rotifers, Cladocerans & Copepods. Like phytoplankton, a few zooplankton species are also considered as indicator of organic pollution by many ecologists. According to Bath (1997), Copepods & Cladocerans are abundant groups in Harike wetlands & Syal (1991) referred these groups as tolerant groups. The dominance of Copepods had also been reported by Seenayya (1973) & Ayyappan & Gupta (1980). Kurasawa (1975) from his study on several Japanese lakes showed the dominance of Copepods & dominance of Cladocerans & Rotifers in oligotrophic & eutrophic lakes respectively. But, according to Varghese et al. (1992), in tropical eutrophic lakes, Cyclops is dominant. Lillieroth (1950) designated *Brachionus* sp as an indicator of eutrophy. According to Ruttner (1974), Rotifers are highly sensitive to low oxygen.

Fishery of the studied Beels

The data provided by the Secretary of the co-operative societies or by the lease owners, indicates good fish production in spite of all the adverse conditions of the beels. Though only Indian major carps are stocked in most of the beels, but during harvesting other weed fishes & some of the catfishes & air-breathing fishes are also noticed in the catch. The overall productions from the beels during the past years are tabled earlier. The data indicates a good fish yield of 78.2 quintal/year, 73.1 quintal/year & 179.9 quintal/year in Hooghly, North 24 Parganas & Nadia respectively. Sugunan & Bhattachariya (2000) had reported a range of 14 kg/ha/yr to 488kg/ha/yr of fish production from the beels of Assam surveyed by them. Yadava & Sugunan (1992) recorded a fish yield of 120kg/ha/yr from a 2000 ha shallow lake of eastern Uttar Pradesh. Acharjee et al. (1999) observed a low fish production of only 4.4 kg/ha/yr from the Dighali beel of Assam. Acharjee et al. (1998) also found that the average annual fish production in the three beels of lower Brahmaputra basin were 14.4, 144.5 & 13.5 kg/ha respectively. Padmavati & Durgaprasad (1997) noticed a fish yield of 4.13t/ha/yr from a pond devoid of aquatic weed in the environments of lake Kolleru.

Sound management practices, mesh size regulation & proper stocking may increase the current fish production to many folds.

Statistical Analysis

In order to find out the differences among the sites, the data are statistically analyzed by employing analysis of variance. The summary of these ANOVA is presented in the next pages.

The significance of variation among the sites is found out by computing F value & comparing with F critical value. For most of the parameters of production, the calculated F values are found to be less than F critical values which indicates that for these parameters there is no significant difference among the sites.

The correlation coefficient values show the positive or negative relationship between the parameters of production, area & depth. The summary of these relationships is also presented in the next pages.

Table 12. A table showing Analysis of Variance of the production from the beels. (Refer to Table 8)

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
2005-06	30	2448.3	81.61	1711.475
2006-07	30	2468.5	82.28333	1917.172
2007-08	30	2443.5	81.45	1747.019
2008-09	30	2446.5	81.55	1916.602
2009-10	30	2509.4	83.64667	2049.671

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	101.7171	4	25.42927	0.01361	0.999631	2.434065
Within Groups	270916.2	145	1868.388			
Total	271018	149				

Comments

The result gives Summary statistics for the five groups & the ANOVA table shows calculated values of Sum of Squares (SS), degrees of freedom (df), Mean Square Probability value (P-value), calculated F & the table value of F is given under Critical F (F crit). In this case, calculated F (0.01361) is less than the table F (2.434065). That is, there is no significant difference between the means of the five groups.

Table 13. A table showing Analysis of Variance of the problems of the beels. (Refer to Table 11)

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Khanakul 1	17	845	49.70588	926.4706
Khanakul 2	17	915	53.82353	814.1544
Barrackpore 1	17	980	57.64706	431.6176
Haringhata	17	840	49.41176	490.2574

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	773.5294	3	257.8431	0.38737	0.762466	2.748191
Within Groups	42600	64	665.625			
Total	43373.53	67				

Comments

The result gives Summary statistics for the five groups & the ANOVA table shows calculated values of Sum of Squares (SS), degrees of freedom (df), Mean Square Probability value (P-value), calculated F & the table value of F is given under Critical F (F crit). In this case, calculated F (0.38737) is less than the table F (2.748191). That is, there is no significant difference between the means of the five groups.

Table 14. A table showing Correlation of Production with Area of the beels.

Production(Q/Yr)	2005-06	2006-07	2007-08	2008-09	2009-10	Area(Acre)
Keshar	183.9	203.1	177.3	190.1	198.7	10.5
Chakrapur Beel	77.2	77.5	79.3	78.2	80.0	3.0
Ramnagar Beel	132.5	133.7	129.0	130.0	131.5	9.0
Matiara Beel	21.2	20.3	19.3	19.5	20.7	7.5
Pannam	91.3	83.9	81.7	83.0	80.0	7.0
Labasan Beel	119.2	116.7	117.6	118.7	120.0	8.5
Bhagabati Beel	60.7	62.8	63.0	69.0	70.2	3.5
Kolupukur Beel	57.3	55.9	56.2	58.7	60.0	3.5
Jhamp Pukur Beel	81.0	82.5	79.3	79.7	80.0	5.0
Banerjee Beel	58.9	57.5	57.2	56.0	55.6	6.5
Chakraborty Beel	70.0	69.2	68.3	65.2	66.7	4.0
Katapukur Beel	54.0	53.0	53.2	54.9	55.7	5.5
Moyla	68.3	64.9	61.2	62.3	60.8	4.5
Block Beel	60.1	61.3	59.9	59.7	60.2	6.0
Rajhati Beel	99.7	98.3	107.0	109.1	110.0	4.5
Borpukur Beel	50.2	46.9	45.2	44.3	49.7	6.0
Ram Dighi	70.0	67.3	69.8	71.0	70.2	4.5

Kumorhat Beel	32.5	34.8	33.4	33.7	35.0	4.0
Khirkir Beel	38.2	39.2	38.3	37.2	39.8	4.0
Dighi	119.8	117.3	115.8	105.3	120.0	4.5
Bharat Housing Beel	30.0	35.0	29.5	32.0	31.0	4.0
Annapurna Beel	98.1	94.7	95.6	90.8	102.3	6.5
Ichhapur Beel	99.4	105.9	120.0	107.8	110.3	4.5
Sodla Beel	65.5	64.0	67.2	66.8	65.3	4.8
Pritinagar Beel 1	99.4	103.6	101.2	95.8	97.3	4.0
Pritinagar Beel 2	75.5	79.4	81.6	75.5	77.3	3.5
Jagaddal Beel 1	55.2	53.6	55.7	53.4	55.8	3.0
Jagaddal Beel 2	45.2	43.2	47.9	46.0	45.6	3.5
Sonakhali (Magra) Beel	185.0	191.0	197.8	209.8	212.7	4.5
Kumli Beel	149.0	152.0	135.0	143.0	147.0	4.0
	2005-06	2006-07	2007-08	2008-09	2009-10	Area
2005-06	1					
2006-07	0.995502	1				
2007-08	0.988479	0.987834	1			
2008-09	0.988343	0.990123	0.993478	1		
2009-10	0.990778	0.992555	0.993984	0.997073	1	
Area	0.396228	0.39787	0.34187	0.360318	0.363485	1

Comments

The result is given in the form of a two-way table. We can identify the correlation coefficient between any pair of variables in the cell at the intersection of one variable in the rows with the other variable in the columns. For example, we have to read the correlation coefficient between Column 6 (Area) & Column 2 (Production 2006-07) as 0.39787 in the cell at the intersection of the consecutive rows. A negative correlation is indicated as - r value. A positive correlation has no sign in front of the r, indicating that it is +. The excel has also calculated the measure for a single variable treating it as a pair of variables, yielding an r of 1 in all the cases. This value is irrelevant & can be discarded.

Fig. A bar diagram representing the Production with Area of the beels.

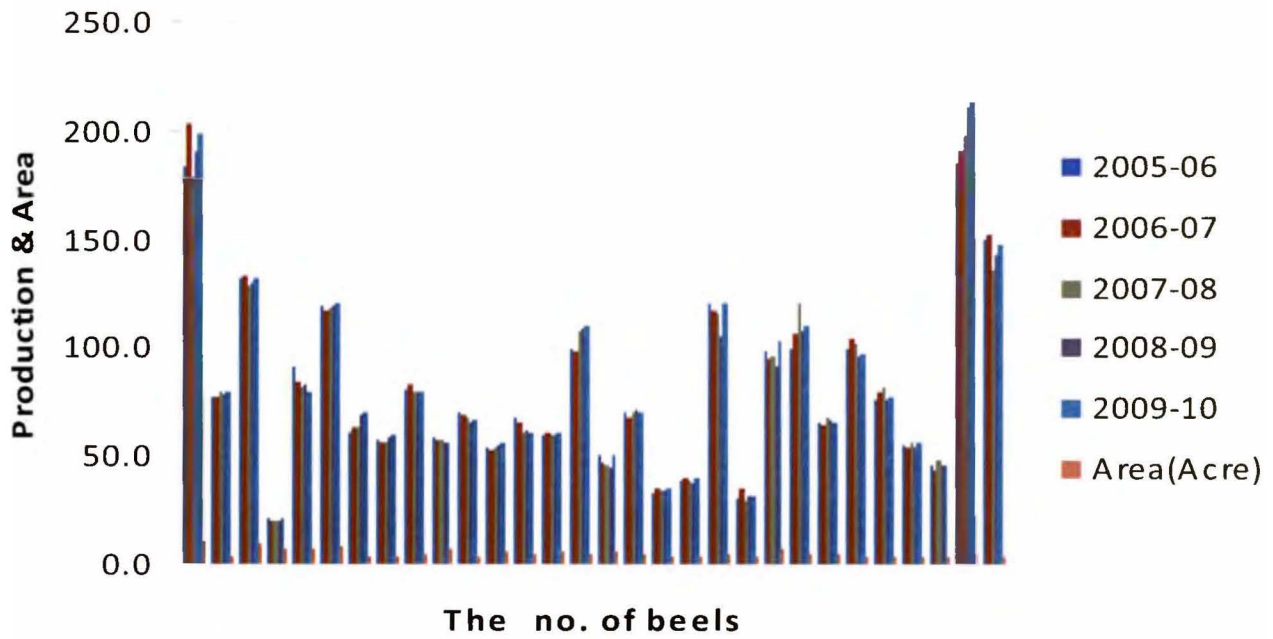


Fig. A graph representing the Production with Area of the beels.

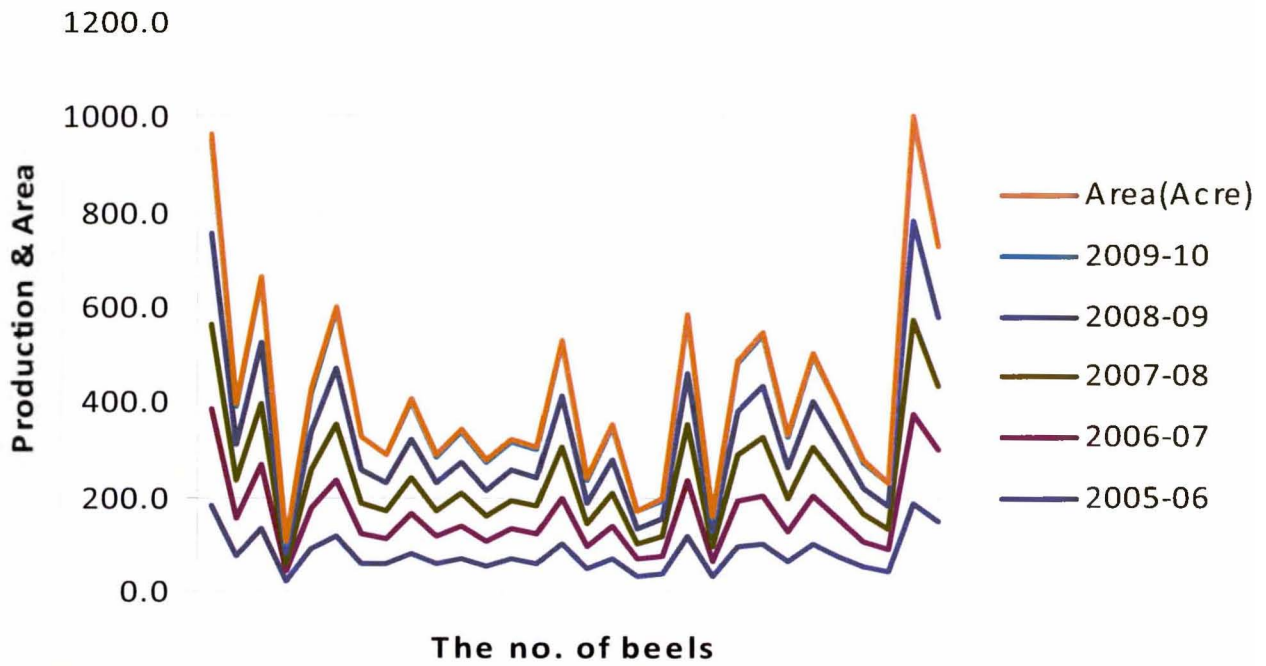


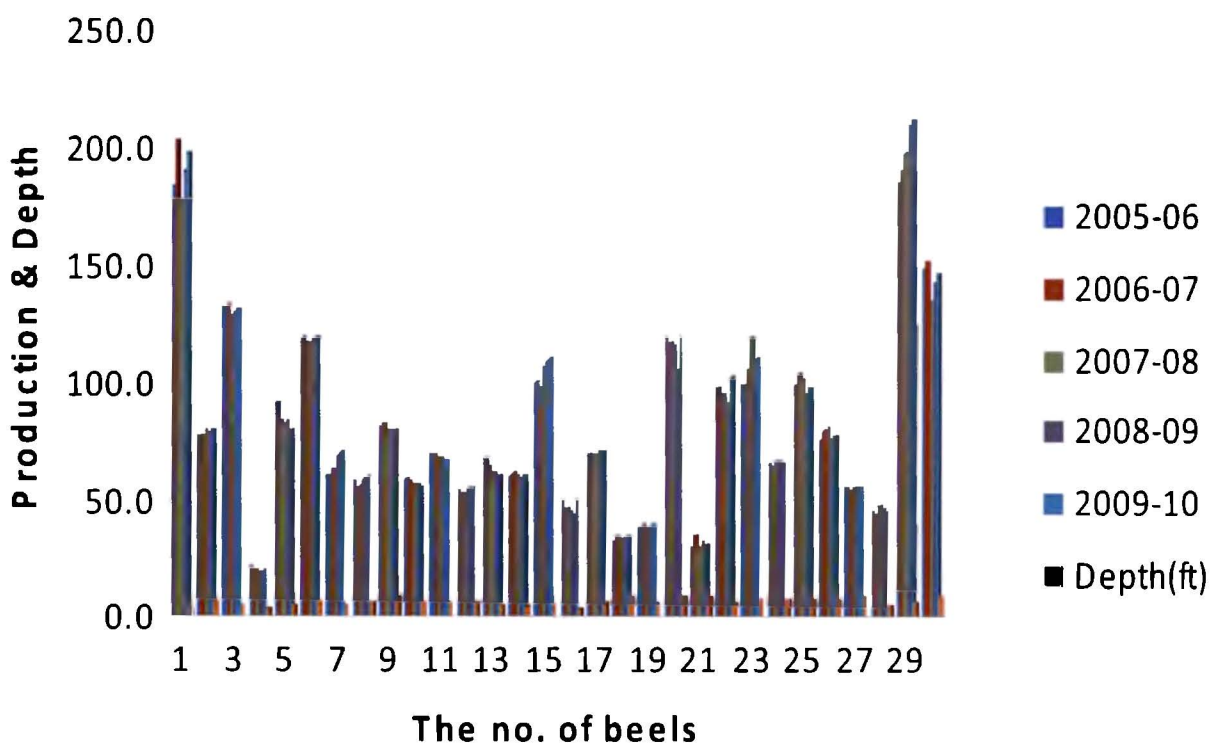
Table 15. A table showing Correlation of Production with Depth of the beels.

Production(Q/Year)	2005-06	2006-07	2007-08	2008-09	2009-10	Depth(ft)
Keshar	183.9	203.1	177.3	190.1	198.7	4.0
Chakrapur Beel	77.2	77.5	79.3	78.2	80.0	6.5
Ramnagar Beel	132.5	133.7	129.0	130.0	131.5	5.5
Matiara Beel	21.2	20.3	19.3	19.5	20.7	3.5
Pannam	91.3	83.9	81.7	83.0	80.0	5.5
Labasan Beel	119.2	116.7	117.6	118.7	120.0	6.5
Bhagabati Beel	60.7	62.8	63.0	69.0	70.2	5.5
Kolupukur Beel	57.3	55.9	56.2	58.7	60.0	6.5
Jhamp Pukur Beel	81.0	82.5	79.3	79.7	80.0	8.5
Banerjee Beel	58.9	57.5	57.2	56.0	55.6	6.5
Chakraborty Beel	70.0	69.2	68.3	65.2	66.7	6.5
Katapukur Beel	54.0	53.0	53.2	54.9	55.7	6.5
Moyla	68.3	64.9	61.2	62.3	60.8	5.5
Block Beel	60.1	61.3	59.9	59.7	60.2	4.5
Rajhati Beel	99.7	98.3	107.0	109.1	110.0	9.0
Borpukur Beel	50.2	46.9	45.2	44.3	49.7	3.5
Ram Dighi	70.0	67.3	69.8	71.0	70.2	6.5
Kumorhat Beel	32.5	34.8	33.4	33.7	35.0	9.0
Khirkir Beel	38.2	39.2	38.3	37.2	39.8	6.5
Dighi	119.8	117.3	115.8	105.3	120.0	8.5
Bharat Housing Beel	30.0	35.0	29.5	32.0	31.0	9.5
Annapurna Beel	98.1	94.7	95.6	90.8	102.3	6.5
Ichhapur Beel	99.4	105.9	120.0	107.8	110.3	8.0
Sodla Beel	65.5	64.0	67.2	66.8	65.3	7.5
Pritinagar Beel 1	99.4	103.6	101.2	95.8	97.3	8.0
Pritinagar Beel 2	75.5	79.4	81.6	75.5	77.3	8.2
Jagaddal Beel 1	55.2	53.6	55.7	53.4	55.8	8.5
Jagaddal Beel 2	45.2	43.2	47.9	46.0	45.6	5.5
Sonakhali (Magra) Beel	185.0	191.0	197.8	209.8	212.7	6.5
Kumli Beel	149.0	152.0	135.0	143.0	147.0	9.0
2005-06	1					
2006-07	0.9955	1				
2007-08	0.98848	0.98783	1			
2008-09	0.98834	0.99012	0.99348	1		
2009-10	0.99078	0.99256	0.99398	0.99707	1	
Depth	0.02918	0.03133	0.06524	0.0309	0.03021	1

Comments

The result is given in the form of a two-way table. We can identify the correlation coefficient between any pair of variables in the cell at the intersection of one variable in the rows with the other variable in the columns. For example, we have to read the correlation coefficient between Column 6 (Depth) & Column 2 (Production 2006-07) as 0.03133 in the cell at the intersection of the consecutive rows. A negative correlation is indicated as $-r$ value. A positive correlation has no sign in front of the r , indicating that it is $+$. The excel has also calculated the measure for a single variable treating it as a pair of variables, yielding an r of 1 in all the cases. This value is irrelevant & can be discarded.

Fig. A bar diagram representing the Production with Depth of the beels.



Picture 7. Activities at the time of harvesting in a Beel in North 24 Parganas.



Picture 8.



Picture 9.



Picture 10.



Picture 11. *Chanda nama* observed in Beels in Nadia.



Picture 12. *Pacu* observed in Beels in Nadia.



CHAPTER -6



SUMMARY

SUMMARY

The status & prospects of aquaculture of the unmanaged beels of the three districts namely Hooghly, North 24 Parganas & Nadia in the state of West Bengal has been studied during 02.02.2010. to 02.08.2010.

The whole work is embodied in this thesis incorporating eight chapters viz. Introduction, Review of literature, Materials & methodology, Results, Discussion, Summary, Suggestions & References.

The principal observations of the study have been cited in the Results section & it has been interpreted in the Discussion section. The main findings of the work is concised herein -

1. Ecologically most of the beels are rectangular or circular shaped & closed type. Thus inherently inhibit introduction of any riverine fish species. Also, because of their true lentic habitat, infestation of huge mass of macrophytes is rampant because of absence of flushing during monsoon months.
2. Because of heavy infestation percentage by the huge mass of macrophytes, sunlight penetration as well as phytoplankton production is greatly limited. Therefore, the production pathway in the beels under study is mainly through the macrophytic production pathway rather than the empirical phytoplankton driven photosynthetic cycle.
3. The beels are heavily loaded with minor fishes & large bodied carnivorous fishes which should be taken into account before formulating any stocking management protocol.
4. As all the beels are heavily loaded with organic bottom deposits & benthic fauna. This should be taken into consideration before selection of suitable species for culture.
5. For practical purpose of aquaculture, large bodied beels might be converted into pen enclosures so that pH correction through liming, eradication of macrophytes, supplementary feeding, stocking & harvesting the fishes could be made effectively.
6. Besides ecological aspects, aquaculture production in the beels under study is found to be plagued by social, financial & anthropogenic problems. This could be addressed in a wholesome way by incorporating the concerned departments of the Government & Non-government organizations up to the grass root administrative levels.

7. The present study was time bound & it is suggested that an elaborate study encompassing all the facets of beel ecology must be undertaken so as to formulate a holistic strategy for profitable & sustainable aquaculture from the beels.
8. For the most of the parameters F values are less than F critical values & it indicates that for these parameters there are no significant differences among the sites.
9. The data indicates a good fish yield of 78.2 quintal/year, 73.1 quintal/year & 179.9 quintal/year in Hooghly, North 24 Parganas & Nadia respectively.

CHAPTER - 7



SUGGESTIONS

SUGGESTIONS

The following suggestions are recommended for overall development in the production from the beels surveyed –

1. Sound management practices, mesh size regulation & proper stocking may increase the current fish production to many folds.
2. Control of macrophytes is the most important measure to be followed in the closed beels. Clearance of macrophytes creates congenial atmosphere for rich plankton growth.
3. In closed beels as there is little chance of getting flooded, grass carp fingerlings @ 10% of the total stocking density may be released to control submerged macrophytes.
4. Liming during post-monsoon or winter season will also help prevent occurrence of Epizootic Ulcerative Syndrome (EUS), a common cause of loss of fish stocks.
5. Wherever possible, the beel should be fertilized through discharge of nutrient-rich waste waters from agriculture or animal husbandry to reduce the cost.
6. Stocking with fish seed is the one & only meaningful conversion of accumulated organic matter of beel into highly valued fish flesh.
7. For achieving the estimated potential of 1000-1500 kg/ha/yr, stocking of advanced fingerlings (10-15 cm) is advocated & stocking density should be 1500-2000 nos/ha/yr.
8. Stocking of the beels with quality fingerlings of economically important & fast-growing species would, therefore be an important step towards the rational management of beel fishery.
9. Selective stock enhancement of commercially important, fast-growing fish species is recommended to improve the fishery.
10. As mortality of fish is size-dependent, it is important to stock fish of proper size to ensure a good survival of stocked fingerlings.
11. In the beels having large carnivorous population like *Wallago attu*, *Notopterus chitala*; the minimum stocking size should be at least 10 cm in length.
12. The bottom of the beels remains full of mud. This creates an unsuitable environment to the fishes. So, this mud should be removed to obtain the estimated production.

13. The depth of water of the beels must be kept 7 to 9 ft as this helps the production of phytoplankton through the entire column.
14. The so called weed fishes or trash fishes, which fetch a good market price, due to their declining nos., should be encouraged & scientific measure should be initiated for conservation & protection of these groups of valued fishes by developing suitable propagation & culture method.

CHAPTER -8



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ANNEXURE

ANNEXURE

QUESTIONARE SCHEDULE

1. Name of the beel -
2. Type of the beel - a) seasonal b) perrineal
3. Address -
4. Ownership -
5. Culture operations in years (Details) -
6. Organizational structure(Staff pattern) -

A) Family labour			
B) Hired Labour			
C) Contractual Labour			

7. Cultural aspects -

Sl.No.	Requirements	Answers
a)	Area & Depth	
b)	Size/Shape	
c)	Species Considered for Culture (Justifications)	
d)	Season (Cultivation period of abundant species)	

8. Rearing -

Sl.No	Requirements	Answers
a)	Stocking Time	
b)	Stocking Density	
c)	Pre Stocking Management	
d)	Post Stocking Management	
e)	Harvesting	

9. Technical output -

a) Lime : i) Quantity:

ii) Value:

b) Fertilizer : i) Organic:

ii) Inorganic:

iii) Any Other:

10. Disease Content -

Sl No.	Disease	Occurrence with any peak	Species affected	Medicine	Dose

11. Co-operative Societies -

12. Management Techniques -

13. Predominant Species -

14. Natural Feed -

15. Artificial Diets -

16. Breeding Activities -

A) Inducing Agents -

B) Breeding Activities (for Specific species) -

17. Other Aspects -

A) Storage facilities -

B) Marketing -

C) Transportation -

D) Problems -

i)

ii)

iii)

iv)

E) Production (in Years) -

F) Rearing Pond management -

G) Species Composition - (Unavailability)

H) Engagement in other part of the year -

I) Source of Information -

a)

b)

c)

d)

e)

- **Idea about the scientific basis of the technology -**
- **Any innovative technique developed by the farmer -**
- **Suggestion from farmers end -**
- **Need of the farmers -**