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Situation analysis

Production systems and natural resource management in PU Kolkata

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DFID Natural Resources Systems Programme

Executive summary

1. The development and evolution of farming strategies in PU Kolkata is reviewed, historical events influencing this process are discussed and prevailing geographic and climatic conditions are presented. Aspects of local governance, population growth and urbanisation are also discussed to better describe the social and institutional pressures that contributed to the emergence of PU farming, and which now threaten its viability.

2. The primary objective of this survey of farm managers was to address gaps in the existing knowledge base concerning current management practices and arrangements. Knowledge generated concerning general employment practices, labour demands and market channels will be used to better focus future project activities, in particular identifying selected groups of the poor for inclusion in focus groups and household interviews. Knowledge on constraints facing producers will be used to identify and promote enhanced PU natural resource management strategies and policy initiatives that benefit the poor.

3. Managers of farms producing fish, vegetables or rice, the three main production systems in PU Kolkata were selected at random and interviewed employing a pre-tested semi-structure questionnaire. Data collected were summarised and information from secondary sources used to better describe the setting in which PU farming is undertaken, and in particular key emerging constraints that threaten the viability of current farming activities.

4. Estimates concerning the extent of aquaculture in PU Kolkata vary from 2,500 ha to over 3,000 ha, however, individual farms are usually small (<2 ha) or moderately sized (2-20 ha). Various management arrangements exist, resulting largely from land reform and prevailing socio-economic conditions. Indian Major Carp and tilapia dominate production, however, several factors influence stocking regimes on individual farms.

5. Direct employment in various capacities constitutes an important benefit of PU aquaculture for poor people in the region, however, labour unions play an important role in regulating employment and setting terms and conditions. These terms and conditions are largely responsible for the widespread strategy of frequent stocking and harvesting, which in turn means regular employment for those engaged in the seed supply network and results in year round supplies of relatively small, affordable fish to local and urban markets. Employment and income generating opportunities provided by supplying seed, distributing and marketing fish and maintaining the system also constitute a significant indirect benefit for the poor.

6. Significant constraints threatening the viability of PU aquaculture include uncertainty regarding the supply of wastewater, limited access to finance, declining wastewater quality, poaching and labour problems and siltation in fishponds and canals.

7. PU vegetable farming is centred around Dhapa with estimates suggesting 320 ha are under cultivation producing up to 370 t ha^{-1} y^{-1}. Several crops are cultivated in a year and inter-cropping of several varieties is common practice. Intensive cropping is possible due to widespread irrigation, much of which involves wastewater reuse. Individual farm units are generally <1 ha, and often consist of several fragmented plots. The land used to grow vegetables in PU Kolkata is owned by the municipal corporation

and usually taken on a short-term lease, consequently farmers feel insecure and are reluctant to invest time and money to enhance productivity. Solid organic waste is widely used to supply nutrients and improve soil quality, however, changing access and declining quality have resulted in many farmers using more inorganic fertiliser. Other problems noted by vegetable growers included limited access to finance, price fluctuations, insect pests and the high cost of fertiliser and pesticides.

8. Unlike ponds managed for aquaculture, separate households manage individual vegetable plots and family members undertake much of the cultivating, harvesting and marketing. During busy periods labourers from local villages may be employed on a casual basis, however, the temporal and uncertain nature of this work makes them vulnerable to changing circumstances. Women undertaking horticultural work are often supporting their family due to the illness, absence or death of their spouse, when work is scarce they will usually find employment as rag-pickers.

9. Paddy culture is the most widespread agricultural activity in PU Kolkata covering several thousand hectares and extending over 50 km from the city. Selection of farmers for this survey was restricted to the WRR, the majority of those interviewed farmed less than 2.6 ha, whilst most farmers owning their own land also cultivated vegetables. Although farmers used rainwater, wastewater and groundwater to irrigate crops, seasonal water shortages were the main concern for producers. Other constraints noted by rice farmers included limited access to finance, insect pests, price fluctuations and seasonal flooding of fields.

10. Labourers employed mostly in the fisheries and agricultural fields can also find employment on farms producing rice during the paddy season. Women are commonly engaged in work relating to paddy culture, usually in post-harvest activities, threshing and drying the grain. Some labourers reportedly travelled several miles to find work on the paddy farms, staying in temporary accommodation until the end of their contracts.

11. Constraints common to fish, vegetable and rice farming included changing access to waste resources and a perceived decline in quality, siltation of fishponds and canals, uncertain and seasonally variable water supplies, insecure tenure and limited access to finance. Although of only moderate concern to most farmers, insect pests and diseases problems were widespread, and when unsure farmers take advice from neighbours and shopkeepers, potentially leading to mis-diagnosis, resulting in more severe problems and money wasted on inappropriate treatments.

12. Possible outcomes of planned development projects appear to constitute important emerging threats to PU farming, whilst possible health risks associated with reusing waste resources to produce food and possible changes in consumer perception constitute serious concerns requiring further assessment. It was considered important to highlight these issues as PU farmers and communities are often poorly positioned to cope with or manage unforeseen problems.

13. Outcomes from this work will be used to guide the planned focus group and household interviews with poor people whose livelihoods depend either directly or indirectly on PU farming. Knowledge generated regarding the most significant constraints to PU farming will be disseminated to local government departments, development agencies and stakeholder groups to assist them in formulating PU natural resource management strategies and policies that safeguard and enhance these systems and benefit the poor.

Glossary

Acronyms and Bengali terms

ADB	Asian Development Bank
ala	small brick built house in the fisheries used by accounts managers and cooks
aratdars	local term for auctioneers
barga	system of community management
bargadars	registered share cropper
bank	yoke for fish seed carriers
BDP	Basic Development Plan
bheri	Bengali name for commercial pond-based fish farm
bigha	unit of land measurement (7.5 *bigha* = 1 ha)
BLLRO	Block Land and Land Reforms Office
block	second smallest administrative unit in India, may cover one to ten *mouza*, there are 343 blocks in West Bengal
cattah	Bengali measure of area (20 *cattah* = 1 *bigha*)
CBO	Community-based Organisation
CEIP	Calcutta Environmental Improvement Project (ADB-DFID funded)
CEMSAP	Calcutta Environmental Management Strategy and Action Plan
CICFRI	Central Inland Capture Fisheries Research Institute
CIT	Calcutta Improvement Trust
CITU	Communist Party of India Trade Union
CLC	Calcutta Leather Complex
CMPO	Calcutta Metropolitan Planning Organisation
CMA	Calcutta Metropolitan Area
CMC	Calcutta Metropolitan Corporation
CMDA	Calcutta Metropolitan District Authority
CMWSA	Calcutta Metropolitan Water and Sanitation Authority
crore	Bengali expression for one hundred million (100,000,000)
CUSP	Calcutta Urban Services for the Poor (DFID funded)
dadan	Bengali expression for financial/credit advance
DFID	Department for International Development (UK Government)
DLLRO	District Land and Land Reforms Office
DoF	Department of Fisheries (now Department of Fisheries, Aquaculture, Aquatic Resources, and Fishing Harbours), GoWB
DoEF	Department of Environment and Forests, GoWB
DoIW	Department of Irrigation and Waterways, GoWB
Durga Puja	Autumn festival for Hindus
DWF	Dry Weather Flow
ECW	East Calcutta Wetlands
EMB	Eastern Metropolitan Bypass
EUS	Epizootic Ulcerative Syndrome
GAP	Ganga Action Plan
ghat	river jetty or steps down to a fishpond
GNS	Gantantrik Nagarik Samiti - Democratic Citizens Society (NGO)
GoI	Government of India
goldars	local Bengali term for agents trading fish seed
GoWB	Government of West Bengal
Gram Panchayat	elected local municipal body covering 10-15 villages
hat	local Bengali term for market
HIDCO	Housing and Industrial Development Corporation
IMC	Indian Major Carp
IWMED	Institute of Wetland Management and Ecological Design
jheel	small pond <2 ha
kalbaishakhi	pre-monsoon storms with high intensity rain from April-May
khal	Bengali term for a drainage channel
khas	vested land holding
lakh	Bengali expression for one hundred thousand (100,000)

LUDCP	Land Use Development and Control Plan
LURM	Land Use Registry Map
maund	Bengali unit of weight (1 *maund* = 37.3 kg)
mouza	smallest administrative unit in India, may cover one to ten villages
NEDECO	Netherlands Engineering Consultants
NGO	Non-government Organisation
NRD	National River Directorate
ODA	Overseas Development Administration (now DFID)
paikers	local Bengali term for 'contract carriers' who transport fish from *bheries* to auction markets
pata bona	handicraft involving weaving of palm leaves
patta	tilling right given to a sharecropper, a licence to till
pisciculture	local phrase for fish culture
Police Station	*Thana* or area of jurisdiction
PRA	Participatory Rural Appraisal
PS	Production System
PU	Peri-Urban
PUI	Peri-Urban Interface
PUBLIC	People United for Better Living in Calcutta (NGO)
raiyata	the right to sell land, although government retains ownership
rupee (Rs)	Indian currency (£1 = ~Rs70)
SC	Scheduled Caste
SDLLRO	Sub-Divisional Land and Land Reforms Office
SFDC	State Fisheries Development Corporation
SLMC	Salt Lake Municipal Corporation
ST	Scheduled Tribe
SWF	Storm Water Flow
tank	local term for small pond
VWSC	Village Water and Sanitation Committee
WB	World Bank
WBIDCO	West Bengal Industrial Development Corporation
WBSHB	West Bengal State Housing Board
WBSPB	West Bengal State Planning Board
WBSPCB	West Bengal State Pollution Control Board
WRR	Waste Recycling Region
WWF-India	World Wide Fund for nature - Indian Branch
zaminder	feudal land owner
Zilla Parishad	elected local municipal body governing ~10 *Gram Panchayats*

Contents

Contents (cont.)

Tables

Figures

Boxes

1. Introducing Kolkata[1], an Indian mega-city

It is widely acknowledged that many of India's mega-cities are still subject to the processes and pressures of urbanisation, driven by rapid population growth, liberalisation, privatisation and rural-urban migration. However, in many cases, lessons from past failures in planning and managing urban growth elsewhere have largely been ignored. Although urban centres constitute the economic backbone of the country, problems associated with rapid population concentration are widespread in many recently urbanised centres, including mass unemployment, illiteracy, slums, congestion, encroachment of public space, water and air pollution and deteriorating infrastructure and services.

According to the 2001 census, around 285 million or ~28% of the Indian population live in urban areas, with 38% of the urban population residing in only 38 agglomerations. In 1991 the census revealed that 217 million people, constituting ~26% of the total population lived in urban areas. These data help illustrate the level of growth of urban centres in India, although it should be noted that the actual proportion of the population living in urban areas only showed a 2% increase. Some economists have suggested that as centres of trade and commerce, urban areas would account for a significant proportion of GNP growth in India, however, the actual situation appears markedly different, with only moderate GNP growth being attributed to urban areas. Despite this it has often been demonstrated that urbanisation is an important driving factor in a county's economic development.

With greater populations concentrated in urban areas, demand for food and the need to develop effective supply and distribution channels often increases. One approach that contributes to the increased efficiency of food supply is to grow it close to the market place, reducing transport times and costs. Proximity to urban markets also holds benefits for producers. Ready access to large numbers of consumers ensures produce always has a market, whilst the relative wealth of urban consumers allows producers to command a premium for fresh, good quality produce, and markets exist for higher cost and value-added products. However, despite these benefits, farming close to urban areas is often associated with problems relating to land tenure, pollution and environmental degradation, competition for natural resources and ineffective local institutions.

Based on preliminary investigations (Bunting, Kundu and Mukherjee, 2001) it appears that the traditional farming systems which developed in PU Kolkata to service urban markets are threatened by various processes associated with urbanisation. In this study the physical, economic and social settings are considered, together with the historical background to better describe the evolution of PU farming practices around Kolkata. The current nature and extent of key farming systems is assessed from interviews with farm managers, and outcomes used to identify important constraints to the specific farming practices. Proposed development initiatives and emerging constraints identified during this study phase are reviewed and potential negative outcomes and mitigating factors discussed.

[1]Since project inception Calcutta has officially been renamed Kolkata, therefore, unless in an historical or official context, the new name will be used in subsequent sections and project outputs

1.1. Geography and geology

Present day Kolkata is situated in West Bengal; the state adjoins four others, namely Assam, Bihar, Orissa and Sikkim, and borders Bangladesh, Bhutan and Nepal (Figure 1.1). West Bengal has an area of around 1,400 km^2 and a coastline extending to several hundred kilometres, much of which is within the Sunderbans mangrove forest, a UNESCO World Heritage Site. Kolkata is centred around latitude 22° 34' N and longitude 88° 24' E. The city is bounded to the west and north-west by the Hooghly River, whilst land to the south and southeast generally slopes away toward the coast and low-lying wetlands. The core area of the city is generally flat with elevations ranging from 1.5 to 9 m above mean sea level (ADB, 2000a); however, there are some natural depressions in this area, many of which are dead river channels.

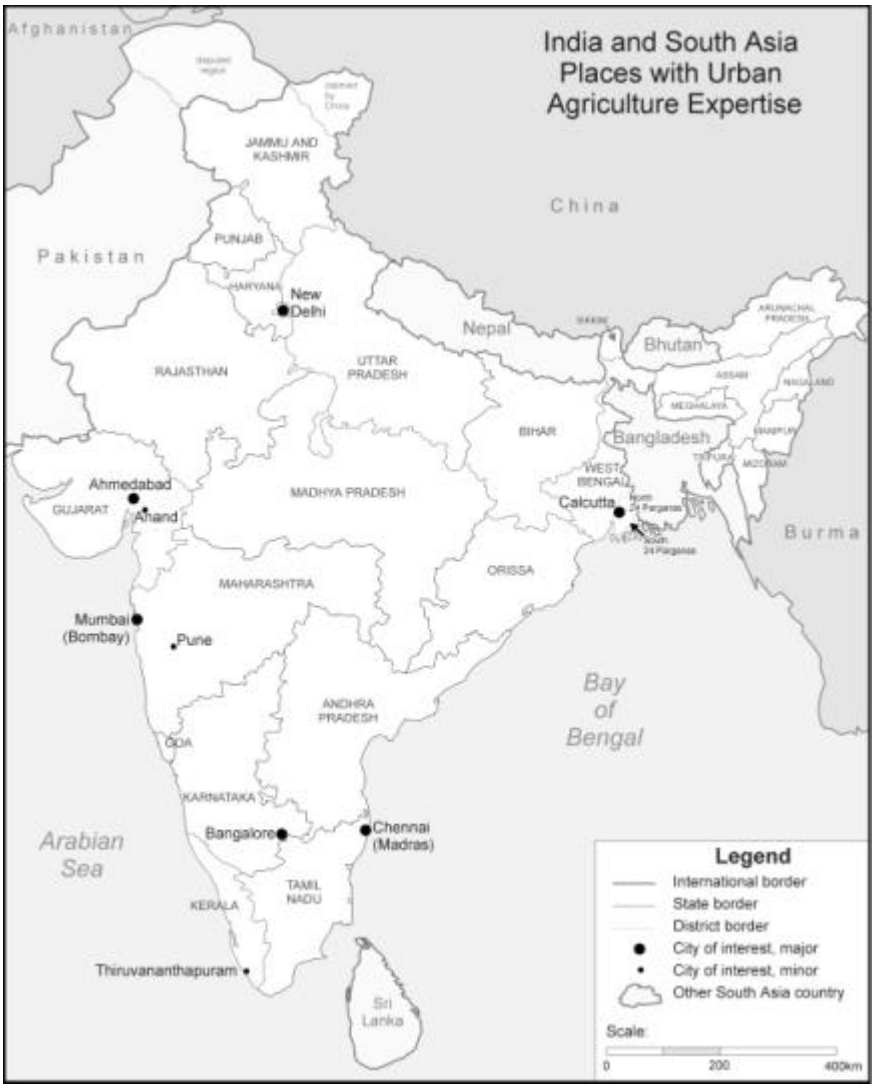

Figure 1.1. Map showing the location of Kolkata in West Bengal, together with other cities in India having a tradition of Urban Agriculture (Source: Yasmeen, 2001)

Quaternary sediments comprising clay and silt, together with various grades of sand and gravel, underlie the city. Above these deposits there is a clay bed which varies in thickness from 10-40 m, whilst below, at depths of 250-650 m there is a second clay bed; groundwater found in aquifers between these beds is extracted using tube-wells. To the west of the city soils are classified as entisols (weakly developed soils), whilst to the east alfisols (forest soils with relatively good native fertility) predominate. The Gangetic alluvium group of soils found in the region are rich in calcium, whilst only medium levels of organic matter, phosphate and potash are present.

1.2. Climate

Situated just north of the Tropic of Cancer, climate in the region is strongly influenced by the annual passage of the southwest monsoon. The rainy season usually commences around mid-June and lasts until mid-September, the winter season follows the rains and lasts until February, whilst March through to mid-June are commonly regarded as the summer months. Mean maximum and minimum monthly air temperatures for Kolkata are presented in Figure 1.2 and show that during the summer months, the average maximum daily temperature ranges from 33-36°C, however, in May maximum daily temperatures above 40°C are common. During May there are often thunderstorms and spells of heavy rain, known locally as *kalbaishakhi*, these downpours bring welcome relief from the high humidity (70-80%) that prevails at this time. Mean maximum temperatures remain around 32°C throughout the rainy season. From October to mid-February the city experiences generally pleasant weather with comparatively low temperature and little rainfall. January is the coolest month, with average minimum temperatures around 13°C.

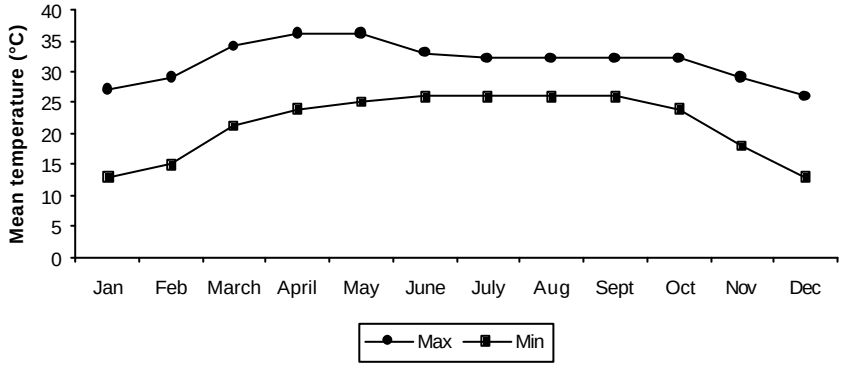

Figure 1.2. Mean average monthly temperatures (°C) for Kolkata (Source: OnlineWeather, no date)

During the monsoon, rainfall is heavy, reaching a peak of 328 mm in August (Figure 1.3); with the retreat of the monsoon this decreases to around 114 mm in October. The lowest rainfall totals are usually recorded during December, with an average of only 5 mm reported. Wind speed throughout the year averages ~7 km h^{-1}, although occasionally storms and cyclones bring much higher winds, usually during the rainy season.

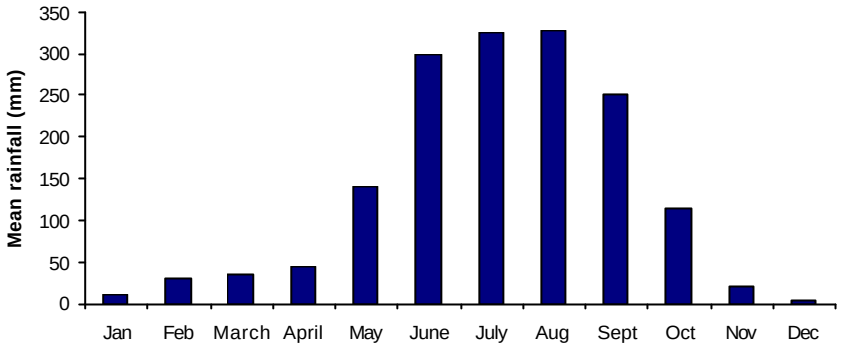

Figure 1.3. Average monthly rainfall (mm) totals for Kolkata (Source: OnlineWeather, no date)

Figure 1.3 demonstrates that rainfall in the region is highly seasonal, consequently access to wastewater from the city during the dry season constitutes a significant advantage to farmers in PU Kolkata. However, where the supply is uncertain or unpredictable this may cause serious problems for producers that depend on wastewater to irrigate vegetable or rice crops or to maintain water levels in fishponds.

1.3. Growth and development of erstwhile Kolkata

Based on an historical perspective regarding the establishment and growth of Kolkata it is possible to gain a clearer insight concerning the origins and driving forces underlying the past and most recent phases of urbanisation. Less than three centuries ago, the area around Kolkata was part of a largely rural district in the delta of lower Bengal, a flat rice-swamp interspersed with patches of jungle and a few scattered villages on the riverbank. In 1690, Job Charnock founded Kolkata, a trading post on the eastern banks of the Hooghly River that soon encompassed the villages of Sutanuti, Govindapur and Kalikata.

Establishment of a trading post and garrison by the British provided a stimulus for urbanisation, the prospect of employment and commercial opportunities drew many indigenous people from rural areas. However, it was only in the nineteenth century, following increased interest by the British, that trade was promoted in the region. With the growth of commerce, attention was given to communications, and railways built to transport goods, people and troops throughout the region. Prior to 1860, the Kolkata port occupied only a small area of the Hoogly, Howrah and 24 Parganas districts on the east shore of the river. These docks served ships exporting raw materials from Bengal, Bihar, Assam and part of the northwest provinces.

Initially exports from Kolkata to Europe consisted of raw materials such as indigo and cotton, and later cash crops such as opium, jute and tea. In 1866-67, jute from West Bengal accounted for 21.6% of India's export earnings, however, by 1870-71 this had declined to 12.4%. The declining importance of jute was partly due to growing demand for products such as tea from the mountains of West Bengal and Assam, and partly due to low prices owing to overproduction. Good dock facilities were also crucial for importing goods, troops and settlers from Europe. With the advent of the industrial revolution in England, demand for coal and iron ore increased greatly and imports from India were used to

supplement local supplies. The export of industrial processes from England to India also meant that during the 19th century, factories and mills began to produce greater volumes of processed and finished products for export to Britain, Europe and America. Due to the importance of trade and commerce, planning and development of port and harbour facilities was directly under the control of the government. Starting in 1860, plans, projects and 'commissions of enquiry' were all focused on the expansion of the port facilities.

From the historical account presented above it is apparent that the origins of both urbanisation and industrialisation in Kolkata may largely be attributed to the presence of British settlers. However, the growth pattern of modern-day Kolkata has largely been dictated by political, and more recently, since the introduction of the New Economic Policy (1991/92), economic objectives. Industrial growth is now widely regarded as a central tenet in the economic development of West Bengal, indeed following the adoption of the New Economic Policy average annual industrial growth almost doubled to 5%, as compared with average growth over the previous seven years (Government of West Bengal, 1999). The overall projected growth in Domestic Product for West Bengal has been estimated at an annual rate of 6.7%; it appears that much of this may be accounted for by industrial development. However, despite the economic benefits of industrialisation, associated negative impacts such as noise, air and water pollution can severely affect the lives of local residents, furthermore, the contamination of municipal solid waste and wastewater with industrial pollutants poses a serious threat to traditional farming practices that exploit such waste resources. The need to develop infrastructure such as roads, railways, housing and commercial buildings, required to support industrial growth, may also displace PU farmers and poor communities or restrict their access to natural resources.

1.4. Demographics

Settlement by the British and the prospect of trade gave impetus to population growth in Kolkata, however, the concentration of commerce and communications in this city meant that urbanisation in other areas of eastern India, and in particular West Bengal, has been retarded. In 1710 the population of Kolkata was estimated at between 10-12,000, in 1831 it was around 187,000 and in 1837 had increased to ~230,000 (National Institute of Urban Affairs, 1998). By 1850 the population had risen to roughly 415,000, however, the next census in 1866 showed a marked decline to ~359,000. This decline was probably due to the emergence of disease problems in the city, causing death and out-migration. By 1872 the census shows that the population had recovered to around 409,000. Rapid population growth shortly after the founding of the city (ten-fold from 1710-1750) was due to immigration by European settlers and rural-urban migration by native people seeking employment and commercial opportunities. More recently, periods of rapid population growth in Kolkata have been associated with mass migration resulting from the partition of India and the war of independence between Bangladesh and Pakistan. Rural-urban migration within West Bengal still contributes to population growth in the city, although there is a widespread belief that many recent immigrants have come from other states in eastern India, such as Bihar, Assam and Orissa.

Recent estimates suggest that during the ten years from 1981 to 1991, population growth in the Calcutta Municipal Area (CMA) was 33.7%, up from 22% during the previous ten-year period (CMDA, 1992). However, population growth in the state as a whole from 1981-1991 was only 24.7%, with an average urban population growth of 29.5%. In 1961, the

population density in CMC was on average ~28,000 km^{-2}, by 1981 it had increased to ~31,600 km^{-2} and in 1991 stood at ~42,300 km^{-2}. The boundaries and extent of the CMC and CMA are shown in Figure 1.4. From this map it is evident that much of the growth in the CMA has occurred along the banks of the Hooghly River. From the 2001 census a population density of ~44,400 km^{-2} was estimated, reportedly one of the highest in the world. One factor contributing to such high densities, in a city where high rise buildings remain relatively scarce, are the highly populated slums which occupy almost every area of vacant land within the city. Roughly one third of the population live in slums or *bustees* in the CMA, most of which are poorly serviced, with only limited access to water, sanitation and medical and educational facilities.

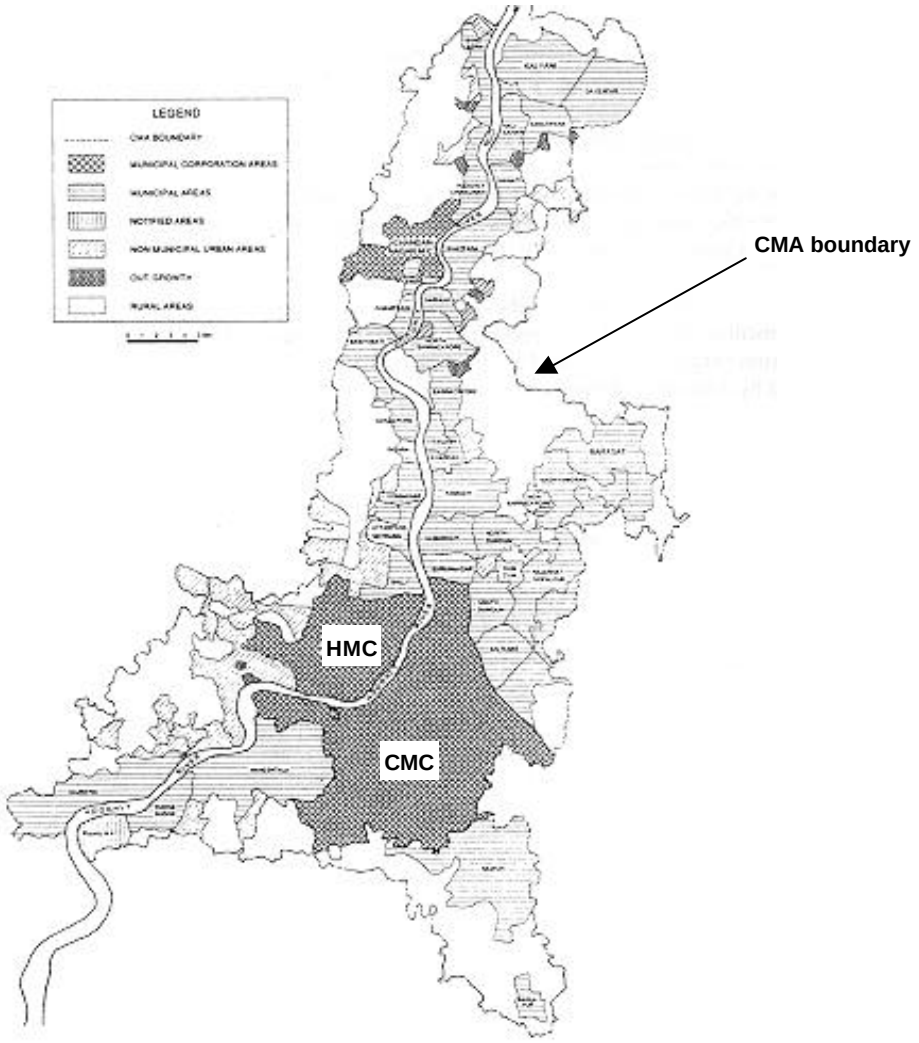

Figure 1.4. Map showing the CMA area and location of the CMC (Source: ADB, 2000a)

1.5. Governance in the CMC and CMA and the Waste Recycling Region

Early settlement in Kolkata was divided into two distinct sections, locally referred to as the black and white towns, however, the native and foreign communities did not remain isolated. For aspirant Indians they found that establishing a relationship with the British settlers could help in gaining access to wealth creating opportunities, however, a prerequisite to establishing such a relationship was confidence in speaking English. Those Indians that undertook a western education and subsequently worked for the British and their followers were referred to as the *baboo* class, in contrast, Indians with anti-British sentiments continued to support traditional education and protested against the exploitative nature of British rule. Despite such protests, the English language dominated and passed into the primary curriculum. Opposition to the imposition of western culture and education emerged as a substantive movement in the mid-1800's and lead by charismatic local figures reached a climax with the Sepoy Mutiny of 1857. However, it was not until 1947, following the passage of the Second World War, that India finally gained independence. Independence for India was also closely associated with partition of the sub-continent, although debate surrounds the events giving rise to this event.

Partition and the migration of people from East Bengal resulted in an influx of some 3 million people to West Bengal during the period from 1947-52 (Som, 1987). The mass migration of people during this period, and more recent movements of economic migrants from rural areas and other states, has resulted in a large proportion of the population of Kolkata having to live in unplanned and poorly serviced slums or *bustees*. In 1981 it was estimated that out of a total population of 10.7 million in Kolkata, 3 million people lived in slums (Som, 1987), however, despite many slum development and rehabilitation programmes, the situation remains desperate for many.

The system of local self-government that is practised in Kolkata has a long history. Under British rule this popular representative system provided a democratic means to express disquiet with British rule, even permitting nationalist leaders such as Subhash Chandra Bose to be elected as Mayor of the Calcutta Corporation. Following Independence, the established system of local self-government continued and remained largely effective. Today the CMC follows a parliamentary form that is similar to the cabinet system established by the British; the Mayor continues to head a council of elected members, however, this body functions under the federal State Government.

Following partition Kolkata became the capital of the newly formed state of West Bengal. The historical centre of the city, the Calcutta Municipal Corporation (CMC), which shares its name with the executive administrative council, covers an area of 187 km^2. However, the wider urban agglomeration surrounding the CMC which covers an area of 1,380 km^2 and consists of 3 municipal corporations, 37 municipalities, 70 non-municipal towns and 450 villages has been defined as the CMA. Figure 1.4 shows that although the CMC constitutes the core of the city, the municipality actually adjoins directly to what are classified as rural areas, both within and outside the CMA. The evolution of farming activities in these rural areas and their relationship with the city is described in Box 1 (Page 11). From this review it is apparent that waste from the city largely supported the early intensification of agriculture in the region, whilst produce cultivated serviced growing urban markets. More recently, however, the close association and proximity of these PU farming practices to urban areas is of growing concern to the municipal authorities, primarily as this activity stands in the path of urban growth. Despite this tension, the

environmental, economic and social benefits attributed to these farming activities by NGOs, select government departments and local advocates lead, in part, to legislation and outline plans for their conservation. Possibly the most significant development was the designation of ~12,500 ha of farmland toward the east of the CMC as a Waste Recycling Region (WRR). This conservation area was formerly implemented through a ruling from the Calcutta High Court (1993) and as a consequence the area is protected against unplanned development.

The WRR is commonly divided into four parts, each under the jurisdiction of a different police station, there are ~4,500 ha under both Bhangor and Sonarpur stations, 2,100 ha under Bidhanagar and ~1,400 ha under Tiljala (CRG, 1997). Figure 1.5 shows the position and extent of the WRR, the main concentration of garbage farming lies adjacent to the Eastern Metropolitan Bypass (EMB) and between the Dry Weather Flow (DWF) and Central Lake canals. The remaining part of the western half of the WRR is dominated by ponds managed for wastewater aquaculture whilst the eastern side consists largely of wastewater irrigated farms. Directly to the northeast of the WRR is Salt Lake City, whilst the Krishnapur Canal constitutes the remainder of the regions northern boundary.

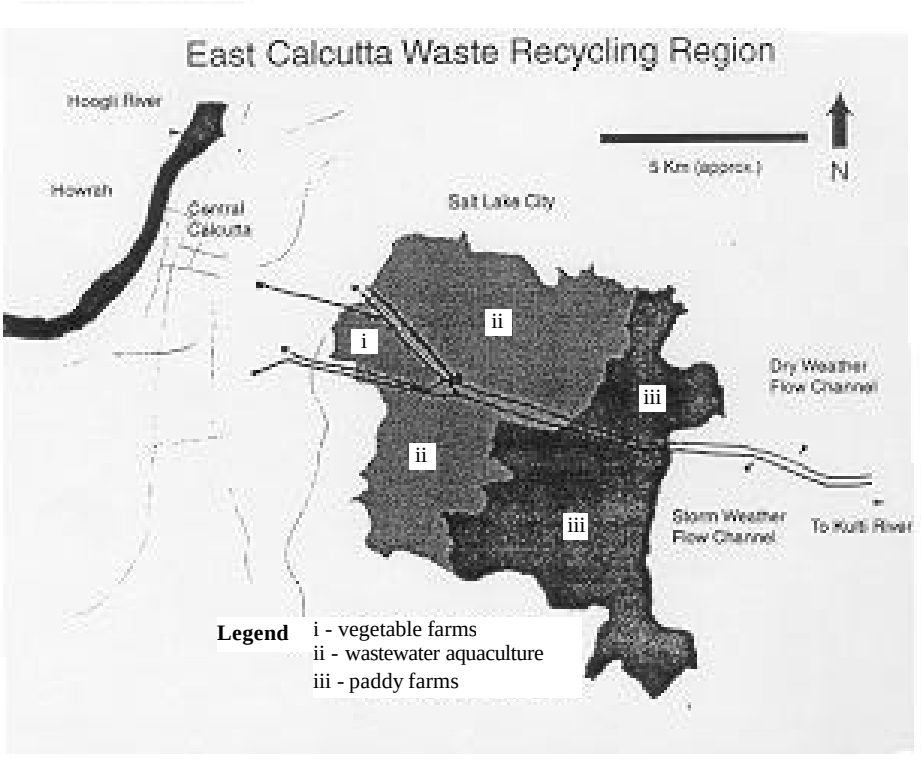

Figure 1.5. Outline of the Waste Recycling Region (WRR) showing different areas of agricultural activity (Source: Gupta, 2001)

1.6. Summary

Past phases of urban growth, prevailing environmental conditions and drainage characteristics of the developing urban area have contributed significantly to the establishment of traditional waste-reuse farming practices in PU Kolkata. Nutrients contained in both solid organic waste and wastewater have contributed to improved yields

whilst reducing input costs, access to urban drainage water also contributes to the avoidance of problems associated with the highly seasonal rainfall that prevails in the region. The managed reuse of city waste has contributed to improved sanitation and reduced public and environmental health problems, whilst population growth in the city has resulted in greater market demand for produce from PU farms and encouraged the expansion of this activity. However, due to a number of threats, many of which are associated with processes of urbanisation, the WRR was established as a conservation area to safeguard against development. In the following sections, the current nature and extent of the principle PU farming activities in this region are reviewed, and constraints facing producers discussed.

2. Survey objective and methodology

The objective of surveying managers of PU production systems was to address gaps in the existing knowledge base concerning current management practices and arrangements, and to triangulate data from previously reported studies. It was anticipated that knowledge generated concerning general employment practices, labour demands and market channels for inputs and products, would contribute to better focusing planned studies concerning the role of PU production systems in poor livelihoods. Furthermore, it was anticipated that knowledge generated concerning major constraints facing producers would constitute a valuable resource for local researchers, government departments and international development organisations. The aim being to help them target resources to safeguard and enhance these farming practices which play an important role in the local economy, supply produce to urban and PU markets and sustain various poor livelihoods.

Due to the extent of PU Kolkata it was necessary to develop a strategy to focus the survey of production systems in the region. From a practical perspective the East Kolkata Wetlands or WRR provide a geographical focus, whilst the volume and diversity of produce cultivated here make these production systems some of the most important in the region. Furthermore, initial analysis suggested that a significant number of poor people depend either directly or indirectly on the continued function of these systems for a substantial proportion of their livelihood or food security (Bunting et al., 2001). By concentrating on this important system, which has been the subject of significant previous research, legal argument and externally-funded development activity, it was anticipated that opportunities for improved governance and management would be identified that could enhance the livelihoods of significant numbers of poor people.

Having decided on a geographical focus, a stratified sampling framework was prepared based on the primary nature of the major production system. Livestock production was considered too infrequent and temporal to be included in the main survey, however, a supplementary enquiry concerning this aspect was undertaken as a separate project activity (Harris, 2001). From the initial literature review (Bunting et al., 2001) it was proposed that the study should focus on the three most significant production activities in PU Kolkata:

- aquaculture - fish production is reportedly widespread in the region and conducted in a variety of water bodies or wetlands[2]. Wastewater from canals draining the city is the major water source in the area, whilst entrained nutrients enhance production in those ponds managed for wastewater aquaculture.

- horticulture - vegetable cultivation exploiting solid waste inputs from the city to enhance production is concentrated in the Dhapa region, recently however, due to uncertain solid waste supplies inorganic fertilisers are reportedly being used. Irrigation of the vegetable plots is undertaken using water from both the main sewage canals, secondary feeder canals and freshwater *jheels*, which are retained specifically for irrigation purposes.

[2] The term 'wetland' is used locally in both official and unofficial contexts to refer to environments that are inundated with water for a significant part of the year, however, no distinction is made between natural and engineered systems

- paddy farming - rice production, both rain-fed and irrigated, occurs toward the margins of PU east Kolkata; irrigation water is either pumped from underground aquifers or, where possible, discharge water from fishponds is utilised.

A draft questionnaire was prepared and tested by local field staff who surveyed a small number of respondents and made appropriate refinements (Appendix 1). Following this trial phase interviews were undertaken with production system managers and results coded (Appendix 2) and compiled using Excel. Sampling of fisheries was undertaken through random selection from a list of operational *bheries* (CRG, 1997); for the smaller *jheels* in the WRR, a list of the managers names was made and a sample selected at random. A similar strategy was adopted for vegetable growers, a random sample was selected from a list, and according to their availability farmers were interviewed. In the case of PU paddy farming, the absence of records meant that a map was used to identify areas where this activity was concentrated, and farmers interviewed at random during trips to the region. Supplementary interviews with workers were also undertaken in some instances, in which case informal interviews and discussions were held whilst the labourers continued to work; this was found to be most convenient. Preliminary analysis and report writing were completed by the local field staff and a draft survey report prepared and distributed to other project team members for review.

In addition to survey data recorded as part of the current project, data from other studies were incorporated in the final report to highlight areas of agreement and discrepancy. The objective was to provide a comprehensive knowledge base from which to formulate future research and development initiatives that better address key constraints and opportunities facing the managers of PU farms. Sections 4-6 present an overview of prevailing systems characteristics that should be considered when assessing the current status and importance of PU farming in poor livelihoods. Further information from secondary sources is presented together with summarised survey data to aid comparison and consolidate the knowledge base.

3. Origins and recent history of production in PU Kolkata

The history of Kolkata since its founding in 1690 by the British East India Company as a trading post on the eastern banks of the Hooghly River is well documented. This is significant as the development and current status of production systems in PU east Kolkata may be largely attributed to critical historical developments (Furedy, 1987; Ghosh and Sen, 1987; Kundu, 1994). The origins of aquatic and terrestrial production systems exploiting waste resources from the city are described briefly in Box 1. However, from a period of rapid and sustained expansion, recent change at the PUI has seen a marked decline in the extent and apparent viability of traditional production systems.

Box 1. Evolution of horticulture and aquaculture in PU Kolkata

Agriculture in PU Kolkata has a long history dating back to the late eighteenth century. Shortly after founding the city, sewage and most of the solid waste were disposed of in the river from a specially constructed *ghat*; some solid waste was also used as infill. Overall, this system proved unhygienic and it was widely acknowledged that a new strategy was needed, however, a system of burning solid waste, which was later tried, was not successful. Mr. William Clark, Chief Sanitary Engineer, then proposed to remove municipal solid waste to the Salt Lake area, and during 1864 a low-lying area to the east of the city was acquired at a price of Rs 93,000 for the purpose of waste disposal; dumping started in 1868.

In 1876 this land was leased for 3 years to Nandalal Das, whilst rights to capture fisheries in the area were given to Durga Charan Kundu for 4 years. However, unsatisfactory management by Nandalal Das forced the Corporation to transfer the lease to Bhabanath Sen, who acquired the right of land including the watercourses for 20 years from 30th April 1879; the following year he acquired the fisheries. Under the supervision of Bhabanath Sen horticulture in the area became established and better organised. In 1904, the sub-deputy Collector reported that of 220 ha taken on lease by Bhabanath Sen, 60 ha were being cultivated; gradually, however, the entire area leased out to Bhabanath Sen was converted to horticulture, and this productive vegetable growing area became known as Dhapa.

In 1872 a fish *ghat* was constructed on Raja's *khal*, and this was closely followed in 1887 by the establishment of a flourishing fish *hat* (market) at Pagladanga, a navigation channel was constructed subsequently to connect the market to the town reservoir. Later, land taken to construct the SWF (storm water flow) canal caused disruption to both the fish *khal* and market. However, discharge of sewage carried in SWF canal resulted in brackish lagoons becoming less saline, and as a result freshwater fish soon colonised these lagoons; it is also likely that some informal stocking of fish was undertaken. An account given by Mr P Ghosh, former Secretary of the Fish Producers Association, suggest that the earliest attempt at formal aquaculture deliberately exploiting wastewater was undertaken by Mr Bidhu Bhusan Sarkar in 1918. Subsequent construction of the Dr B N Dey Outfall Scheme increased access of farmers in the area to wastewater, which in turn encouraged others to adopt wastewater aquaculture.

From a peak in 1945 when ~350 fisheries managed for wastewater aquaculture covered 7,300 ha, recent estimates have put the remaining pond area at 2,500-3,000 ha. In 1956 the Salt Lake Reclamation Scheme was formulated and acquisition notices served on nearly half the farms managed for wastewater aquaculture. Between 1962 and 1967, under the direction by the Government, about 1,200 ha of ponds were filled with silt dredged from the Hooghly River; this reclaimed land was used to develop Salt Lake City, a major residential area to the northeast of Kolkata. From 1967 to 1972, a further 320 ha were reclaimed to extend Salt Lake City. In 1972, there were 11,480 acres of fisheries. During the period 1978-79 the East Calcutta and Patuli Townships were developed converting 670 and 240 ha, respectively. Figure 3.1 shows the location of major wetlands in PU Kolkata (dark shading), together with an indication of the areas under agricultural production (hatched).

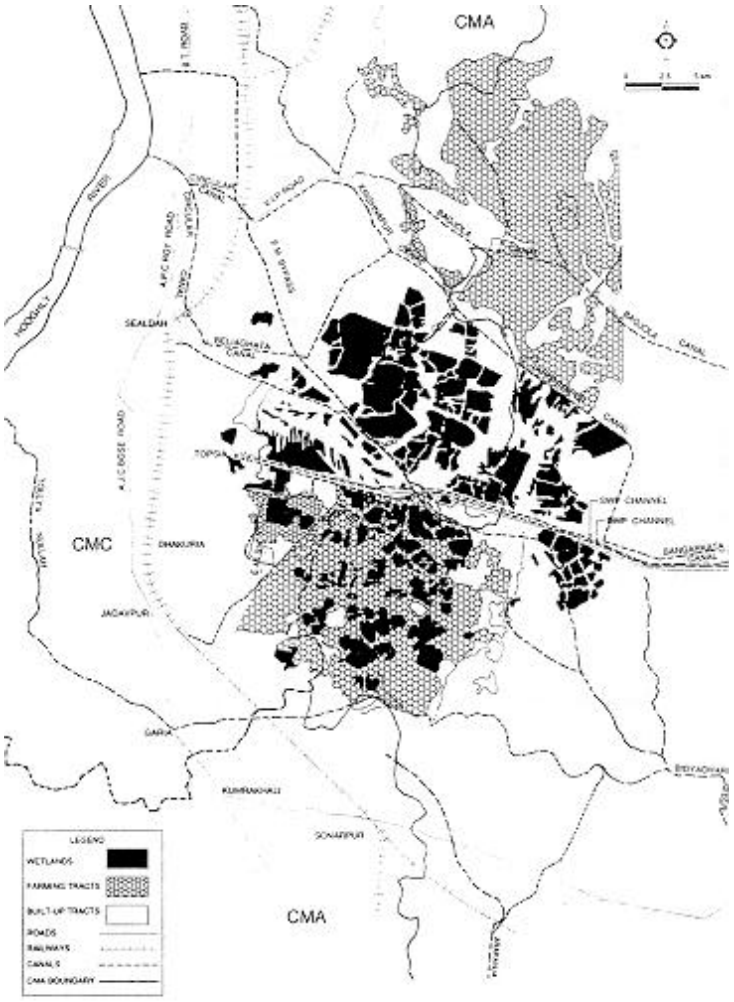

Figure 3.1. Water-bodies and tracts of agricultural land in PU Kolkata (Source: ADB, 2000a)

Following these major projects, recent pond conversions in the area have proceeded in a less overt fashion, with initial conversion to paddy farming, which is more easily developed for light industry or residential purposes. Since the early 1980's, roughly 2,200 ha of ponds have been converted to rice farming. Paddy farming is widespread in West Bengal and the influence of Kolkata on production extends throughout the region. Demand from the huge urban markets helps sustain higher than average prices, whilst nutrient rich wastewater is used for irrigation over 50 km from the city. Naskar (1985) reviewed the practice and history of brackish-water rice cultivation and reported that it was common for farmers in the region to integrate the culture of fish and shrimp with paddy farming. It was also widely reported that water from the Kulit estuary used to irrigate rice fields in these areas contained significant concentrations of sewage water. The author noted that integrated farming was being conducted on 7,000 ha of paddy land in Minakhan block and 11,200 ha in Haroa block. Figure 3.2 indicates the general location and extent of brackish-water rice cultivation downstream of Kolkata, much of which is irrigated partly with wastewater.

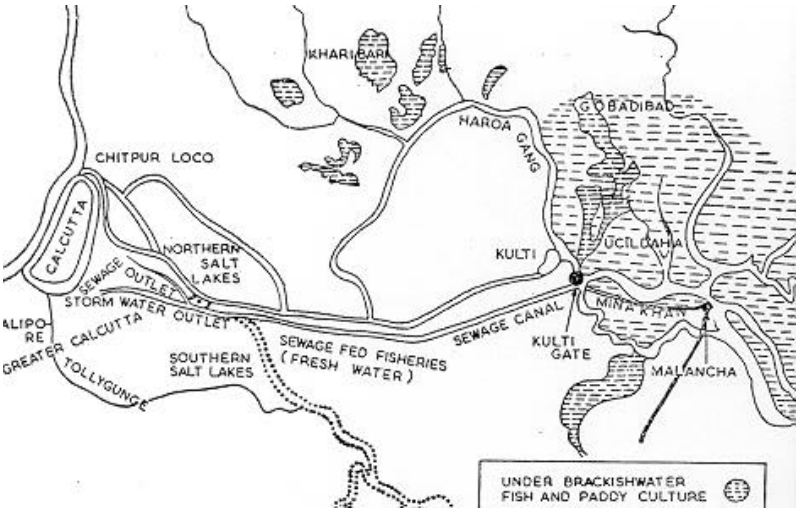

Figure 3.2. Extent of brackish-water rice cultivation downstream of Kolkata (Source: Naskar, 1985)

As noted in Box 1, vegetable farming in PU Kolkata developed in the region surrounding Dhapa and this area continues to be a centre for vegetable production. Arrangements between the Calcutta Corporation and a single private leaseholder, who took responsibility for systematic garbage disposal continued until 1968. At this time the total area estimated to be under vegetable cultivation had risen to 810 ha. Recent estimates have put the area remaining under horticulture in PU Kolkata at ~320 ha, whilst production on this land may be up to 370 t ha^{-1} y^{-1}. Despite the productive nature of horticulture in the area it is apparent that the land area under cultivation has declined significantly, suggesting that land is being converted for other purposes.

Construction of the EMB in the 1980's involved the conversion of selected wetland areas and portions of the solid waste disposal ground. Improved communications associated with the EMB have increased the attractiveness of the area to developers, consequently the potential financial returns for fishery owners that sell their land may be substantial, making the temptation to sell stronger. Furthermore, the role of Government in regulating conversion remains somewhat ambiguous. Although conscious of the need to retain PU wetlands, some recent plans suggest that limited conversion to support infrastructure and economic growth may be desirable; the acquisition notice still threatens ~1,100 ha of wetland at the Kolkata PUI. The KMC, which retains ownership of all the land used for horticulture around Dhapa, also issues only short-term lease agreements that further contribute to uncertainty and insecurity amongst the farming community.

Attempts have been made in recent years by fishery owners and others to stop further encroachment of the wetlands, and as mentioned previously, following a lawsuit filed by NGOs the Calcutta High Court ruled in September 1992 that:

> 'no government or non-government body can reclaim any more wetlands, on the eastern fringes, where wetlands are defined in terms of being wet for 6 months or more in a year.'

This was widely considered a landmark judgement, but doubts have been expressed regarding its implementation. Moreover, as yet no measures have been taken to properly conserve the remaining wetlands. The potential of community-based organisations in developing enhanced natural resource management strategies for PU Kolkata is discussed further in Section 7. The following sections describe the current status of aquaculture, horticulture and rice farming in PU Kolkata. Constraints identified by respondents are discussed.

4. PU aquaculture

Fish cultivation in ponds managed for wastewater aquaculture in PU Kolkata is a practice that has been developed by local farmers and entrepreneurs during the past century; Kundu (1994) presents a comprehensive review of the systems origins and development. A recent report noted that there were 264 individual fisheries or *bheries* operating on a commercial basis with a cumulative surface area of 2,480 ha; these fisheries were distributed within four PU wards, namely Bhangor, Bidhannagar, Sonarpur and Tiljala (CRG, 1997). This report also noted that there were a further 22 fisheries with an area of 970 ha distributed throughout this region that were either lying idle or only informally used for aquaculture. Fish cultivation is also practiced in the numerous *jheels* in the Dhapa area and in several homestead ponds concentrated in Sonarpur and Bhangor, some of which are managed for wastewater aquaculture. Preliminary stakeholder consultations suggested that ~400 households may be producing fish in ponds receiving wastewater.

4.1. Scale and distribution

Aquaculture-based production systems are distributed throughout the WRR and vary markedly in size. Assessing the distribution of commercial fisheries based on location suggests that smaller fisheries below 2 ha occur mainly in Sonarpur and Tiljala, whilst large fisheries >40 ha predominate in Bidhannagar; Bhangor is characterised by a mixture of small to medium sized fisheries (Table 4.1). Although roughly 89% of the 264 commercial fisheries are below 20 ha in size, occupying 1,080 ha, the scale of the remaining 11% of fisheries over 20 ha results in them accounting for a disproportionately large area of 1,400 ha (CRG, 1997).

Table 4.1. Frequency distribution for aquaculture operations with respect to size (ha) and location

Farm size (ha)	Region				Frequency (%)
	Bidhannagar	Bhangor	Sonarpur	Tiljala	
<2		3	41	32	28.8
2-10	21	21	51	32	47.3
10-20	7	8	10	9	12.9
20-30	6	2	2	3	5
30-40		2		1	1
40-50	1				0.4
50-60	3				1
60-70	4	1			2
>70	4				1.5
Total	46	37	104	77	

Developed from CRG (1997)

Table 4.2 shows the size distribution for the 56 aquaculture-based production systems surveyed during the situation analysis. Holdings varied from 0.4-162 ha, whilst the frequency distribution compares well with that for all commercial aquaculture operations in the region (Table 4.1). Individual holdings with an area below 13.3 ha accounted for 59% of the sample, whilst the proportion of farms above the median range of 6.7-13.3 ha

skews the average farm size in the survey to ~18.5 ha; mean pond depths reportedly ranged from 0.15-1.2 m.

Table 4.2. Frequency distribution of aquaculture-based farms with respect to size (ha); figures in parenthesis indicate farms practicing integrated production

Farm size (ha)	Police station				Frequency (%)
	Bidhannagar	Bhangor	Sonarpur	Tiljala	
0-3.3		14	2	1	30
3.3-6.7	1		2	5	14.3
6.7-13.3	2	2	2	2	14.3
>13.3	12 (2)	7 (4)	1	3	41
Total	15	23	7	11	

From the survey data it is apparent that integration of additional production activities with aquaculture appears to occur on some commercial farms with areas exceeding 13.3 ha in Bidhannagar and Bhangor. The nature of these integrated production systems is discussed in Section 4.8. Larger farms (>13.3 ha) occurred mainly in Bidhannagar and Bhangor, and while Bhangor was also characterised by a number of smaller fisheries (0-3.3 ha), no fisheries in this size range were surveyed in Bidhannagar. Subdivision of lakes in Bhangor, as a result of infilling with garbage and land reforms, has resulted in a large number of *jheels* in this region. The size distribution of fisheries in Sonarpur and Tiljala indicates a mixture of small and medium sized fisheries, although larger *bheries* are less common.

4.2. Management pattern

A diverse range of management strategies have developed in association with aquaculture production systems in PU Kolkata (Table 4.3), the evolution of which has largely been governed by socio-political forces and legislative restructuring. Perhaps the key issue in this respect, however, has been land reform in West Bengal, implemented to increase access by poor families to scarce land resources; traditionally feudal landlords or *zamindars* governed access to much of the land in the State. Box 2 outlines the key reforms that have contributed to the current pattern of land holding and use at the Kolkata PUI. Key enactments were the West Bengal Estates Acquisition Act (1953) and West Bengal Land Reforms Act (1955), however, due to exemptions covering tea gardens, orchards and fisheries, the *bheries* in PU Kolkata remained largely intact until only recently. Amendments to the Land Reforms Act in 1995 brought fisheries within its jurisdiction, and consequently lead to significant reorganisation, with many private holdings being vested from their owners by the State and transferred to fishermen's groups (non-registered cooperatives). Having demonstrated their competency, such groups may subsequently apply to become registered cooperatives. The practice of vesting land has resulted in a decline in larger fisheries under private ownership, however, there are a number of smaller, independently managed household ponds and *jheels* in the region. The majority of *jheels* are found on land that was vested from *zamindars* as part of the land reform programme in West Bengal. Two of the largest fisheries in the region, (Nalban and Goltala *bheries*) remain under the direct control of the State Fisheries Development Corporation, GoWB.

Box 2. Land reform in West Bengal

According to planners, land reforms may be used to describe land levelling, consolidation of fragmented holdings or changes in agrarian relations and structure. In India, a complicated issue like land reforms, which includes economic, sociological and political issues must be addressed through a process of evolution, unlike in some other countries where revolutionary changes have brought about desired outcomes in a short span of time. However, since independence, certain shifts in political leanings have been reflected in amendments and new legislation passed concerning land reformation. The West Bengal Estates Acquisition Act (1953) and West Bengal Land Reforms Act (1955) stand as two major pieces of legislation concerning land reforms in West Bengal. The Bengal Tenancy Act (1885) was the first piece of legislation seeking to define the various relationships between different classes of tenants and their landlords. However, not until independence, and the enactment of the Estates Acquisition Act (1953) was the *zamindari* system, introduced under the Permanent Settlement Regulation (1793), abolished in West Bengal. The main objects of the Estates Acquisition Act (1953) were to eliminate the interests of *zamindars* and intermediaries by acquisition on payment of compensation and acquire their mining rights. However, the Act also permitted intermediaries to retain possession of their *khas* lands up to certain limits, whilst treating them as tenant holding directly under the State. Although commonly overlooked, other legislation such as the West Bengal Estates Acquisition Rules (1954), West Bengal Land Reforms (Bargadars) Rules (1956) and West Bengal Land Reforms Rules (1965) has contributed to the pattern of landholding in PU Kolkata. Other enactments such as the Restoration of Alienated Land Act (1973) and Urban Land (Ceiling and Regulation) Act (1976), together with minor Acts have also influenced the process of land reform.

Amendments to the rules of Permanent Settlement and codified by the Tenancy Act (1885) dispensed with large numbers of intermediaries acting between the cultivator and State. The Land Reforms Act (1955), which repealed the Tenancy Act (1885) sought to further refine agreements, stipulating that no intermediaries were permitted between the raiyat and State; this simplified the relationship of the State to the raiyat, as well as that between raiyats. The Estates Acquisition Act (1953), for the first time laid down an upper limit of land that could be held by a raiyat; amendments in the Land Reforms Act (1955) further reduced this limit. The 'land ceiling' as it is now known was fixed by an amendment of the West Bengal Land Reforms Act (1971). Regulations outlined in the Land Reforms Act (1955) stipulate ceilings of 2.5 ha for a raiyat or sole surviving member of a raiyat family and 5 ha for a family comprising two to five members. For a *raiyat* family having more than five members, the limit was 5 ha plus 0.5 ha for each member in excess of five, although the aggregate of the ceiling area for such raiyat shall not exceed 7 ha; for any other raiyat the ceiling was 7 ha.

Land holdings exceeding the relevant ceilings were vested by the government and distributed to the landless and land-poor; this has been a major goal of land reform in West Bengal. The maximum area of land that may be allocated to an individual is 0.8 ha (2 acres), whilst the minimum is 0.14 ha (1/3 acre). Prior to distribution, District Officers make a list of eligible persons in order of priority; local officers then distribute the vested land only to those people that appear on the list. Priority is given to certain groups as stipulated by the Board of Revenue, West Bengal. Landless agricultural workers receive priority, followed by landless Bargadars; landless people who used to cultivate the land in question as Bargadars or agricultural workers under the previous owners; and raiyats owning less than 1 ha of land. For each category, however, members of Scheduled Tribes, followed by Scheduled Castes receive priority. Initially, however, tea gardens, orchards and fisheries were not covered by the land reform Acts, and as a result some large landholdings have remained in private hands. An amendment to the Land Reforms Act in 1995 bought fisheries within its jurisdiction, and recently several large fisheries in PU Kolkata have been vested and distributed among poor fishermen.

Table 4.3. Management strategies and associated observations for PU aquaculture activities

Management strategy	Operation	Comment
Owner managed	- farms managed by the owner who engages labour as required; according to local knowledge this type of management practice is declining	- fisheries of this type were distributed throughout the WRR
Own land with joint management	- land or ponds with multiple owners is developed for fish culture and the owners share investment and operating costs, as well as profits	- this strategy benefits owners who otherwise without joint management could not practice aquaculture
Registered co-operative	- groups of fishermen holding the required land deeds may approach the DoF to form registered co-operatives; following registration co-operatives may be eligible for government support in the form of seed inputs or loans	- despite the advantages many potential co-operatives remain unregistered as they do not possess the correct papers
Fishermen's group or non-registered co-operative	- land vested by the state government is distributed to a group of landless people residing locally and assistance is provided by the DoF in managing the fishery; this is the first step to forming a co-operative	- these groups could potentially form co-operatives but lack the papers required for formal registration
Owner-worker participatory	- Although individually owned the workers take responsibility for investment, management and marketing, giving a fixed portion of the production to the owner	- this ownership pattern benefits both the owner and workers as increased production result in mutual benefits
Leased	- leases are arranged for various periods, although in all cases the owner is given an single payment, the leaseholder is then free to culture fish for the duration of the lease	- a common management pattern although there may be negative environmental and productive impacts as the leaseholder has no incentive to consider long-term change
Leased with joint management	- several leaseholders share responsibility for decision making and profits are distributed according to individual shareholdings	- this type of ownership is common for larger fisheries
Vested CMC land	- the CMC gives water bodies under its ownership to farmers	- vested water bodies (referred to locally as *jheels*) are generally small in sizes
Sublet vested land	- large *bheries* were subdivided and vested among local farmers by leaders of the Left Front Government which has held power in West Bengal for 24 years, the water bodies are then sublet to other farmers	- water bodies resulting from the subdivision of the *bheries* are referred to locally as *jheels*
Incorporated company	- fisheries of this type function as commercial businesses	- only one fishery was managed as a commercial business
Government undertakings	- these farms are maintained by the government	- access to these fisheries is difficult without prior arrangement

Fisheries that remain in private hands are usually run on a partnership, shareholding or leasehold basis; owners rarely operate fisheries directly. In the case of partnerships the landowner is paid a rent but may still participate in decision-making and take a share of the profits. In the shareholding system, profits are divided amongst the shareholders, although the owner generally takes 40% of the profits. When land is taken on lease, usually by five to ten people, the owner is paid an annual rent and profits are shared in proportion to each lessee's financial contribution.

4.3. Water source

Access to wastewater draining from Kolkata city was one of the primary driving forces behind the emergence of PU aquaculture. Initially, opportunistic farmers exploited the wastewater resource to cultivate fish and vegetables, however, as siltation in the Hooghly River became more problematic, the authorities diverted a greater proportion of the silt laden wastewater to agriculture, and in particular fishponds. This strategy required the construction of an extensive canal network that extended throughout the eastern PUI; key arteries in this network include the fisheries feeder canal and Ghosh's canal. The drainage network was engineered to distribute wastewater under gravity to the majority of fisheries, however, as silt has accumulated in the fishponds, an increased proportion of farmers find it necessary to pump wastewater from the canals. This problem has been further aggravated by the need to maintain a low hydraulic head at the pumping stations transferring wastewater from the city sewers to the drainage canals (Edwards, 2001). In the current study it was reported that ~32% of pond managers were required to pump water from the drainage canals to their ponds during the year.

As part of the comprehensive survey of fisheries undertaken by the Creative Research Group (CRG, 1997), operators access to sewage water was assessed, results from this study are summarised in Table 4.4. Respondents were requested to score the supply of sewage water on a five-point scale, where 1 indicated a more than adequate supply and 5 a highly inadequate supply. In the region under Bidhannagar police station perceptions of the sewage supply appear variable, 43% of respondents scored the supply as adequate or more than adequate and an equal proportion scored it as inadequate or highly inadequate. Scores in Tiljala were also distributed across the possible range of responses, although the largest proportion (73%) classified the supply as inadequate or highly inadequate. During the survey 10 respondents in this region did not consider the question applicable, whilst 18 fisheries were rain-fed. The number of respondents in Sonarpur who classified the supply as inadequate or highly inadequate was also significant at 63%, whilst no respondents in this area considered the supply 'more than adequate'. The modal score in both Sonarpur and Tiljala was 4, indicating an inadequate sewage supply. Overall, the majority (60%) of farm managers questioned regarded the sewage supply as inadequate to highly inadequate, a further 22% considered the supply adequate for part of the year, suggesting perhaps that the sewage supply is governed by seasonal changes. Only a relatively small proportion of respondents (18%) scored the supply as adequate to more than adequate.

The historical perspective presented by Furedy (1987) provides an insight to one of the key constraints in reusing wastewater for aquaculture. Siltation problems in the Kulti river were a driving force behind the diversion of wastewater to PU fishponds, however, since this remedial action, no sustained effort has been undertaken to reduce or manage the high loading of suspended solids present in the wastewater. Therefore, the problem of siltation

was merely transferred from the river to the secondary canal network and PU fishponds. As the ponds and feeder canals have become silted, decreasing access and consequently reuse of wastewater in fishponds, siltation in the primary canals and river is again a problem for the municipal authorities. The fact that many fishpond operators experience significant problems in accessing wastewater, and as a result increased volumes of wastewater are having to be discharged to the Kulti river, also belies the myth that reuse in PU fishponds treats a significant proportion of wastewater discharged from the city. Even when functioning ideally, wastewater flowing through the fishponds is not discharged directly to the Kulti River, but passes into downstream paddy fields and drains away from the primary canal network. The volume of wastewater that, having passed through the reuse system, is ultimately discharged to the river network has not been evaluated.

Table 4.4. Access to wastewater, as perceived by pond managers in PU Kolkata

Police station	Scores*					Modal score
	1	2	3	4	5	
Bidhannagar	8	12	6	17	3	3
Bhangor (<2 ha)		1	2			
Sonarpur		5	34	30	35	4
Tiljala	6	4	3	15	21	4
Total	14	22	45	62	59	4

1 - more than adequate; 2 - adequate; 3 - adequate part of year; 4 - inadequate; 5 - highly inadequate
Note: data for Bhangor for fisheries >2ha were not available
Adapted from CRG (1997)

During the 1940's an ambitious scheme was implemented to intercept wastewater draining to the fishponds, and to treat it in primary settlement tanks situated at Bantala. The scheme also extended to transporting sludge, thickened in earthen basins, by train to tea growing plantations in Darjeeling. Although successfully commissioned, the settlement tanks only remained functional for one to two years. Several reasons including technical problems, high operation and maintenance costs and vandalism have been given for the failure of the treatment plant. However, it is likely that a combination of factors lead to such a rapid systems failure. The now defunct settlement tanks remain as a reminder to future planners and policy makers concerning the need to develop appropriate and demand lead interventions that consider the range of stakeholder demands. This is particularly pertinent considering the planned initiatives outlined in the forthcoming ADB-DFID funded Calcutta Environmental Improvement Project (CEIP) urban development project, details of which are discussed in Section 7.3.

Problems with accessing sufficient wastewater from the secondary canal network have resulted in a significant number of operators using pumps. Table 4.5 shows that producers in Tiljala can still rely on gravity to supply wastewater, producers in Bidhannagar also depend mainly on gravity although a few (4) are also required to supplement this by using a pump. The majority of managers (14) in Bhangor rely largely on gravity, although some (6) also need to pump water and 3 depend solely on pumped water. In Sonarpur, the majority of respondents reportedly had to pump wastewater to their fishpond, whilst only two were able to depend on gravity to supply their needs. This is consistent with the

findings of the earlier survey (CRG, 1997) during which the majority of fishpond managers in Sonarpur reported the supply of sewage water to be inadequate or highly inadequate (Table 4.4).

Although in common parlance, references to gravity being employed to supply wastewater to fishponds may, in some cases, be considered an oversimplification. Due to the nature of the sewerage system in the CMA, all drainage water must be raised by pump several meters so that there is a sufficient hydraulic head to enable drainage under gravity through the primary canal network to the discharge lock on the Kulti river and the secondary canals supplying the PU fishponds. Edwards (2002) discussed further problems that have emerged recently due to the technical and operational constraints associated with pumping large volumes of water from the city and the differing demands of stakeholders in the PU area. Furthermore, due to the topography of the region and barriers such as roads, various siphons have been constructed, whilst controlling distribution through the drainage network means that several lock gates on the primary and secondary canals must be regulated and maintained. Unfortunately, farmers frequently complain that due to the prevailing systems for controlling the sluice gates, significantly less wastewater enters the secondary canal network than is actually required to sustain the fisheries; several of the sluices in question are under the control of the Department of Irrigation and Waterways. Some individual fisheries are dependent on the maintenance of siphons to enable them to extract wastewater from the canals.

Table 4.5. Methods employed to deliver wastewater to PU fishponds

Water supply method	Police station				Frequency (%)
	Bidhannagar	Bhangor	Sonarpur	Tiljala	
Gravity	11	14	2	11	68
Pump		3	5		14
Gravity and pump	4	6			18
Total	15	23	7	11	

Maintenance of lock gates, siphons and the secondary drainage network by fishery managers, and the considerable cost of pumping wastewater from the feeder canals to the fishponds, constitutes a significant indirect subsidy supporting the managed disposal of wastewater from the city. However, the formal system draining Kolkata serves only a proportion of the population, usually middle class and more affluent households, together with businesses, that can afford a connection to the sewage mains. Greater understanding concerning the volume of wastewater used in fishponds, and where pond water is discharged to downstream users, the degree of treatment achieved, could be useful in the evaluating the economic benefit of PU fishponds in terms of offsetting the costs of wastewater treatment. Furthermore, wider appreciation of the value of environmental protection, wildlife habitat, employment and food production associated with PU aquaculture, together with other benefits and costs may contribute greatly to informing a rational debate concerning the future of the system.

Pumping of wastewater from the drainage canals is routinely undertaken to sustain both water and nutrient levels in the fishponds, however, pumps are also employed on many of the larger fisheries to drain ponds and move water between ponds, often in an attempt to facilitate oxygenation. The need to pump wastewater to maintain water levels in the majority of ponds highlights the fact that many of the PU wetlands are man-made, and that their existence depends on the continued functioning of the fisheries. Despite this dependence, many environmentalists do not perhaps appreciate this synergy. Were there greater awareness of this issue, it may contribute to building consensus amongst environmental campaigners, producers and policy makers.

The necessity of having to pump wastewater to many of the fisheries also has other consequences: employing diesel pumps represents a capital and operating cost to producers, and also brings into question the environmental credentials of the system. However, owing to an agreement between the managers and labour unions, those fisheries required to pump wastewater are only required to engage labourers at a rate of one per 5 *bigha* or 0.7 ha, as compared with one per 3 *bigha* or 0.4 ha where water is delivered under gravity. Presumably the rationale is that the added cost of pumping means that the imposition of higher labour demands could threaten the viability of the farms.

4.4. Species cultured

Traditionally, aquaculture at the Kolkata PUI was dominated by the production of Indian Major Carp (IMC), specifically a polyculture of rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*). However, there has reportedly been a trend towards culturing tilapia (*Oreochromis niloticus*), usually as part of a polyculture with IMC but sometimes in monoculture. Several other fish species, including common carp (*Cyprinus carpio*), silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) are produced, however, the volume of production appears limited. Tilapia culture is associated with several advantages, self-recruitment in ponds, which is absent in IMC, demanding less investment in stocking, rapid growth and reportedly good disease resistance. Their omnivorous feeding behaviour also means they exploit various feeding niches, whilst the ability to feed efficiently on phytoplankton makes them highly productive in systems receiving significant fertiliser inputs, but where supplementary feeding is limited. Table 4.6 shows the predominate fish species stocked in PU fishponds.

Table 4.6. Predominant fish species stocked in PU ponds

Species stocked	Police station				Frequency (%)
	Bidhannagar	Bhangor	Sonarpur	Tiljala	
Indian major carp dominant	13	10	6	6	62.5
Tilapia dominant	2	12		5	34
Mixed species			1		1.8
Total	15	22	7	11	

It is notable that IMC are stocked predominantly in PU ponds situated in Bidhannagar, a region characterised by larger *bheries*, whilst in Bhangor, where the majority of water bodies are small, tilapia monocultures are more widespread. Several factors may be governing the decision as to which species or combination of species to stock. Investment costs associated with establishing tilapia monocultures may be less, making them more attractive to small producers; returns associated with culturing IMC may be higher, although so too may be the risks, thus deterring more vulnerable small-scale producers; water quality in ponds in Bidhannagar may suit better the requirements of IMC. This may also be the case in Sonarpur where 6 of the 7 producers interviewed stocked mostly IMC, however, in Tiljala the number of farms stocking tilapia and IMC was roughly equal. The decision making process is likely to be influenced further by labour union demands concerning harvesting days per year, fish seed costs and market demand.

4.5. Fish seed and supply chains

The majority of producers (~64%) purchase both fry and fingerlings, however, despite being less costly, only a small proportion (~5.4%) stocked just fry due to the higher risk of mortality. Fry are much more prone to poor water quality, disease, predation and environmental perturbations such as fluctuating temperatures. The fisheries buying fry tended to be larger, with more space available for separate nursery ponds in which the fish may be on-grown prior to stocking in the larger, less manageable *bheries*. The remaining 17 fisheries that only purchased fingerlings tended to be smaller in size, hence with no scope for on-growing.

Regarding fish seed trading it was considered important to assess the characteristics of the supply chains, including:

- the nature and extent of the network, and hence vulnerability to external factors,
- the role of seed trading in supporting poor livelihoods throughout West Bengal,
- technical, financial, institutional and social issues governing the shape and effectiveness of the network.

From those farmers surveyed it was apparent that the majority (64%) depend solely on agents (commonly called *goldars*) to supply fish seed (hatchlings and fry) (Table 4.7). Producers prefer to buy seed from *goldars*, this way the producers avoid the risks associated with transporting fish seed and they are not required to travel long distances from their farm to collect the seed. The *goldars* are also better networked, enabling them to easily find the species, size and quality of seed required by the producers. *Goldars* purchase seed from either Naihati fish market or the *bandhs* in Bankura district; it is then either delivered by truck or the *goldars* commission carriers to transport it on their bikes, or manually on their head, to the desired fishery. Managers requiring larger fingerlings tend to purchase them directly from producers. In Bhangor, where the majority of managers operate small fisheries and *jheels*, fish seed are more likely to be purchased directly from hatchery operators; the hatchery manager will usually arrange for the delivery of seed to Sealdah fish market. Some fishpond managers are also involved with on-growing hatchlings to produce fingerlings that they then sell to other farms in the local area.

Table 4.7. Supply channels employed by managers to acquire fish seed

Seed supply	Police station				Frequency (%)
	Bidhannagar	Bhangor	Sonarpur	Tiljala	
Agents	12	10	4	10	64
Purchased directly		6	1		13
Agents and purchased directly	3	7	2	1	23
Total	15	23	7	11	

Milwain (2001) discussed in detail the organisation and structure of fish seed networks supplying fisheries in PU Kolkata. This author also makes a series of recommendations concerning possible improvements to fish seed production and distribution in West Bengal. Important areas identified for further consideration including improved water quality monitoring and management in hatcheries, better surveillance of tube-well water characteristics, particularly arsenic and iron concentrations which may negatively affect seed quality, better information on risks from flooding and assistance with marketing to reduce competition amongst producers. Milwain (2001) also proposes a workshop with government staff, specialists and business managers to develop improved management strategies; this could constitute an important aspect of future research and development in supporting poor livelihoods and enhancing the viability and efficiency of fish production in PU Kolkata.

From participant responses during the situation analysis, it is apparent that Nihati is the most common source for fish seed (35.7% of respondents), although, sources in the local area were cited almost as often (32% of respondents) (Table 4.8). Local sources probably include the purchase of fingerlings from other farmers in the area who may have on-grown a surplus of fish, either intentionally to sell to other producers, or inadvertently owing to better than expected survival. Producers citing sources in the local area may, however, be buying from local traders but unaware of the origins of the seed they purchase.

Other significant sources for seed include Bankura, Sealdah, Bandel, Tribeni and Pandua, with 10.7-19.6% of producers interviewed purchasing seed from these regions. Suppliers in each of the remaining 18 regions were used by less than 10% of participants. From this study it is apparent that producers in PU Kolkata use fish seed suppliers from a broad geographical distribution to meet their requirements. Further information would be required from participants to identify which factors e.g. proximity, reputation, quality, cost or past experience, govern the decision concerning the selection of seed suppliers, although Milwain (2001) provides a preliminary review. The fact that 45 respondents identified 115 suppliers also suggests that producers purchase seed from several sources. However, more information would be required to assess whether this was due to producers trying to spread risks associated with buying seed of unknown quality from one source or if producers were forced to use multiple suppliers to achieve their preferred stocking regime, in terms of species, size and timing. It is also uncertain whether producers consider possible negative factors such as potential increases in disease risk associated with sourcing seed from multiple suppliers.

Table 4.8. Regions from where fish seed are purchased based on responses from farm managers (n = 56)

Seed purchase point	Police station				Frequency (%)
	Bidhannagar	Bhangor	Sonarpur	Tiljala	
Nihati	9	5	2	4	35.7
Local area	4	5	3	6	32
Bankura	3	4	2	2	19.6
Sealdah	2	3	2	1	14.3
Bandel	3	3	1	1	14.3
Tribeni	4	2	1	1	14.3
Pandua	1	1	2	2	10.7
Kalna		3	1		7.1
Howrah	3			1	7.1
Hooghly			1	2	5.4
Burdwan			1	2	5.4
North 24 Parganas		1		2	5.4
Balagar	1	2			5.4
Jirat		2	1		5.4
Kalyani	1	1			3.6
Nadia	1			1	3.6
Ramsagar	1				1.8
Tripura		1			1.8
Ranaghat		1			1.8
Bongao		1			1.8
South 24 Parganas	1				1.8
Basirhat	1				1.8
Magra	1				1.8
Halisahar	1				1.8
Chandannagar	1				1.8
Total	38	35	17	25	
Information not available		8	2	1	

4.6. Feed and fertiliser application

Although not considered here, wastewater introduced to fishponds represents a significant production enhancing input that stimulates the autotrophic food web. The objective of this section was to ascertain which other inputs are used in PU fishponds to enhance production, and to assess whether the use of such inputs is dependent on access to wastewater. A combination of mustard oil cake and mohua cake was reportedly applied by 64.2% of producers, 16.1% and 7.1% of producers applied leather milk and hotel dust, respectively, whilst 12.5% employed no additional feed or fertiliser. Mustard oil cake and mohua cake are traditional fish feeds, however, due to their relatively high cost alternative nutrient sources such as leather milk and hotel dust are now being exploited. Leather milk is a waste product of the leather industry and is being used in several areas; middlemen collect this material from slaughterhouses and tanneries in containers and transport it to the fisheries on trucks. Hotel dust consists of organic waste from hotel kitchens, the use of this material in fishponds is a recent innovation facilitated by local entrepreneurs who collect and transport it to the PU fishponds. Although obviously meeting a demand, potential negative environmental health impacts associated with these management practises remain

to be assessed. According to some respondents, in *bheries* where the integrated production of ducks and hens is practiced, litter is used as a supplementary feed input, however, no information on the extent and management demands of this practice are available.

4.7. Integrated production

Fisheries commonly have facilities to on-grow seed to fingerlings in smaller nursery ponds prior to stocking in the main *bheries*, however, further vertical integration through the development of hatcheries and maintenance of broodstock may be constrained due to poor access to good quality water in the area, limited financial resources and knowledge and competition from established commercial seed producers in the State. More general farm level integration was reported on six of the larger holdings (Table 4.2) with activities such as growing vegetables, producing coconuts and rearing ducks and hens for eggs and meat. Such integration is usually undertaken on a relatively small scale, largely for self-consumption, although, some produce may be sold at local markets. However, more widespread and intensive integration is reportedly constrained by a number of factors. One example reported was that of law and order problems, farmers are unwilling to risk the theft of livestock or unguarded crops from embankments, whilst the threat of poaching deters mangers from planting trees along their embankments, through fear of reducing visibility and consequently security. Restrictions imposed by labour unions limiting the types of work undertaken by some employees and the added risk and demands of managing integrated systems may also constrain further integration.

4.8. Disease and pest problems

Of 56 farmers interviewed, the majority (47) reported that aquaculture production had been moderately affected by disease outbreaks, only one reported severe affects on production whilst 8 did not consider disease to have an impact. Disease problems mentioned included fin rot, gill rot, dropsy, *Argulus* sp. (fish louse) and *Lernia* sp. (anchor worm), however, it should be noted that some of these terms refer to disease symptoms as opposed to causative agents. Summarising the occurrence of diseases affecting fish in PU ponds, CRG (1997) noted seven potential problems. The incidence of *Gyrodactylus* sp. and *Dactylogyrus* sp. parasites was reportedly insignificant, whilst that of epizootic ulcerative disease, tail rot, dropsy and fish leeches was low. The incidence of fin rot was reportedly moderate, occurring mainly from mid-July to mid-August and from October to February; this problem was also reported to affect all fish species cultured, whilst the usual treatment was the application of formalin. The most serious problems encountered were infestations with *Argulus* sp. and *Lernia* sp. which reportedly had a high incidence; the occurrence of these parasites was reportedly most common amongst IMC species.

Producers depend largely on their own experience in detecting and diagnosing disease outbreaks; a lack of scientific support from government and agricultural service providers was noted, as was the absence of a formal monitoring programme. Despite these constraints producers reported that if detected in the primary stages, and appropriate treatments applied, mortalities may be avoided. Furthermore, producers reported that where fish receive proper nutrition, resulting largely from adequate access to wastewater, the effects of disease are minimised.

4.9. Chemical applications

Lime is generally applied to the sediments during fishpond preparation to kill pathogens, predators and trash fish that may harbour disease; lime is also applied to the water prior to stoking to reduce turbidity. Furthermore, where there is a history of disease outbreaks lime is used in conjunction with potassium permanganate for the regular treatment of pond water. Roughly 82% of respondents reported employing this management strategy, however, of these farmers, 46.4% reported using other treatments. Chemicals employed when fish show visible disease signs include terramycine (oxytetracycline) and metacid (methyl parathion). Treatments are usually purchased from retailers in local markets, who also provide advice concerning the appropriate compound and application rate, however, rarely do they have scientific training, the materials or specimens to make valid diagnoses or a complete understanding of the factors contributing to the disease outbreak. Consequently, disease diagnosis and identification is largely based on guesswork and consultation with other producers having experience of similar problems. Of those farmers interviewed 17.9% reported that no chemical treatments were employed on their farms.

4.10. Labour arrangements and unions

Employment opportunities associated with PU aquaculture have been cited as one of the major reasons why the system is worthy of protection. Reports have suggested that 8,700 people are directly employed as labourers to assist in the operation of the fisheries (CRG, 1997). Furthermore, it has been proposed that the operation of these largely commercial aquaculture systems sustains several thousand jobs in allied support activities such as the supply of inputs, including seed, and the marketing of produce. As with other examples of PU farming, it was envisaged that work in these systems would enable recent migrants from rural areas to find employment. Furthermore, it has been reported previously that several groups of migrant labour have specialised skills, such as bamboo screen making, that ensure they are able to secure employment, although timing and duration may be variable. However, despite the apparent benefit of PU aquaculture in providing employment opportunities, arrangements at the Kolkata PUI are largely governed by the labour unions. This suggests that lessons and recommendations drawn from an assessment of the current system concerning employment should be viewed cautiously and that where labour markets are more flexible, practical and financial considerations may dictate that modified employment arrangements should be adopted. Labour costs in the PU Kolkata system represent the greatest operating cost (CRG, 1997) whilst the majority of farming systems are reportedly not financially viable (Mukherjee, 1996), therefore, in the absence of enhanced production or higher fish prices, major restructuring of the labour force may be required to sustain the system.

Labour unions are well established in the fisheries of PU Kolkata and on behalf of the labourers negotiate terms and conditions for both temporary and permanent employees. Daily wage rates, benefits, job specification, minimum employment days per year, leave and the number of employees to be engaged are all governed by agreement between the labour union and farm managers. However, terms and conditions vary with respect to fishery size and key management aspects. The Dakshin 24 Parganas Zilla Bheri Mazdoor Union represents temporary labours who constitute the majority of the workforce in the fisheries, this union is affiliated to the CITU and largely dictates the terms and conditions for employment in the fisheries. Periodically the unions and fishery managers meet and

negotiate terms and conditions, however, a number of disputes over employment rights resulted in a conflict resolution meeting between the union and managers. In 1992, a draft Code of Conduct was agreed at a meeting of the 24 Parganas Fish Producers Association and district level union officials (Box 3).

The majority of labourers are closely allied to party leaders and union representatives who, following consultation with the workforce, negotiate terms and conditions with members of the fish producer associations. Based on this arrangement, conditions such as the number of harvest days per year, minimum harvest quantity per day, and daily wage levels are fixed; in many cases managers have also been forced to create full-time employment for labourers, thus ensuring they get a regular income. However, due to the strength of unions in the region, several managers reported that the prevailing terms and conditions are biased towards the demands of the workers. Fisheries with an area below 1.3 ha do not have to adhere to the Code of Conduct, therefore, all labourers employed by these farms are casual employees and lack the security of a permanent position. Larger fisheries, do sometimes hire casual labourers to undertake specific tasks, however, it is difficult to judge the frequency of such opportunities as such employment is usually in response to emergency situations, such as burst embankments.

Box 3. Code of Conduct agreed between unions and fish producers

The size of a *bheri* has a bearing on wages paid to labourers and the rate at which labourers should be employed, small *bheries* are classified as those between 1.3-13.4 ha, medium range from 13.4-33.4 and large *bheries* cover an area above 33.4 ha. Aquaculture-based production systems below 1.3 ha in size are excluded from the 'Code of Conduct' as labourers working on operations of this scale are not unionised. Employment rates are based on the premise that *bheries* that are not required to pump wastewater require a greater number of labourers (one per 3 *bigha* or 0.4 ha) whilst those that pump wastewater to the ponds require less labour (one per 5 *bigha* or 0.7 ha). The number of harvest days and quantity of fish to be marketed are fixed based on the area occupied by the *bheri*:

Bheri area (ha)	Harvest days per year	Minimum harvest quantity (kg d^{-1})	Minimum production required (t ha^{-1} y^{-1})*
1.3-4	-	-	-
4-6.7	120-135	150-200	2.7-4.5
6.7-13.4	180	240	3.2-6.4
13.4-26.7	240	360	3.2-6.4
>26.7	300	500-800	5.6

*preliminary calculations demonstrate that some medium sized fisheries must achieve relatively good production rates of 6.4 t ha^{-1} y^{-1} to meet the requirements of the Code of Conduct.

Compensation should also be provided to labourers employed on fisheries over 26.7 ha at a rate of half the annual wage, whilst additional conditions state that labourers should only engage in one type of work and have a minimum of six-month employment per year.

Developed from Mukherjee (1996) and CRG (1997)

Although many of the farm managers may consider the Code of Conduct restrictive, it can be argued that terms and conditions set out in this agreement have largely been responsible for several of the key benefits attributed to PU aquaculture around Kolkata. Stipulating a minimum number of harvest days per year and minimum harvest quantity contributes to the predominant stocking and harvesting strategy in the region, which in turn results in a constant supply of small fish to urban markets. The small size of fish cultured means they are affordable, and are generally sold in markets serving poor communities, whilst the year

round supply of fresh fish has benefits for food security in poor households. The consistent nature of stocking and harvesting also means that small-scale suppliers and traders are routinely involved in servicing the needs of producers, and therefore receive regular commissions or wages.

Despite these benefits, producers face the same fixed employment costs, irrespective of production rates or price levels, therefore, a decline in either may threaten the financial viability of the farm. The fixed term nature of employment arrangements also means there are few incentives for labourers to contribute to achieving higher production or enhancing the quality of fish produced. The introduction of practices such as profit sharing or bonuses could contribute to enhanced production, better returns for managers and employees, more fish for sale in urban markets and greater employment opportunities in associated activities. Although some managers did consider the specified employment rates per unit area high, it was noted during other project work that some co-operatives reportedly provided employment for larger numbers (Edwards, 2001). The caveat concerning pumping in the Code of Conduct and its influence on employment rates is also significant in light of proposed development initiatives. Renovation of the canal network feeding the fishponds and establishment of secondary pumping stations to enhance wastewater delivery may mean more fisheries are required to engage one employee per 3 bigha (0.4 ha); this could almost double the number of people employed by these fisheries. Furthermore, added labour costs may negate any saving achieved through not pumping.

4.11. Employee livelihoods

Based on survey outcomes it is possible to identify several categories of labour associated with the various stages of fish production in PU ponds managed for wastewater aquaculture (Table 4.9). Labourers employed directly to manage and maintain the *bheries* and *jheels* include fishermen, who undertake the main work of netting, fish carriers, land cutters and several others who work cleaning grass or applying lime, fertiliser and medications. The permanent workforce, which mainly lives on-site, consists of the manager and those engaged in net making, construction work, weed clearance, harvesting and cooking. Members of the permanent workforce earn ~Rs1,200 (£17) per month and receive other benefits such as board and lodging, medical expenses and a small subsistence grant; they are also entitled to 4 days leave per month. Casual labourers employed for netting, desilting, guarding, transporting, net repairing and various other activities, usually live in villages adjacent to the ponds. General information concerning the location of these villages in relation to the fisheries was noted and in some instances arrangements made with employees for further visits to the local communities to initiate the process of focus group and household interviews.

Considering the gender of managers and labourers engaged in PU aquaculture, it was noted that no fisheries were owned or taken on lease by women and that hardly any women were employed as workers. Women are present as members in some co-operatives and undertake activities such as weeding and transporting fish, however, in such cases women are only permitted to work if no other members of their family are employed in the fisheries; labour unions make the final decision concerning the allocation of jobs. Further knowledge on the nature and outcomes of selected permanent and casual employment opportunities associated with PU aquaculture will be collated during subsequent focus group and household interviews.

Table 4.9. Primary livelihood strategies associated with PU aquaculture practiced on 56 farms

Primary livelihood	Permanent	Casual	Total
Permanent			
Netting	690	125	815
Desilting	103	62	165
Weed clearing	192		192
Day guard	149		149
Night guard	719	25	744
ala staff	346		346
Transportation	184	157	341
Net repairing		50	50
pata bona		15	15
Total	2,383	434	2,817

4.12. Finance

Regarding finance, the survey revealed that most managers, 57% of those surveyed, depended wholly or partly on *dadan* or advances from traders to finance their production activities. Such arrangements usually involved managers entering into agreements with *aratdars* (auctioneers). Loans are usually taken in the form of subsidised fish seed, with an undertaking that when the fish are harvested they will be marketed through the same *aratdar*, who will take some fish as repayment and a commission of 3% on the remaining fish for providing the initial loan. Finance in the form of private loans or credit was reportedly used by 45% of respondents, whilst 43% utilised their own savings for investment. Only a small proportion of producers (~5%) reported that they made use of formal loans from banks, co-operatives or local government departments. A couple had received loans from the DoF, although this usually depended upon prior involvement of the department in developing a management plan for the fishery. Many of the participants interviewed (46%) reported using more than one source of finance for investment, however, the relative advantages or problems encountered with each requires further investigation.

4.13. Constraints

The following section reviews the major constraints facing producers and discusses the knowledge required to address such problems, as well as opportunities to improve the situation. Many of the issues outlined in Table 4.10 are mentioned frequently in conversations with farms in PU Kolkata, however, few attempts have been made to prioritise the major constraints based on the perceptions of farm managers. Based on outcomes from the survey it is apparent that the most widely reported constraint is uncertainty concerning the supply of wastewater; 86% of respondents mentioned this factor and participants assigned it a mean rank of 1.1, which resulted in it being ranked as the most important constraint. Factors contributing to this problem were discussed in Section 4.3.

The second most important constraints, with overall ordinal ranks of 2.5, were "financial problems" and "declining wastewater quality", mentioned by 25 and 9 per cent of respondents, respectively. Aggregation of responses under a general heading of financial problems means that it is difficult to specify whether these are due to poor financial returns, high input costs, restricted access to credit and loans or other factors; therefore, further work on assessing the nature of these problems may be useful. Declining water quality apparently affects fewer producers, and although quality may be a largely subjective term, widely reported concerns relating to wastewater quality are reduced nutrient status following the removal of cattle sheds from the city and industrial contamination.

Table 4.10. Constraints to PU aquaculture based on the perceptions of farm managers (n = 56)

Constraint	Proportion of respondents affected (%)	Mean rank assigned by participants	Overall ordinal rank
Uncertain wastewater supply	86	1.1	1
Financial problems	25	2	2.5
Declining wastewater quality	9	2	2.5
Poaching	34	2.5	4
Labour problems	30	2.6	5.5
Siltation	23	2.6	5.5
Management problems	5	3	8
Poor road infrastructure	5	3	8
Poor seed quality	2	3	8
Limited access to electricity	9	3.2	10
Disease	29	3.3	11
Threat from land developers	7	4	13
Law and order problems	4	4	13
Inundation during flooding	2	4	13
Declining production	5	4.3	15
Transport problems	2	5	16

Note: 5% of respondents were unable to identify specific constraints to production

Poaching was reportedly the second most widespread constraint faced by producers. All fisheries employ night guards, and some also deploy day guards; of all the livelihoods supported by PU aquaculture, guard duties account for the greatest number. It has been suggested that fishery workers with low incomes sometimes steal fish from neighbouring farms, and that residents from particular villages are renowned for poaching, however, there is no evidence to support this. Small-scale 'poaching' by some of the most vulnerable members of local communities may be vital to their survival and such activities are often overlooked, however, other accounts suggest poaching in the area can be highly organised and orchestrated by armed gangs. Constraints associated with 'labour problems' and 'siltation' each received an ordinal rank of 5.5, these problems were mentioned by 30 and 23 per cent of respondents, respectively. According to farm managers, labour problems include unwillingness to work and forced employment by the unions, however, during the course of discussions some labourers remarked that inefficient management also represents a problem. Without some form of wastewater pre-treatment, the problem of siltation is likely to persist and gradually threaten the continued operation of the fisheries, however

measures to control this problem may be difficult to implement and would likely require the support of all producers in the region. The cost and logistical problems of renovating those fisheries already badly affected by siltation are also likely to be prohibitive. The possible synergy between de-silting the fisheries and filling land for urban development is discussed in Section 7.1.

Management problems were mentioned by a small proportion of respondents (5%), and received an overall ordinal rank of 8, however, further information is required to assess the nature of these. Poor road infrastructure was mentioned by a similar proportion of people, and also received an ordinal rank of 8. Poor seed quality was also assigned an ordinal rank of 8, although only mentioned by 2% of respondents. Limited access to electricity was of concern to slightly more producers (9%) but only received an ordinal rank of 10. One of the most common constraints, mentioned by 29% of respondents, was a problem with disease affecting production, however, with an overall ordinal rank of 11, the severity of the problem appears generally low. However, where disease problems are present, even at low levels, there is the possibility that management difficulties or slight environmental perturbations may trigger a more severe or widespread outbreak. Only a small proportion of respondents mentioned the remaining problems, which were ranked 13-16; thus suggesting these may be localised and of generally low importance. During this phase of the interview, it was apparent that respondents were sometimes reluctant to discuss some of the more sensitive problems they may face, e.g. antagonism with local political activists, law and order problems and question marks over land entitlement and documents.

5. PU horticulture

Disposal of municipal solid waste is generally regarded as a significant problem by urban authorities. However, the tradition of organic waste reuse through horticulture in PU Kolkata has meant that farmers have managed, and indeed subsidised, the disposal of a significant proportion of solid waste generated by residents and businesses in the city. This arrangement has also benefited farmers in the area as municipal organic waste has been less expensive than alternative inorganic inputs, and conferred additional benefits such as maintenance of soil quality and suppression of pests.

The origins of PU horticulture exploiting municipal waste were described in Box 1. Dhapa still constitutes a centre for horticulture in PU Kolkata, although a number of factors are reportedly constraining this practice. Horticultural production during the 1960s was estimated at 56,000 t y^{-1}, today the daily supply of vegetables to urban markets has been estimated at 147 tonnes. However, despite its contribution to supplying urban markets with year-round fresh produce, appreciation of the benefits associated with PU horticulture and understanding of issues that threaten its viability is reportedly limited amongst urban communities. The objective of this survey phase was to describe the general nature of vegetable farming in the WRR and identify where further research might be appropriate. It was also anticipated that knowledge generated would assist in developing recommendations for policy makers and PU natural resource managers, to safeguard and enhance this established farming sector.

5.1. Scale and distribution

The current extent and location of horticulture in PU Kolkata may largely be attributed to historical factors relating to solid waste disposal from the city, as outlined in Box 1. However, other factors such as recent changes in access to solid organic waste and wastewater, competition from producers in other parts of West Bengal due to improved communications; and the level of market demand are increasingly likely to influence the scale and distribution of PU horticulture. From the survey it is apparent that the majority of horticulturists interviewed (97%) were located in Tiljala, which includes Dhapa, Boinchtala and Dhalenda; the area around these villages has traditionally been the centre for vegetable growing in the region.

Of the 33 farmers interviewed, four had land holdings of <0.13 ha, twelve had 0.13-0.39 ha, eight had 0.39-0.65 ha, five had 0.65-1.3 ha, whilst the remaining two had over 1.3 ha. Land farmed by many respondents (21) was classified as fragmented, with individuals managing more than one plot; frequently these plots are highly dispersed and sometimes in different states, notably Bihar and Orissa. Land-holdings in other states were usually associated with the family home, although this land too was sometimes reportedly fragmented. From these findings it is apparent that migrants from other states do find employment growing vegetables around Kolkata, however, the scale and fluidity of this livelihoods strategy remains uncertain, as does knowledge concerning the relationships and resource flows between migrants and their families.

5.2. Management pattern

Without exception, all land farmed by participants in the current survey was under the ownership of the KMC, of the 33 farmers interviewed, 20 had taken their lease directly from the KMC, whilst 13 had taken on land which had been sub-let by one or more intermediaries. As a condition of the lease, which usually lasts for a single year, farmers are only permitted to undertake agricultural activities, and do not have rights to sell the land or use it for other purposes. Such short-term arrangements result in feelings of insecurity and uncertainty meaning farmers are less likely to invest time and money to ensure the long-term future of the production system. Consequently, soil quality, both in terms of structure and nutrient status is under threat; consideration of management impacts on the wider environment, less; and investment in new technology and supporting services, e.g. improved solid waste and wastewater delivery mechanisms, enhanced marketing channels or better extension services, severely limited.

5.3. Solid organic waste application

During the course of the last century, low-lying land surrounding Dhapa, Boinchtala and Dhalenda was in-filled using solid waste from the city; solid waste was used subsequently to supply nutrients for growing vegetables. However, during the survey, around half of the farmers interviewed (16) reported that they no longer exploit this nutrient source, instead preferring to use chemical fertilisers. Factors contributing to the decline in solid organic waste exploitation include difficulty in ensuring continued access to inputs, declining quality and the low price of some inorganic fertilisers owing to government subsidies. Three farmers interviewed reported that they had never used organic waste on their farms, although the factors behind this require further investigation.

Access to organic waste inputs has reportedly been constrained due to the difficulties faced by truck drivers trying to deliver loads along narrow and sometimes poorly maintained roads and paths servicing the vegetable growing areas. Financial incentives were previously employed by producers to ensure delivery of good quality organic waste, however, with growing competition from the recently commissioned composting plant for organic matter, the farmers now find themselves unable to pay sufficient incentives to secure regular deliveries. Where truck drivers do deliver loads of municipal solid waste, it frequently has to be left some distance from the fields, meaning farmers have to arrange for carriers to transport it by hand to the vegetable plots where it is required. This may represent a significant cost to the producer, and considering the perceived decline in quality of solid waste inputs, many producers are reluctant to pay for this service. Prior to using trucks to remove solid waste to the dumpsite, a light railway transported solid waste from the city to Dhapa; parallel tracks were used alternately to ensure a constant supply to farmers throughout the region, however, this system was discontinued in 1974. An interesting opportunity might be to investigate the possibility of renovating this solid waste transport system, however, such a rehabilitation project would require careful assessment and widespread consultation to ensure an equitable and appropriate outcome.

Considering solid waste to which they have access, farmers perceive two key factors that are contributing to a decline in its quality; the first is the greater proportion of non-biodegradable material thrown out by city residents and the second is the fact that better quality waste with a high organic content, e.g. from markets and food processing facilities,

is taken preferentially to the organic composting plant where truck drivers receive a premium from the operators. The organic composting plant is also a joint venture between the KMC and commercial operators, and as such truck drivers working for the KMC are more inclined to transport waste to the plant.

Problems of accessing solid organic waste outlined above appear considerable, however, despite these constraints, 14 respondents reported that they still rely on inputs of solid municipal waste to cultivate vegetables. This suggests that producers still regard solid organic waste as a useful input to PU farming systems. Several advantages are reported for plots in which organic waste is routinely used: firstly producers are required to apply less inorganic fertiliser, thus reducing costs and avoiding environmental problems associated with fertiliser wash-out; secondly, mulching facilitated through solid waste applications helps suppress weed growth and conserve soil moisture; thirdly, organic inputs help maintain soil quality, enhancing production and avoiding erosion. Based on these observations it appears reasonable to suggest that opportunities to safeguard continued access, and where possible widening access, should be investigated.

5.4. Irrigation strategy

Vegetable growers in PU Kolkata predominantly use water from *jheels* and fishponds to meet their irrigation requirements; of the 33 farmers interviewed, 32 exploited these water sources, whilst only one relied on rainwater. All producers irrigating with water from *jheels* and ponds routinely used pumps to extract the water and deliver it to their fields; however, in times of need, clay pots may also be used to carry water to the fields manually. Although producers reported using pumps, it is not clear if individual operators own pumps, if several producers buy sets collectively or whether producers hire pumps to meet their requirements. It would also be interesting to know how access to water resources in the region is regulated, and if the owners or managers of the *jheels* and ponds demand payment for extracted water. In the dry season *jheels* in the region are prone to drying and producers either have to access alternative water sources or modify their cropping patterns to account for such water shortages.

Combinations of solid organic waste and wastewater used by different producers in the main vegetable farming region have been described in detail (IWMED, 1999). In this study it was reported that nine distinct combinations of waste resources could be identified and that use patterns could largely be described based on geographical distribution (Figure 5.1). In areas **a** and **g** sewage water was reportedly used directly from the canals, although solid waste was only used in area **a**. Other areas where solid waste was exploited included **b**, **c**, **d**, **e** and **f** although a distinction was made between the application of 'fresh' and 'old' waste. Areas **b** and **d** received largely domestic wastewater, whilst areas **c** and **e** received wastewater containing tannery effluent, area **f** being rain-fed. Areas **h** and **i** did not receive solid waste inputs and rainwater and wastewater-fed pond water were used for irrigation, respectively. Based on this characterisation of farms, it might be suggested that those using wastewater directly (**a** and **g**), wastewater containing tannery effluent (**c** and **e**) and fresh solid waste (**a**, **b** and **c**) pose the greatest health risk to workers and consumers. Furthermore, where rainwater is used for irrigation producers are likely to be more vulnerable to drought, whilst producers exploiting solid organic waste and wastewater are more likely to be vulnerable to changing access to these resources. Information presented in Figure 5.1 could prove useful in targeting resources and future research.

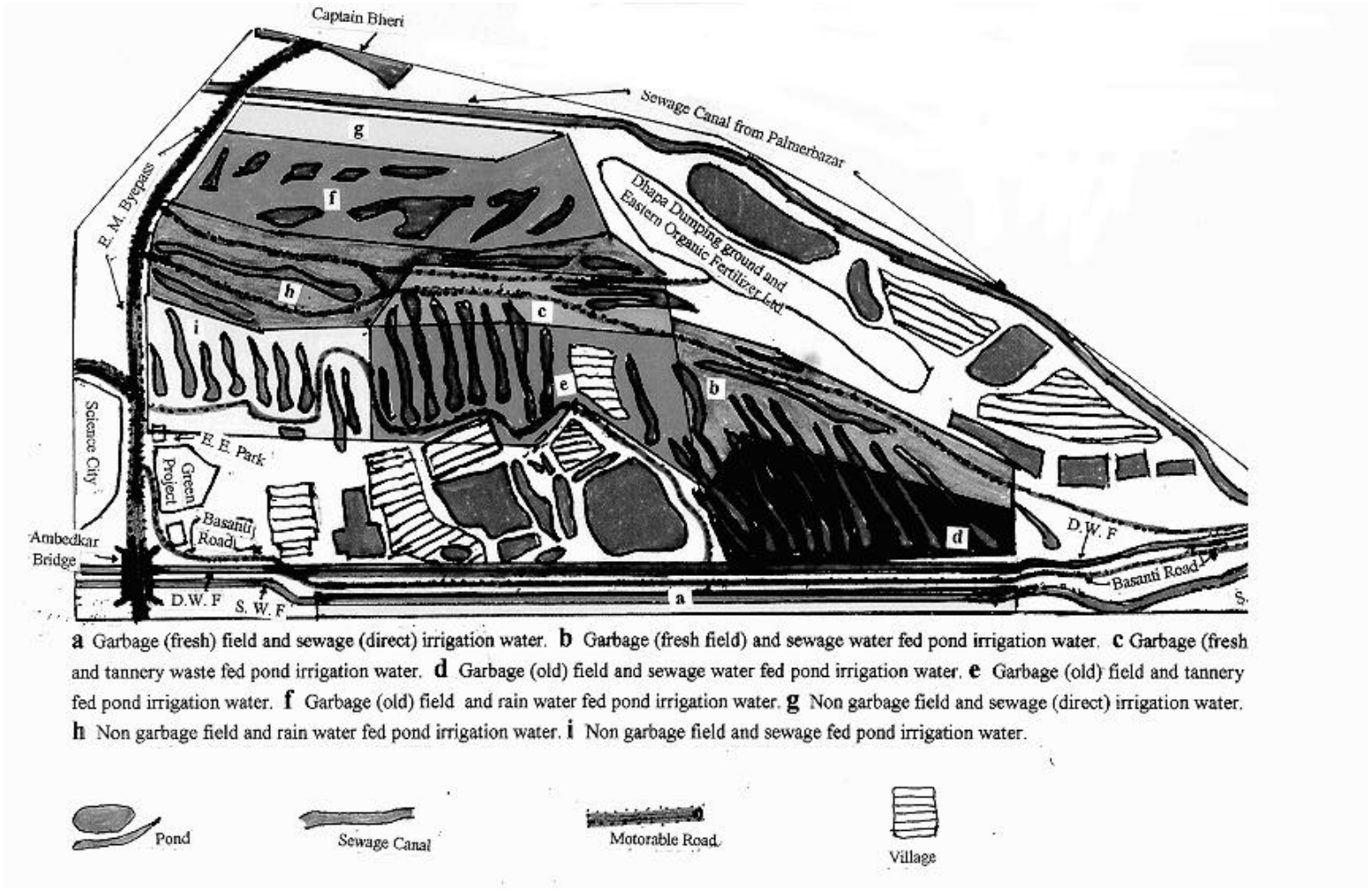

Figure 5.1. Distribution of vegetable cultivation practices in the Dhapa region based on use patterns of solid organic waste and wastewater (Source: IWMED, 1999)

5.5. Crop varieties cultivated

Vegetable farmers in PU Kolkata cultivate a range of species and varieties, including bottle, bitter and ridge gourds, *lalsak* and *dhulisak* (*Amaranthus* spp.), cauliflower, *brinjal* (*Solanum melongena*), radish and several recently introduced Chinese leafy vegetables. More than sixteen vegetables are commonly produced on PU farms and as many as 11 separate crops grown annually; the selection of vegetables to be grown in each crop is dictated largely by the availability of water and organic waste. Due to prevailing soil conditions it is also common practice for farmers to simultaneously crop 3-5 varieties on the same land. Cropping strategies generally follow a seasonal pattern based on successes and failures in past years. During the dry season it is common for farmers to cultivate leafy vegetables that can survive with a nominal amount of water.

Anecdotal evidence suggested that growing cauliflowers shows the greatest potential in terms of profit, although associated risks were not assessed. Maize cultivation is also reportedly increasing in the region although the reasons for this remain unclear. Innovations, particularly concerning the introduction of new varieties appear largely to result from farmer led initiatives, no respondents reported receiving advice or assistance from local government departments or NGOs. Although not scientifically trained, farmers in the region have acquired significant knowledge through practical experience. However, the absence of ongoing support and training in the region means new entrants may not be able to readily adopt horticulture on vacant or accessible land, whilst existing producers may be poorly equipped to cope with rapid change associated with urbanisation or unforeseen perturbations.

5.6. Seed supply

Of the farmers interviewed, 30 purchased seed from the market, and for 16 respondents this was reportedly their only source of seed, the remaining 14 also prepared their own farm-saved seed. One farmer interviewed reportedly saved all the seed required for replanting, purchasing none from the market. From the data collected it is not clear if the varieties being cultivated dictate whether farmers have to buy seed from the market. Further investigation concerning the perceptions of farmers regarding the performance, production and disease resistance of farm-saved seed, as compared with seed purchased from the market may also be useful. Helping assess prospects for improved seed management, whether producers require more knowledge, or whether improved marketing channels for seed would be beneficial. Farmers in the region generally bought and sold seed at Mathpukur market, however, data on the origins of seed in this market, and the number of farmers interviewed that sell seed there, is not currently available.

5.7. Fertiliser use and application

Until recently, solid organic waste from the city was commonly the only nutrient source used to cultivate vegetables in PU Kolkata. Following composting in heaps along the field margins, garbage from the city reportedly formed very good organic manure. However, recent problems with declining quality and reduced access to solid organic waste have lead to an increasing number of producers turning to inorganic nutrient sources. Of the farmers interviewed ~50% rely on chemical fertilisers such as urea, *sona saar* (calcium aluminium

nitrate), super-phosphate and DAP (di-ammonium phosphate) to meet crop nutrient requirements. Urea usage is relatively widespread due to a comparatively low cost, as compared with other fertilisers, and the level of growth enhancement associated with its application. The comparatively low cost of urea is also partly due to the government subsidy, introduced with the aim of increasing agricultural output. The recent transition to inorganic fertilisers and apparent priority given to cost considerations suggests producers may require further knowledge concerning the relative performance of different fertilisers in terms of yield and product quality. Further trials in the region concerning the impact of changing from largely organic to inorganic inputs on soil quality, disease resistance and pest and weed infestations would also potentially be useful. Opinions expressed by fellow farmers and shopkeepers also reportedly influence the selection of fertiliser by producers.

5.8. Pest and disease problems

Problems with pest infestations were reportedly widespread, effecting crops planted by 97% of farmers questioned; of those effected, 2 reported severe problems whilst the remaining 30 reported moderate problems. Although many farmers in the region are experienced vegetable growers, many were only able to give the local names of pests such as *sutulipoka* (*Epilachna* sp.) and *kestokalipoka* (green leaf hopper). Limited knowledge concerning the scientific name and identification of pests and their developmental stages represents a considerable constraint to selecting the most appropriate and specific treatment. Evidently, from these responses it is apparent that the use of garbage appears to have little effect on the perceived severity of pest problems encountered by producers.

5.9. Pesticide use and application

Of the 33 farmers interviewed, 32 reported using pesticides on their crops, only one reported not using such products. Pesticides such as Follidol® powder (methyl parathion) are routinely applied by dusting over the plants; several oil based pesticides e.g. Ustad® (cypermethrine-10) and Hildon® (endrosulphurece) are applied by mixing in water and spraying onto the crop. Due to limited knowledge concerning the type of pests encountered and suitability and action of particular pesticides, producers frequently mentioned that they follow the advice of sellers or other farmers in selecting and applying pesticides. In many instances farmers reported using the same pesticide irrespective of the pest attacking their crops. In certain cases we found producers applying Gamaxene® (hexachlorocyclohexane) to plants with the aim of preventing damage by ants. It was interesting to note that in some instances, farmers did not use pesticides on vegetables used for their home consumption. However, further investigation would be required to assess whether the reason for this was concern over the likely health effects of pesticide residues or the fact that farmers were not worried about the quality and appearance of vegetables for home consumption.

5.10. Labour, livelihoods and gender

Labourers are employed on a casual basis depending on the availability of labour from the manager's own household and workload; during busy periods of planting and harvesting more labour is likely to be employed. Having completed work on their own land, farmers with small land holdings sometimes find employment as labourers on neighbouring plots to

earn extra income. The casual nature of the labour force means that a union has not been created to represent them. Agricultural labourers generally reside in villages adjoining regions where horticulture is practiced, although a number live in the *bustee* or slum near Mathpukur market. Labourers are generally employed to undertake specific tasks, such as cleaning and weeding, ploughing, garbage sorting, sowing, harvesting and transporting the vegetables to Mathpukur and Choubaga markets. From wealth ranking in the first project workshop it was apparent that casual agricultural labourers are amongst the poorest groups present at the Kolkata PUI, furthermore, the casual and unpredictable nature of their employment also makes them some of the most vulnerable.

With respect to gender, it was observed that both men and women were employed as agricultural labourers. Based on informal discussions it was apparent that many women who worked in the fields were largely responsible for supporting their families; often this was due to the absence of a partner through bereavement or separation, or the inability of a husband or father to work due to ill health. When not engaged in agricultural labouring, many of the women find employment as rag pickers at the local garbage dumps. Other employment opportunities in the region are severely limited, and resources and training to diversify livelihoods difficult to access. Declining horticultural activity in the region or decreased demand for agricultural labour resulting from mechanisation could therefore have significant negative impacts for many households, particularly those that are female headed. During the survey it was apparent that female managers of plots managed for horticulture were very much in the minority, although a few exceptions were found.

5.11. Finance

Access to finance for many farmers in the region appears to represent a potential constraint to production; of those responding to this question none accessed finance from banks, local government departments or NGOs. The most common finance source, mentioned by 21 respondents, was that of personal savings, however, more information on the nature of such personal savings, where they are kept or invested and the rates of return may be useful in assessing relative financial performance and risks. Further information concerning 'personal savings', for example, if they are savings accumulated by individuals, households or families and how decisions are made concerning the allocation of savings could potentially be useful. The second most common source of finance was a private loan or credit, mentioned by 18 respondents. If the loan is taken after mortgaging assets the interest is 5%, but if the farmer has nothing to mortgage, the interest rate is 10%. Only one respondent reported taking an advance from a *dadan* to finance his farming activities, however, the interest rate and repayment arrangements were not discussed. Further information of the comparative terms and conditions associated with different finance options may be useful in assessing the usefulness of working to provide alternatives. From this study, however, it is apparent that horticulturalists are much less dependent on finance from *dadans*, as compared with aquaculture producers.

5.12. Constraints

Constraints to horticulture identified by participants are outlined in Table 5.1; of the 11 factors identified, concern over the inaccessibility of solid organic waste and difficulties with its transportation were mentioned by the largest proportion of respondents (42%)

making it the most widespread problem. Issues relating to changing access to solid waste and potential causes and consequences were discussed in Section 5.4. During discussions a further problem was identified: when trucks do drive over farmland to deliver solid waste to remote holdings, the physical compaction of the soil can significantly affect soil quality and production. The second most common problem, cited by 30% of farmers, was limited access to finance, however, from discussions in Section 5.12 it is apparent that several finance options appear to be available, therefore, it may be possible that farmers are concerned about the terms and conditions attached to finance agreements available to them. Also as the farmers do not hold the deeds to the land they farm, securing loans from formal institutions may be problematic.

The vulnerability of producers is apparent from the concerns expressed regarding 'seasonal water shortages' and 'price fluctuations', mentioned by 21% and 18% of respondents, respectively. Water pumped from neighbouring *jheels* is the major source of irrigation for vegetable growers in the region (Section 5.5), however, for ~2 months at the end of the dry season these water bodies are prone to drying out. As a consequence, some farmers have modified their cropping pattern growing leafy vegetables that are more tolerant of drought conditions, however, some are forced to cease production. Connecting drought affected *jheels* with perennial ponds and canals through secondary canals or underground pipes may be possible in some cases, whilst increasing the capacity of *jheels* to hold water would benefit all those that depend on this water source. However, in either case such actions are likely to be costly and potentially difficult to coordinate, particularly where producers are unable to reach consensus on the best approach. Seasonal over-production of selected commodities also negatively affects market prices, however, the diversity of crops grown by farmers offers them some protection against this, whilst multiple crops grown and marketed throughout the year helps ensure a regular income for farmers. Some growers reported the depressed prices caused by seasonal commodity gluts sometimes caused them to discard significant amounts of produce, as after paying for transportation to market, they are sure they will lose money.

Table 5.1. Constraints to PU horticulture based on the perceptions of farm managers (n = 33)

Constraint	Proportion of respondents affected (%)	Ordinal rank
Inaccessibility/solid waste transport	42	1
Limited access to finance	30	2
Seasonal water shortages	21	3
Price fluctuations	18	4
Insect pests	6	6
High fertiliser/pesticide prices	6	6
Declining solid waste quality	6	6
Health problems of workers	3	9.5
Adverse chemical effects	3	9.5
Poaching	3	9.5
Problem of land security	3	9.5

Note: 21% of respondents were unable to identify specific constraints to production

Problems with insect pests, high fertiliser and pesticide prices and declining solid waste quality were each mentioned by 6% of respondents. Concerning the specific question posed concerning insect and disease pests, a large proportion (97%) of respondents noted a problem, although only two reported severe effects (Section 5.9). Responses recorded in Table 5.1 also demonstrate that when considered alongside other possible constraints e.g. inaccessibility to solid waste and limited access to finance, pest problems appear relatively unimportant. High fertiliser and pesticide prices were also problematic for some producers, although the majority were reportedly unconcerned. Site-specific conditions and individual management regimes may influence the need to apply fertiliser and pesticides. Therefore, further information would be required to assess why more farmers are not concerned about inputs prices, especially as 50% of vegetable growers now depend on inorganic fertiliser (Section 5.8) and all those providing information employ pesticides (Section 5.10).

Each of the remaining four constraints were only mentioned by single farmers (3% of respondents), suggesting that these problems are not widespread and may be associated with specific features of the farms in question. Health problems of labourers were of concern on one farm, workers suffer from cuts, wounds or stomach problems, whilst access to medical care is largely unavailable or expensive. During discussion of this topic the farmer reported that most labourers were now used to such problems and had stopped complaining. One farmer mentioned adverse chemical effects although no further information on the nature and severity of these impacts was recorded; further information would be required to state whether it was the crop, labourers or wider environment that was effected. Poaching was apparently much more problematic for managers of PU fishponds, perhaps due to the size of the ponds, and difficulties in monitoring activities over such large areas. Many vegetable producers engage night guards or watch over their own and neighbouring plots, whilst casual labourers living nearby are also likely to be vigilant. Insecurity of land tenure was apparently not widespread, however, knowing that all land holding in the area are under the ownership of the KMC, may mean farmers are resigned to having insecure tenure and consequently making management decisions based on short term assessments. Some farmers that had migrated from other states, given the chance, would reportedly like to sell off rights to their holdings to developers, however, local farmers wished to continue farming, as it represents the only accessible livelihood strategy.

The practice of ‘garbage farming’ has been a major source of income and employment in the Dhapa region for many decades, however, due to the constraints outlined and discussed above, the majority of farmers considered their livelihoods threatened and believed that the land would not remain under vegetable cultivation for much longer.

6. PU paddy farming

Rice cultivation is widespread in West Bengal and forms an integral component of many rural livelihoods, however, the scale and influence of Kolkata means that rice cultivation over 50 km from the city may be regarded as PU in nature. Demand from urban markets influences the value of rice grown in much of West Bengal, many consumers also express a preference based on price, as opposed to nutrition, taste or aromatic properties, and consequently many farmers have changed from growing high quality indigenous varieties, to high yielding introduced strains. Flows of wastewater connect the rice producers to the city; for many years nutrients entrained with this water used for irrigation have been perceived as a benefit, however, increasing contamination and changing consumer perceptions may change this. This section aims to describe the nature and prevailing management approaches used in PU rice production, and to elucidate some of the most important constraints, as perceived by farmers.

6.1. Scale and distribution

Of the 22 producers interviewed, 13 were solely growing rice, whilst 9 were farming predominantly rice with some land given over to vegetable cultivation. Of those producing only rice, 7 were farming less than 1.3 ha, 4 were farming 1.3-2.6 ha and 2 were farming over 2.6 ha. Of those engaged in mixed farming, 6 were farming 0.26-1.3 ha, 2 farmed 1.3-2.6 ha and 1 farmed between 2.6-3.9 ha. All producers interviewed were farming rice in either Sonarpur (12) or Bhangor (10); of those farming in Sonarpur, 9 were growing only rice, whilst 3 were also growing vegetables, in Bhangor, 4 were growing only rice and 6 were also producing vegetables. Due to the relatively small sample size it is difficult to say that mixed farms producing both rice and vegetable are more common in Bhangor. However, during discussions with farmers in the village of Tardah Kapasiti, it was suggested that water scarcity during the dry season in Bhangor meant vegetables, requiring less water than rice, were grown during this period. In Tardah Kapasiti farmers are largely dependent on natural rainfall to sustain production, in such circumstances information on more efficient rainwater harvesting and storage might be useful, although, existing practices would first require assessment.

Fragmentation of paddy fields occurs mainly as a result of land subdivision owing to marriage and inheritance, and the acquisition of new land to extend traditional family holdings, through redistribution under the Land Reforms Act (1955) and the purchase of vacant plots. Fragmentation was reported by ~50% of respondents who considered it problematic owing to logistical and security difficulties. Anecdotal evidence suggests that in the village of Nayabad, Sonarpur, several farmers manage large land holdings producing rice, however, no information is available concerning the relative efficiency and productivity of such farms and whether they confer greater or lesser benefits to poor communities in the region.

6.2. Management pattern

Of those farmers only producing rice, 5 managed their own land, 6 rented land owned by the KMC and 2 rented KMC owned land, sub-let by intermediaries. The majority of farmers producing both rice and vegetables (8) owned the land they farmed, whilst only

one leased land from a neighbour. Farmers owning the land they farm are often referred to as *raiyatas*, indicating that although ultimately the government retains ownership, they have the right to sell the land, although its use may not be changed. Much of the land let by the KMC had previously been vested from feudal owners under the West Bengal Land Reform Act (1955). In many cases, vested land in Bhangor and Sonarpur was formerly given over to fishponds, consequently when sub-divided the only crop that may be grown on such low-lying land is rice. Unlike aquaculture, joint management of farms is not generally practised by rice growers; often families are able to manage rice paddies, whereas in fish production the large ponds act more as a common property resource, where joint management has proved largely effective and equitable. Mechanisation on small family plots is also not practical, however, on larger plots holdings some new technologies have been adopted.

6.3. Water source and irrigation strategy

Regarding irrigation water, it was reported by producers that three main sources are exploited. The first is natural rainfall, this occurs mainly in Tardah Kapasati region and 11 farmers reported using this water source. Some farmers harvest rainwater for storage in ponds, however, stored water is usually only sufficient to meet household needs. The second water source, used by 10 producers, was wastewater from drainage canals; 9 of these producers were only growing rice. According to growers in Tardah and Hatgachha regions, the ability to access wastewater for irrigation means they have to apply less inorganic fertiliser to achieve acceptable yields. The third source, used by 5 farmers, is underground water extracted using shallow tube wells; although more costly than pumping from surface canals, groundwater exploitation becomes a necessity in some regions during the dry season, enabling two crops to be grown. Groundwater exploitation was noted mainly in Dharmatala Pachuria and the surrounding region. From discussion with farmers in Tardah they noted an inability to exploit groundwater due to the low level of the water table and the capital and operating costs of pumps.

Some paddy farmers that have invested in pumps frequently permit neighbours to rent them to irrigate their own plots. In many districts of West Bengal three crops of rice are grown, however, in PU Kolkata no farmers reported cultivating a third crop. Some farmers use water stored in ponds and *jheels* during the dry season, however, often storage capacity is insufficient to irrigate crops throughout the entire period. Where underground water is employed, it appears to be used primarily to supplement more accessible sources, 3 farmers exploiting wastewater from canals also used groundwater, whilst 2 using rainwater irrigated with groundwater during part of the dry season.

Of those exploiting only wastewater, 4 relied on gravity to irrigate their fields, whilst 3 employed a pump. The three farmers using both wastewater and groundwater relied on gravity, a pump or a combination of the two, respectively. Five of the farmers dependent on rainwater exploited gravity and used pumps to direct, collect and redistribute water to which they had access, however, four relied only on natural rainfall and drainage. The two farmers depending on both rainwater and underground water used pumps to irrigate their fields when required.

6.4. Fertiliser use and application

Fertiliser use in rice production is common practice with urea, super-phosphate and calcium representing key inputs. Quantities employed depend on several factors including rice and soil type, irrigation rate and plant growth; other factors such as the level of risk associated with production and the cost and availability of fertiliser will also influence the timing and level of application. Of the farmers interviewed, 6 used only inorganic fertiliser inputs, whilst 15 used both inorganic and organic nutrient sources. Organic inputs included cow dung and compost, most of which was derived from household waste and by-products from vegetable growing and processing.

Based on past experience and site-specific characteristics, many farmers have developed the capacity to assess the rate at which to apply organic and inorganic fertiliser to achieve the most effective results. However, with changing access to waste resources, particularly due to the removal of cattle sheds from eastern Kolkata, knowledge concerning traditional practices becomes redundant and inappropriate, as reliance of inorganic fertilisers to supply all plant nutrients increases. In some situations, ash was being used as a supplementary fertiliser, although it also reportedly helped reduce pest problems, whilst the origins of this practice were not clear, it was mainly observed in the Tardah region.

Rice farmers in PU Kolkata generally depend on advice from their neighbours concerning the application of non-traditional fertilisers. Therefore, although there was reportedly a trend toward using relatively cheap inorganic fertilisers that produce immediate benefits, it is possible that application rates are sub-optimal, that excess nutrients are lost in runoff or that potential impacts on soil quality following long-term inorganic fertiliser use are poorly understood. One reason for the shift to inorganic fertiliser is that in India most fertilisers are highly subsidised, although some more so than others. Urea receives the highest subsidy, and therefore farmers tend to apply it when a deficiency in plant growth is observed, although it may not be the correct supplement. Where wastewater from canals is accessible to farmers, they reported having to use less fertiliser, as compared with their neighbours. Farmers also stated that if wastewater is used, only urea application is required to achieve good growth.

6.5. Seed supply

Paddy seeds of varying quality are widely available in local markets, and many farmers, having fulfilled their own requirements often sell some seed at these markets. Of the farmers interviewed, 13 reported using farm-saved seed, however, 6 noted that in roughly alternate years they purchased seed from off-farm sources. Where farm-saved seed is used constantly, these producers believed that the strain becomes weaker, yields decline and crops become more disease prone. Seven farmers reported using only purchased seed; in some cases farmers were given seed by officials at the Block Office, this is the administrative office for district subdivisions run by the State government. Access to seed when required and in sufficient quantities did not appear to be a problem for PU rice growers.

6.6. Pest and disease problems and treatment

The majority of farmers (19) reported experience of moderate problems with pests and disease outbreaks, whilst only 3 reported severe problems. Some of the most common pests affecting the rice crop were named as *majra poka* (gall midge), *gandhi poka* and *jhalsa poka* (leaf faller). In case of *jhalsa poka*, if pesticides are not applied in the initial stages the entire crop may be destroyed; leaves redden and appear burnt and finally the plant shrivels and dies. Although most farmers rely largely on their own judgement concerning which pesticides to use and when to apply them, they sometimes take advice from either neighbouring farmers or people that sell the pesticides. Pesticides routinely used by the farmers include Hildon® and Demachrome®.

6.7. Labour, livelihoods and gender

Paddy farmers in the region are not affiliated to the unions, however, most are members of the local *Krishi Samabay* (farmer co-operative). This organisation looks after the interests of agricultural labourers, making sure they receive a proper wage and that they are not exploited. However, labourers employed in the paddy fields are commonly engaged on a casual basis and therefore lack the security of a regular income. When employed the daily wage is around Rs50-70 for men and Rs40-50 for women. Labourers working for rice farmers usually also have their own land, yet work in the fields of larger farmers to earn extra income. Labourers that work predominantly in the fisheries sometimes also engage in agricultural work during the paddy season.

During the survey, very few women were reported to manage farms producing rice, however, many of the labourers engaged in activities related to paddy farming were female. Male agricultural labourers usually undertake activities such as ploughing, sowing and harvesting, whilst women are more commonly engaged in post-harvest work, threshing and drying the rice. Occasionally women were observed working in the field but this was usually related to severe financial hardship, forcing them to engage in physically arduous activities. Poor wages received by their spouse, bereavement or a husband leaving his wife were given as possible reasons why women might face financial hardship, compelling them to work in the fields.

The majority of labourers reside in villages adjacent to the paddy fields with many living only a few minutes walk from the farms on which they work. However, in some instances, labourers reportedly travelled several miles from their villages to find work, staying in temporary accommodation until the end of their contracts. Some farmers also managed land some distance from their native village, and as a consequence it was suggested that younger generations were dissuaded from pursuing agriculture as a livelihood strategy, preferring to engage in more local activities. Where this situation arises an aging farmer will often sub-let the land to others.

6.8. Finance

The range of finance sources available to paddy farmers is similar to horticulturalists. However, unlike the vegetable growers, two rice farmers were reportedly making use of loans from banks, local government departments or co-operatives. According to many

producers bank loans are not popular, as it is difficult to access loans from sources such as this, especially as most farmers don't have land deeds to use as security. For rice growers the most common source of finance was private loans and credit, however, in such cases, interest rates charged are usually around 10%, which is relatively high when compared with other finance options. To secure private loans it is often necessary for borrowers to deposit assets with the moneylender, otherwise the rate of interest may be increased. Where the loan is not repaid within the given time the borrower risks losing assets deposited as security. For most farmers harvest periods represent the only times when there might be money available to invest in the production system, however, financial returns are often only sufficient to repay debts and purchase seed and fertiliser.

6.9. Constraints

Demand for rice in the region is strong, local people eat rice with two or three meals per day, whilst the huge area under paddy cultivation in West Bengal means prices are cheap, perhaps making rice more attractive than other cereals. Although prices might be low as compared with other crops, average yields, relatively low input costs and limited barriers to entry, mean farming rice remains an attractive livelihood option. This is supported by the fact that a significant area of PU Kolkata has been converted from aquaculture to paddy farming. However, despite the growth in this agricultural sector, farmers undertaking paddy cultivation around Kolkata face several constraints (Table 6.1).

Seasonal water shortages were the most widely reported problem, noted by 68% of those surveyed; from Section 6.4 it is apparent that this problem is usually associated with farmers that depend largely on rainwater for irrigation. A common solution to avoiding dependence on rainwater is to install a tube-well, enabling the farmer to extract groundwater when required, however, this is costly and probably beyond the means of many, especially in the Tardah region. Farmers could form collectives to pay jointly for a pump and its instillation, however, management, especially the scheduling and allocation of water may be difficult to co-ordinate. Improved approaches to rainwater harvesting and storage may be more appropriate, but again will require some investment of resources on behalf of both farmers and local government department or NGO groups.

Limited access to finance was mentioned as a constraint to production by 45% of respondents. Farmers reported that this was a significant barrier to adopting modern technologies, however, the prospect of co-operative farming was regarded as a possible strategy to permit investment and enable members to benefit from economies of scale. In general, farmers thought that the return from paddy farming was not sufficient considering the level of time and money invested and the risks faced, however, many mentioned that they thought themselves incapable of doing an alternative job, or simply that to their knowledge there were no other jobs available.

Pest problems and price fluctuations were each noted as constraints by 14% of farmers. Issues relating to pest problems were outlined in Section 6.6, and from that discussion it is apparent that farmers would benefit from greater support regarding the diagnosing and treatment of pest problems. Furthermore, knowledge concerning integrated pest management approaches could potentially make a significant contribution to avoiding problems, reducing expenditure on pesticides and safeguarding public, producer and environmental health.

Farmers attributed price fluctuations to two main factors. A long-term decline in the value of rice was attributed to processes of globalisation, in particular cheap imports from Thailand, which have meant farmers no longer have access to the larger markets, and consequently only find an outlet in local markets where the price is comparatively low. Secondly, seasonal fluctuation in the price of rice, associated with over-supply during certain periods of the year, were regarded as problematic as few farmers have the capacity to store grains successfully, and are instead forced to sell in depressed markets. Farmers also noted that sometimes, due to the poor quality of their produce, they are unable to attain higher prices; farmers blamed quality problems on the varieties they cultivate and inability to adopt advanced paddy cultivation methods, due largely to financial constraints.

Table 6.1. Constraints to PU paddy farming based on perceptions of farm managers (n = 22)

Constraint	Proportion of respondents affected (%)	Ordinal rank
Seasonal water shortages	68	1
Limited access to finance	45	2
Insect pests	14	3.5
Price fluctuations	14	3.5
Seasonal inundation of fields	5	5

Note: 14% of respondents were unable to identify specific constraints to production

Only one farmer mentioned seasonal problems associated with the inundation of land and property during the rainy season; his farm was situated in a flood prone area on particularly low-lying land. To compensate for this problem the farmer outlined how, based on his own experience, he had modified his cropping pattern to avoid planting out when there was still a risk of losing the rice crop due to excessive inundation.

The nature and range of constraints identified by participants will probably change in response to various external forces, for example, modifications in legislation and policy relating to PU natural resource management, variations in input or borrowing costs or changing consumer perceptions. From the patterns of constraints reported it is also apparent that farmers in the same region may each face a different range of problems, largely depending on their personal circumstances and site-specific variables. In such settings, the most effective approach to solving existing problems and dealing with potential future threats is to strengthen the capacity of farmers and local institutions to identify, assess and address constraints. During discussions one farmer proposed that one reason why there is not more support for one another within the farming community was the fact that they are all poor. Financially, individual farmers in the region may be relatively poor, however, each farmer has their own knowledge and experience, and collectively it may be that farmers in the region have access to the resources required to address many of the constraints they might face. The *Krishi Samabay* represents one institution that may be able to represent rice producers and work toward consolidating and extending the existing farmer centred knowledge base. However, other local institutions and organisations such as NGOs, CBOs, universities and local government extension services may also have important roles to play.

7. Summary and emerging issues

Outcomes discussed in the previous three sections have related largely to responses by individual farm managers. In general the findings agree with those of previous studies, whilst new knowledge concerning the range of constraints faced by managers should have an important role in guiding future research and more particularly, policy initiatives and development orientated work. An important aspect of the process reported here was widespread research fatigue amongst participants, this is due partly to the failure of past projects to address constraints facing producers and partly due to the failure of researchers to communicate findings effectively to policy makers and development agencies.

One useful outcome of the survey with managers has been further knowledge concerning the number and general nature of people whose livelihoods depend either directly or indirectly on farming systems at the Kolkata PU interface. Dialogue initiated during the survey should also prove useful in gaining access to groups of labourers from poor communities. Outcomes from this work will be used to guide a more focused assessment of the benefits poor people derive from PU farming. Incorporating knowledge from both the stakeholder workshop and farm manager interviews, selected poor groups will be identified and representatives invited to participate in household and focus group interviews, permitting them to share perceptions of their livelihoods and discuss constraints and opportunities.

During the course of this survey, and as a result of discussions undertaken as part of the first project workshop and institutional assessment, it has been possible to identify some emerging constraints that may seriously threaten the viability of traditional farming practices in PU Kolkata (Table 7.1). Although many existing constraints have been well documented and are widely recognised, for example, insecure land tenure and industrial contamination of waste resources, unforeseen problems may have much more severe impacts. During the first project workshop the vulnerability of poor PU communities to rapid change was highlighted, limited access to resources and knowledge mean it is particularly difficult for such communities to plan for, and cope with, change.

In the following sections the most significant emerging constraints to PU farming are described; a number of other proposed development initiatives are also reviewed as they too may have unforeseen consequences that constitute potential threats. It is intended that this preliminary review will contribute to a more detailed assessment of the primary constraints and opportunities to livelihoods enhancement in PU Kolkata. Where possible, knowledge of potential constraints identified will be communicated to policy makers, development agencies and stakeholder groups, the objective being to increase their capacity to plan and cope with these emerging problems.

7.1. Siltation

A widespread problem that affects all farmers in the region is siltation, both of the primary and secondary canals and fishponds. Issues related to the problems of siltation were discussed in Sections 4.3; from this it is apparent that the logistical problems of desilting the fishponds would be considerable. Furthermore, limited financial reserve and restricted access to finance may mean producers are unable to initiate work on removing silt. Considering the scale of the problem it is probably true that without external assistance, for

example soft-loans or grants from the government or development agencies, the farm managers will be unable to address the problem.

Table 7.1. Emerging constraints to the viability of farming systems exploiting wastewater in PU Kolkata and potential management strategies

Constraint	Potential management strategies
Siltation of canals and ponds	- desiltation of canals and ponds, using sediment to enforce embankments and off-site as fill for construction sites - primary effluent treatment to reduce suspended solids load entering drainage network and ponds
Decreasing access to wastewater	- renovate canal network and increase pumping capacity, permitting wastewater transfer to secondary canals servicing fisheries
Increasing industrial contamination	- improved planning, discharge standard enforcement, treatment, HACCP and product monitoring
Advanced wastewater treatment plant	- increase wastewater supplied to ponds or provide supplementary nutrients to sustain production
Decreased access to and quality of solid organic waste	- encourage separation at source to reduce inorganic content, and better co-ordinate waste distribution
Wastewater from new urban developments	- re-engineer distribution network to accommodate new and existing flows
Employee health problems	- promote strategies to limit health risks, implement HACCP framework
Changing consumer perceptions	- extend HACCP to processors and retailers, monitor products to reassure public and provide consumers with guidance on storing and preparing products from PU farms

Edwards (2001) described possible synergies arising from the need for desiltation and the demand from developers for fill to prepare land for urban developments. Indeed fishponds managed by the Nalban co-operative society have recently been desilted to provide fill for part of the planned Rajarhut new township development. Despite the potential of such arrangements the logistical problems remain, much of the WRR is largely inaccessible to heavy pant and haulage vehicles, suggesting that it may be necessary to implement a wider infrastructure programme, including road building, to facilitate the removal of sediments. Unfortunately, such infrastructure projects may be at odds with the objectives of local conservation groups who are reluctant to see any development that may disrupt the perceived ecological balance. Improved road access may also permit greater access to the largely isolated villages in the WRR, which may in turn increase pressure for unplanned development. The need to renovate the canals and ponds obviously represents a pressing problem for producers, but management of the underlying problem of high suspended solids loading in the wastewater will probably require individual managers to implement appropriate treatment strategies. An alternative approach would be to commission a centralised wastewater treatment plant, however, a number of technical and operational constraints may be associated with such a strategy; issues relating to centralised wastewater treatment are discussed further in Section 7.3.

7.2. Decreasing access to wastewater and declining quality

Further to affecting production by decreasing the volume of water in fishponds, siltation also prevents the effective distribution of wastewater in the secondary canal network serving the farms. Uncertain wastewater supplies for aquaculture managers and seasonal water shortages for vegetable and rice growers represent significant constraints. Indeed considering the seasonal nature of rainfall in the region (Figure 1.3) urban drainage water has, in the past, permitted farmers to cope with periods of natural water scarcity and to intensify and extend production into what may otherwise have been fallow periods. However, owing to problems of siltation, and ongoing conflict between the needs of the urban drainage authorities and the requirements of producers (Edwards, 2001), benefits once associated with access to wastewater are being reduced. Desiltation of the secondary canal network would contribute to farmers regaining access to wastewater, however, renovation of the primary canals and upgrading of the pumping stations draining Kolkata would be required to completely restore the system. An alternative approach being proposed by the DoF would be to install secondary pumps to transfer wastewater from the primary to secondary canals. However, this would increase energy consumption by what is regarded as a largely ecologically balanced system and also incur capital costs and demand resources for operation and maintenance.

Better co-ordination by farmers in the region could contribute to the more effective operation of the silted canal network, especially where the canal is used to both supply the fishponds with water and drain them. Through a collective effort by farmers in the region it may also be possible to arrange for sections of the secondary canal network to be desilted, however, limited access to finance and insecurity of tenure appear to constrain investment in such activities. Declining wastewater quality, both in terms of perceived nutrient levels and greater industrial contamination, is also of concern to producers. During preliminary discussions with farm managers they reported that the nutrient status of wastewater reaching their farms had decreased following the removal of cattle sheds from the city. Furthermore, increased per capita water supply and usage in the city may be diluting the available nutrients.

Perceived declines in wastewater nutrient status suggest that modified management strategies may be required to optimise production efficiency, however, prior to such work, further assessment should be made to quantify the changing availability of nutrients. Contamination of wastewater with industrial effluents also affects the quality of the resource; the problem of tannery effluents has long been recognised, but effluents from various other industries also present a serious threat. Ideally monitoring and enforcement of discharge standards should safeguard against contamination, however, the complex urban drainage system and the limited resources of the regulatory authorities mean discharged standards are not always enforced. Consequently, the onus falls on the producer to try and prevent contaminated produce from reaching the market, however, limited knowledge concerning possible health hazards or appropriate strategies to minimise potential risks mean producers are unable to safeguard against this.

7.3. Ongoing and planned development initiatives

During stakeholder meetings, institutional analysis and the initial project workshop, several planned development initiatives were identified that could potentially have a significant

impact on poor livelihoods at the Kolkata PU interface. State authorities plan to relocate tanneries from the eastern edge of Kolkata to a designated complex 20 km further east, whilst a new township to the northeast of Kolkata is planned for 1 million people. Major projects concerning urban planning and development are also being implemented by various State level authorities with external loan and grant aid assistance. The CEIP project funded by the ADB and DFID, to be executed by the KMC and DoIW aims to '… improve the welfare and well being of the people of Calcutta, especially the poor, though an improved urban environment, equitable access to municipal services, and more effective municipal management' (ADB, 2000, p. ii). Each of these planned initiatives is described briefly below and potential impacts on poor PU livelihoods discussed.

Tanneries relocation

During the 1990's awareness and concern regarding the discharge of tannery effluents to PU Kolkata increased significantly, as a consequence it was proposed that the tanneries should move to a dedicated facility further from the city. However, despite setting up the Calcutta Leather Complex (CLC) and a ruling by the Supreme Court of India (1996) ordering the closure of tanneries close to city, discussions with stakeholders suggest that none of the estimated 500 individual tannery operations have relocated. Although plans to move the tanneries to a centralised complex, where the needs of operators can be met more effectively and waste discharges more easily managed, appear reasonable, a number of concerns have delayed the process. Operators have particular concerns: the lack of nearby housing to accommodate the considerable workforce; perceived law and order problems that may make the transfer of money and goods unsafe; increased government scrutiny; and the costs and inconvenience of moving further from the city and their traditional customer base. The treatment of effluents originating from the CLC was widely regarded as one of the key benefits, helping reduce levels of industrial contamination in the PU environment and WRR. However, due to poor planning, it has been reported that a common effluent treatment plant will not be commissioned until two years after the complex becomes operational. There is also concern that if the planned effluent treatment plant is not well designed and maintained that pollution, particularly heavy metals, will again result in public and environmental health concerns.

Rajarhat township

Figure 7.1 shows an outline land-use plan for Rajarhat. This development, covering 2,750 ha, will include commercial and business districts and housing for an estimated 1 million people, whilst open spaces to encourage wildlife and recreation will cover 1,310 ha (Anon, 1995). Although the township is outside the WRR, a development on this scale, with an associated increase in groundwater abstraction and runoff and wastewater discharges is likely to disrupt the local hydrology. Furthermore, it is proposed that Rajarhat wastewater could be discharged to the WRR, augmenting recent declines in wastewater flows from Kolkata. However, where Rajarhat wastewater has different characteristics, such as nutrient or pathogen loadings, to that from Kolkata, farmers may be required to adjust their management practices to maintain the quantity and quality of production. Modifying the canal network to convey Rajarhat wastewater to the WRR may also conflict with the existing drainage pattern, possibly demanding construction of a separate canal system or the diversion of Kolkata wastewater to areas outside the WRR for reuse or to the Kulti River for discharge. A positive aspect of the Rajarhat development is the possible use of silt from fishponds as construction fill, an issue discussed above.

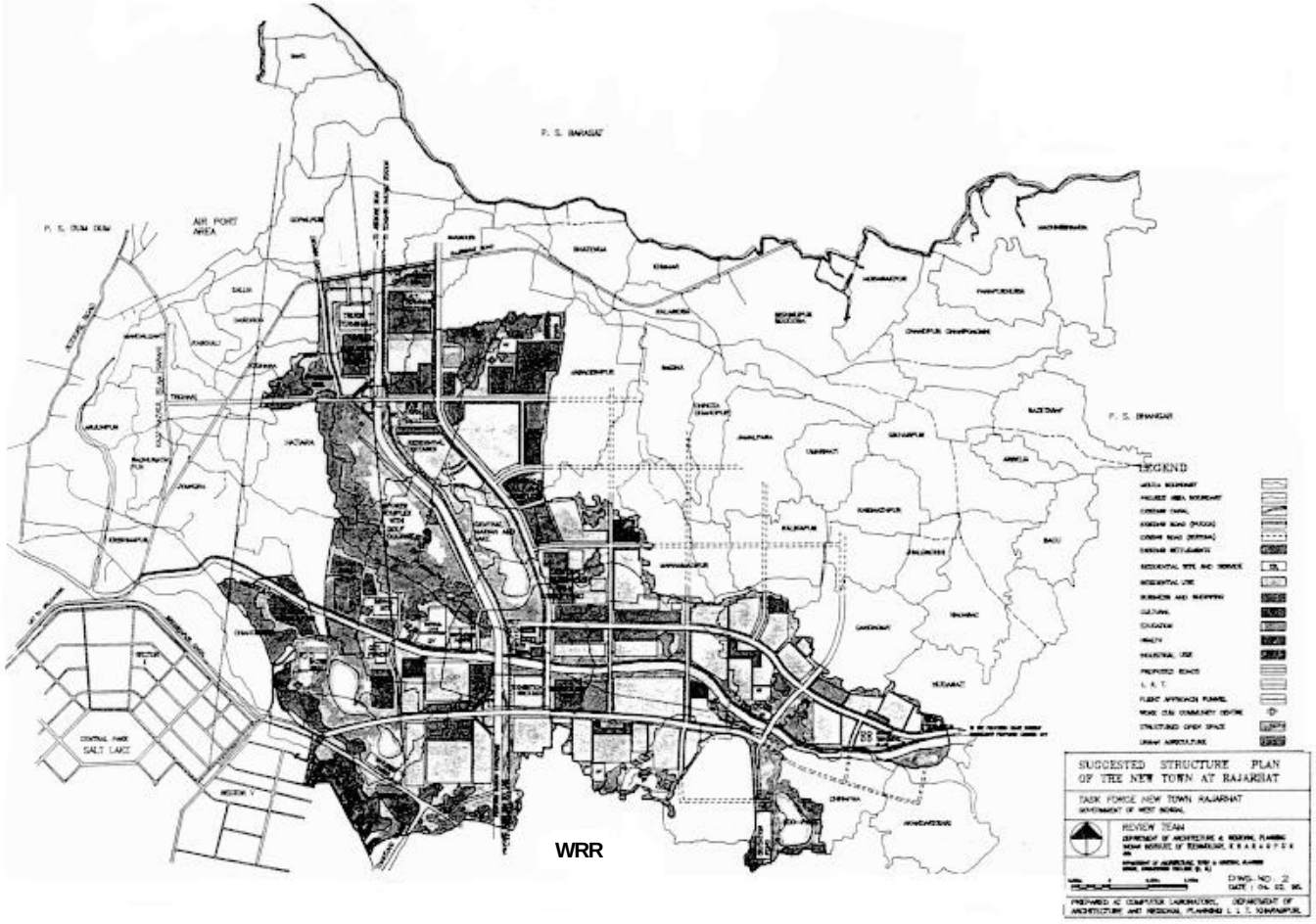

Figure 7.1. Outline plan for Rajarhat covering an area of 2,750 ha and bordering the northern boundary of the WRR (Source: Anon, 1995)

Advanced wastewater treatment

Although largely focused on urban communities, in the initial CEIP project report the objective and scope, under point (i) emphasises the need to 'improve the environment in the outer areas of Calcutta' (ADB, 2000, p. ii). Consequently, as part of the project engineers are proposing to construct an extended aeration wastewater treatment plant to remove potentially harmful substances from wastewater flowing through PU Kolkata. However, treatment using this process is likely to remove a significant proportion of the nutrients present in the wastewater, whilst pathogen removal may be variable. Consequently, access to nutrients by producers is likely to decline, whilst using more water to deliver the required nutrient levels to fishponds and irrigated agriculture will increase costs and may increase risks from pathogen transfer and microbiological contamination. Under such circumstances, alternative management approaches involving feeds and fertilisers to sustain production may become appropriate, however, the strong position of labour unions makes changes to management practices problematic and may require negotiation with unions, retraining of labour, etc.

Bioeconomic modelling could provide an insight concerning likely impacts of changing wastewater quality or modified farming practices on production and financial returns, enabling producers to refine their management and providing knowledge to inform influential labour union bosses. The model may also be employed to assess likely microbiological impacts of alternative wastewater application strategies. The contribution of a multi-disciplinary stakeholder committee, including labour union representatives, in guiding research could be crucial in facilitating the assessment of strategies to enable the equitable implementation of such changes. Furthermore, results of such research are more likely to be implemented having been sanctioned and overseen by union representatives together with other stakeholders.

A question remains as to whether extended aeration is an appropriate treatment process for wastewater valued as an input to farming systems. Mara, Edwards, Clark and Mills (1993) described a lagoon-based treatment approach that optimised pathogen removal whilst limiting nutrient retention; such a strategy may be more appropriate for Kolkata. In the CEIP report Appendix E (ADB, 2000a, p. 47) the authors note that the current quality of some receiving waters in the WRR is below that anticipated for 'wastewater that would be discharged as a result of the project improvements.' Despite recognising that 'A balance must be struck in Project design so that dangerous substances, including toxics and pathogens, are removed from the wastewater, while maintaining the organic content required to support the fisheries and agriculture' (ADB, 2000a, p. 47), it is noted in the following sentence that 'the overall design concern must be ensuring that wastewater discharged to the ECW is of sufficient quality to protect public health and surface and groundwater quality.' From the discussion above it appears that further work on the relative merits of extended aeration, treatment lagoons and other options is critical to better balance health and environmental concerns with the nutrient requirements of producers, ensuring that the treatment strategy implemented is equitable.

Expanding capacity at the organic composting plant

Vegetable farmers surveyed described how changing access to municipal solid waste represents a significant constraint to production, and issues relating to this were discussed

in Section 5.3. However, from the CEIP report it appears that capacity at commercial organic composting plants at Dhapa is planned to rise from the current 700 to 1,850 t d^{-1} (ADB, 2000, p. 15). This would probably result in a further decline in the quality and quantity of solid waste to which PU farmers can gain access. Where the organic content of available waste is low, producers may have to purchase greater amounts of unprocessed material to maintain production, whilst also increasing expenditure on associated transport and waste handling and sorting costs. Furthermore, reduced access to solid waste and a shift to inorganic fertiliser may have negative impacts on soil quality and permit colonisation by weeds; consequently research on enhanced management practices may be required to mitigate against such negative outcomes. In the CEIP report it is noted that compost produced as a result of increased capacity at commercial plants in Dhapa would have a market value estimated at Rs6.3 million ($144,828) (ADB, 2000, Appendix 13, para. 5). However the value of the unprocessed organic waste used in the compost to poor farmers in the region may well be significantly higher.

Closing Dhapa and other landfill sites

Activities relating to improving municipal waste management planned for the CEIP project will focus on 'segregation of waste at source, effective collection of the various wastes, and disposal in an environmentally safe manner' (ADB, 2000, p. 15). The report also describes how the waste management strategy includes provision for '… an integrated hazardous waste management facility developed at the Dhapa landfill site' and that 'The facilities will be equipped with adequate leachate collection and treatment' and 'Nonplastic biomedical wastes will be incinerated at Dhapa' (ADB, 2000, p. 15). However, it is also noted that the development programme will close off the existing Dhapa and Noapara landfill sites to trash sorters and that approximately 655 people will lose their livelihood (ADB 2000, Appendix 10, para. 4). Provision has apparently been made to find alternative employment for those displaced, however, the fact that people had to sort trash for their livelihood suggests that alternative livelihood options in the region are limited. It should also be recognised that there may be social problems, including a stigma associated with rag-picking, that could making finding alternative employment difficult.

7.4. Public health concerns

Public perception and food safety issues may be critical to continuing consumer acceptance of products from PU farms. Furthermore, safeguarding the health of poor labourers may make a significant contribution to enhancing their livelihoods and those of their families. Although focused on fish farming, the following section highlights problems of working on PU farms and outlines some of the hazards of reusing waste resources, many of which are common to workers growing vegetables and rice. However, when reusing solid waste risks from cut injuries and exposure to biomedical and other hazardous waste may be greater.

7.4.1. Epidemiological evidence from fishery workers

Epidemiological data presented in Table 7.2 demonstrates that workers employed on fish farms managed for wastewater aquaculture experience a range of health problems.

However, there do not appear to be notable differences when compared to health problems encountered by a control group also engaged in aquaculture, but where wastewater was not used.

Table 7.2. Epidemiology of workers employed in wastewater aquaculture and a control population

Health problem	Rahara (%)	Salt Lake (%)	Kalyani (%) (control)
Diarrhoea	40	34.5	33.3
Fever	33.3	31	38
Cough and cold	50.3	58.6	76.8
Cut injury	40	17.2	38
Sore eye/redness	16.7	6.9	19
Skin ulcer	10	-	-
Itching skin lesion	40	75.9	57.7
Other skin complaint	13.3	-	14.3
Jaundice	3.3	-	4.8
Dyspnoea/respiratory disease	20	13.8	28.6
Worm expulsion	30	44.8	57.7

*3 month study; 1 year study (Source: Bhowmik, Chakrabarti and Chattopadhyay, 2000)

From worm expulsion data presented in Table 7.2 it appears that pathogen levels are highest in the control group, however, findings from stool sample analysis shown in Table 7.3 support a different conclusion. Round worm (*Ascaris lumbricodies*) were present in stool samples from 25% and 14% of people surveyed in Salt Lake and Rahara, respectively, however, were absent in the control population. Low levels of *Enterobius histolytica* (causing amebiasis) 4% in both Rahara and Salt Lake, were also present in the population engaged in wastewater aquaculture, but absent from the control group. Furthermore, although present in 25% of the control population, *Giardia lamblia* (causing giardiasis) was recorded in 86% of samples from Slat Lake and 89% from Rahara.

Table 7.3. Prevalence (%) of pathogens in stool samples from fishery workers from locations shown

Health indicator	Rahara (%)	Salt Lake (%)	Kalyani (%) (control)
Hook worm	-	-	-
Round worm (*Ascaris lumbricodies*)	14	25	-
Giardia lamblia	89	86	25
Whipworm (*Trichuris trichura*)	-	-	-
Pinworm (*Enterobius vermicularis*)	18	40	10
Entamoeba histolytica	4	4	-

(Source: Bhowmik, Chakrabarti and Chattopadhyay, 2000)

The prevalence of *Enterobius vermicularis* at 18% and 38% was also higher in the Salt Lake and Rahara populations as compared with 10% for the control; the higher prevalence of this pathogen in the Rahara population indicates that a contributing factor, other than

wastewater reuse, influenced the level of infection. Bhowmik, Chakrabarti and Chattopadhyay (2000) noted an absence of hookworm in the populations tested, this is significant as this pathogen can cause severe problems for communities engaged in wastewater reuse.

More general assessment by Bhowmik et al. (2000) of the health of workers engaged in wastewater aquaculture, through assessment of disease symptoms related to nutritional deficiencies, revealed the presence, at low levels (<10%), of anemia, oedema, night blindness and bleeding gums (Table 7.4). These conditions were absent in the control population. Several other health problems, including angular stomatitis, glossitis, teeth caries, gingivitis and skin disease were identified in all communities. However, the prevalence of both glossitis and skin disease were higher, 17% and 37%, respectively, in the Salt Lake population, as compared with 6.7% for these conditions in Rahara. Both symptoms are consistent with exposure to chemical irritants, whilst the differences observed in the two populations exploiting wastewater may be attributed to greater chemical contamination from industry in the Salt Lake area; further work would be required to corroborate this. From Table 7.4 it is also apparent that some symptoms such as cheliosis and clubbing occurred in the control population and one of the populations engaged in wastewater aquaculture, but were absent in the other exposed group.

Table 7.4. Prevalence of disease symptoms related to nutritional deficiencies for workers at sites shown

Nutritional disease symptom	Rahara (%)	Salt Lake (%)	Kalyani (%) (control)
Anaemia	6.7	6.3	-
Oedema	3.3	-	-
Night blindness	3.3	6.3	-
Angular stomatitis	6.7	12.6	9.5
Cheliosis	-	3.5	4.8
Glossitis	6.7	17.2	4.8
Bleeding gum	3.3	-	-
Teeth caries	40	17.2	23.8
Gingivitis	30	20.7	19.1
Skin disease	6.7	37	9.5
Clubbing	3.3	-	4.8

(Source: Bhowmik, Chakrabarti and Chattopadhyay, 2000)

Although described as the symptoms of nutritional deficiency, several of the conditions described in Table 7.4 may also be attributed to other causes, for example, parasite infection, chronic disease and substance abuse. Several of the symptoms are consistent with prolonged alcohol or tobacco abuse, and from Table 7.5 it is apparent that such practices are widespread in the populations surveyed. Smoking was widespread in all communities (<52%) as was chewing tobacco (19-40%). Alcohol abuse was highest in workers engaged in wastewater aquaculture (35-53%), although still apparent in the control group (19%). Workers in Rahara (10%) and Salt Lake (25%) also abused ganja, however, the control group reportedly abstained; intravenous drug abuse was not reported whilst the use of snuff was limited. Complete abstinence was highest (33%) in the control group and dropped to 17% in Salt Lake and 7% in Rahara, and although the underlying reason

remains unclear, possible explanations may include cultural and socio-economic differences.

Table 7.5. Prevalence of substance abuse amongst fishery workers for sites shown

Substance	Rahara (%)	Salt Lake (%)	Kalyani (%) (control)
Smoking	63	62	52
Chewing tobacco	40	31	19
Ganja	10	25	-
Intravenous drugs	-	-	-
Snuff	-	4	-
Alcohol	53	35	19
Nil	7	17	33

(Source: Bhowmik, Chakrabarti and Chattopadhyay, 2000)

7.4.2. Consumer health risks

Generally good hygienic practice and food preparation by Bengalis has been proposed as one mitigating factor reducing the risk of food-borne illness from aquatic products. However, with a growing immigrant population in both urban and PU Kolkata, dependence on such cultural facets may no longer be adequate. Therefore, a public information exercise, at markets and in the mass media, to inform consumers of general food safety issues, particularly the storage and preparation of aquatic products, could have a significant impact. Furthermore, where management practices are modified due to changing access to waste resources, health risks associated with traditional farming practices may change significantly as prior safeguards, precautions and mitigating factors are rendered obsolete. Further work should be undertaken to quantify the health risks associated with various products from PU farms in the region. Not only would this contribute to safeguarding public health, but also contribute to reassuring consumers regarding the safety of products from these systems. A major shift in consumer acceptance of products from PU production systems, irrespective of the actual health risk, could have severe implications for producers.

7.4.3. Safeguarding public, producer and environmental health

Development and implementation of a HACCP (Hazard Analysis and Critical Control Point) framework for farms reusing solid waste and wastewater could make a significant contribution to improving both the health of workers and food safety. Furthermore, HACCP could be used to identify changes in health risks associated with modified management practices, and consequently opportunities to avoid such problems. Such an initiative could also extend beyond waste management, to include other health and safety issues at work, and possibly personal and household health. Considering the widespread health problems experienced by workers, particularly those engaging in aquaculture (Table 7.2 and 7.3), a programme to improve occupational health could significantly enhance their livelihoods. HACCP appears preferable to product monitoring due to the logistics of sampling and testing produce which is sent daily to market by the large number of PU

producers, the complex and disparate distribution networks involved and the limited capacity of institutions with facilities to implement such a programme. Although desirable, several limitations have been suggested, constraining development of HACCP for small-scale farmers, therefore, only by working together may producers be able to formulate management plans that minimise risks to the environment, workers, local communities and consumers. Furthermore, given the need to base HACCP on sound scientific principles, it is evident that local government agencies and NGOs would have important roles in monitoring the system, identifying critical control points and assessing the magnitude of risks posed.

7.5. Knowledge dissemination and exploitation

Key constraints described in the previous sections, including siltation, decreased access to wastewater (and solid organic waste) and declining quality, increased contamination, potential changes in wastewater treatment and distribution, excessive labour union demands, restrictive conservation measures, urbanisation, health problems and changing consumer perceptions all represent possible constraints. Furthermore, although potential management strategies to mitigate such factors may be proposed, the consequences of untested approaches are not always predictable and may in turn create problems. The limited capacity of most farmers and households in PU Kolkata to pre-empt and plan for many of the emerging constraints means that traditional farming practices, and the poor that depend upon them, are increasingly vulnerable. Initiatives to increase the capacity of local communities and farmers to assess and manage emerging and unforeseen problems are therefore required; it is anticipated that knowledge from this initial review and future project activities could contribute to processes of awareness raising and empowerment.

Producer associations and co-operatives represent potentially important recipients for project outputs and hopefully such groups would be able to use this information to formulate strategic plans to address the key constraints identified. Another CBO that has recently emerged as an important voice for stakeholders in PU Kolkata is the Save Wetland Committee. Impetus for the committee began to build when the owner of the Nalban fishery attempted to sell, despite the land having been vested by the government. During the ensuing dispute, the workers were made jobless and as a result decided to start a movement, with the objective of countering such moves in the future.

On 26th November 2000, numerous workers and local people, together with government officials, researchers and the Minister for Fisheries and Minister for the Environment attended a meeting where a proposal was put forward concerning the formation of the committee; this was supported by all those present. During the meeting 27 people spoke to those assembled and that evening, Mr Abdul Rashid Mullah (Headmaster, Tardah High School) was elected President, with Mr Pitambar Das, a local leader, being elected Vice President. Mr Tushar Ghosh was chosen as the Secretary. Representatives were also elected to fill the other posts on the committee. The meeting, attended by an estimated twenty thousand people, demonstrated the widespread concern felt by many different stakeholder groups and the broad-based support for action.

Since its formation, the committee has meet once a month, with a general meeting of 65 people every three months; there is also an annual general meeting where anyone can participate. The core work of the committee is to stop encroachment of the fisheries and to

prevent the illegal selling of vested land. Involvement of local people on the committee ensures that recent events requiring action are addressed in a timely fashion; one such event was the proposed Lakeland Project (see Edwards, 2001). Through quick recourse to legal action the committee succeeded in stopping the development, and won the case by arguing that the proposed project would destroy both biodiversity and the livelihoods of people in the area. This has been probably the most notable achievement by the committee, whilst future aims include:

- increasing the depth of fishponds in the WRR,
- ensuring the proper supply of sewage to fisheries throughout the year,
- safeguarding the income of 150,000 people from PU communities,
- supplying electricity to all villages where fisheries are located,
- declaration of the East Kolkata Wetlands as a national wetland area in accordance with the Ramsar Convention,
- categorising fishermen who fall below the poverty line,
- providing proper housing and amenities for labourers.

7.6. Future strategy

Resistance to further research may represent a significant constraint to testing enhanced management strategies, such as those proposed in Table 7.1, and developing action plans that meet the demands and expectations of stakeholders, particularly those poorly served by existing approaches to policy formulation. To overcome this, prior to further research, it would be advisable to consult with local stakeholders and target institutions to assist in both assessing the existing knowledge base and to prioritise specific research areas. Such an approach would engender greater ownership and may yield more valuable outcomes. Inappropriate and extractive research methods, poorly targeted investigations and the replication of studies have further alienated stakeholders in PU Kolkata.

Having noted the success of the Save Wetlands Committee, it appears that one strategy to avoid such problems would be to convene a steering committee to oversee the research process. A multi-disciplinary committee, consisting of representatives from key stakeholder groups, could develop a research strategy for the PU region to address priority issues, evaluate research proposals and communicate findings to appropriate policy makers and implementing agencies. The strategic perspective of the committee should ensure resources are targeted toward key development constraints and prevent replication of effort. Furthermore, approval from the committee may reassure participants that knowledge generated would be used effectively to formulate policy and bring about substantive livelihoods enhancement. Additionally, the committee would be beneficial to strategic development planning at the Kolkata PU interface more generally, providing a point of contact for external agencies wishing to support research and development in the area.

Encouraging diverse stakeholder groups to participate on the committee would permit local agencies and institutions greater ownership of research undertaken and help avoid conflict between institutional bodies. The committee would command a strong position to promote commissioning of research to address emerging threats to PU farming systems and to safeguard livelihoods that may otherwise be vulnerable. However, despite its potential, such an approach would require broad-based support from stakeholders including policy makers, producers and local communities, and to achieve such support it may first be necessary to reach a consensus amongst these different groups concerning the objectives and functioning of the committee. To further ensure that the research commissioned by the committee fits with the development aims set out by the Save Wetlands Committee, it would be advisable to invite this body to nominate one or more members to sit on the panel.

It is anticipated that outcomes presented in this report will prove useful in helping researchers, local government departments and development agencies target resources on the most significant constraints facing producers and the emerging problems that threaten the viability of traditional farming practices in the region. Knowledge from this study concerning the role of labourers in operating, servicing and maintaining the PU production systems will also be used to guide future project activities, particularly the planned focus groups and household interviews, to assess the importance of PU farming in poor livelihoods.

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Appendix 1 Situation analysis questionnaire following pre-testing

Fishery managers questionnaire

1. Date:
2. Name:
3. Police Station/Block:
4. Village:
5. Owner:
6. Type of farming:
7. Ownership Pattern: (a) own land (b) Leased land (c) Co-operative (d) Joint ownership
8. (e)Any Other
9. Size: a) Main fishery
   b) Nursery pond/s
10. Type of management or any other information about the ownership pattern.

Inputs

11. a) Source of water
    b) Pump/other methods used
    c) Amount per bigha

12. a)type of fish feed
    b) brought from where
    c) amount per bigha
13. Type of fertilizers
14. Information about sewage water used
15. Fish Seed:

Type	From where brought (region and distance)	Transportation(middlemen)
i)		
ii)		
iii)		
iv)		

Other information about seeds including the quality and people involved in the work.

16. Labour

Permanent labourers who have been benefited

Type of work	No.	Age									residence	Total Mandays
		< 20 years			20-40 years			> 40 years				
		M	F	T	M	F	T	M	F	T		
i)												
ii)												
iii)												
iv)												
v)												
vi)												
vii)												
Total												

Any other information about the type of labour eg from which region, means of transportation etc.

17. Casual labourers

Type of work	Time of work	Months they do work	Where they live
a)			
b)			
c)			
d)			

18. What do the casual labourers do otherwise?
Part time/ whole time/ Others
19. Other people who benefit directly from the work

	How	Monetary benefits
a)		
b)		
c)		

Rank importance wise
20. Source of finance: a)
b)
c)
20. Source of information: a)
b)
c)
21. Any other information regarding the finance and information.
22. Production:

Type	% of total production	Distance from the market	Transportation and the type of sellers
a)			
b)			
c)			
d)			

23. How are you linked to the market sellers/ paikars?
24. Regarding seeds and other inputs whose help do you take and how?
25. Other information about the products, total production and market.
26. Problems:

Problems	Rank	Any other information about problems
i)		
ii)		
iii)		
iv)		
v)		
vi)		
vii)		

26. Map drawing: This was not asked anywhere keeping in mind the sensitivity of the area.
27. Management, Infrastructure, Other facilities, Planning: NA.
28. Timeline:
29. The effects of urbanization
30. Regarding your occupation what have been done by the local bodies related to your occupation?

Regarding your fishery
Labour related
Local Corporation
Local Panchayat
Any other

31. What has the Government done to solve your existing problems?
32. The bodies which have come forward to solve your problems?
    Name of Organization Part it plays
33. Do you think that because of the present condition of the wetlands the city of Kolkata faces water logging?
34. Do you support expansion of the city, which involves the destruction of the wetlands?
35. If due to development present existing activities are destroyed how will it affect you?
36. Are you associated with any of the bodies, which are fighting for the existence of the wetlands?
37. Any other information other than the ones discussed which you would want to tell.
38. How did you get the capital for investment? a) from bank b) private loan c) other sources
39. Any comments about getting a bank loan?
40. What is the interest for a private loan?
41. Fish Diseases

Local name	When it usually occurs	Prevention (is help received)
Khata		
Gaye Poka		
Lege Ghosha		
Pakhna pocha		
Kankote slesha		
Ras pandu		
Jok laga		

41. Type of labourers Number
    Fishermen
    Transport
    Guard
    Weeding hands

Farmer's questionnaire

Date

1. Geographical region
   Village
   Police Station/Block

2. Total amount of land
   Number of pieces
   How far

3. Owner of land
   Relation of land with farmer

4. Water supply to land
   How is it supplied
   When

5. What do your grow When How much

6. Seed
   From where
   Price

7. How do you cultivate?

8. Fertiliser
   Whether you get garbage
   At what price
   The components you take

   Chemical fertilisers

   Type Where from How much Price

   Other organic fertilisers

9. Pests
   Name Time Affects which crop

10. Pesticides

    Type Bought from where Price How are they used

11. Labour
    Type Number Wage

Whether unionised
What else do they do?

12. Finance
    From where do they get money?
    About ban loan
    Interest rate
    Time in which it must be given back

13. Whether any organisation Govt. or otherwise ever helps

14. Problems

Appendix 2. Questionnaire coding system for data interpretation

Question	Description	Column	Code
1	Serial number	1	
2	Location	2	1. Bidhannagar (Salt Lake): Dhapa Manpur 2. Tiljala: Dhapa, Boinchtala, Dhalenda, Paschim Choubaga, Choubaga 3. Sonarpur: Chak kolar Khal, Karimpur, Jagatipota, Mukundapur, Atghara, Ranbhutia, Kantipota, Nayabad, Tihuria, Tardaha, Kumarpukuria, Goalpota, Khedhati, Kheadaha, Deara, Kharki, Bhagabanpur, Samukpota, Garal, Pratapnagar 4. Bhangor: Tardaha Kapasati, Beonta, Hadia, Dharmatala Panchuria, Hatgachha, Kulberia
3	Activities	3	1. fishery and *jhils* 2. fishery with other related activities 3. vegetable farms 4. paddy fields 5. mixed farming
4	Ownership type	4	1. own land 2. own land with joint management 3. co-operative (registered) 4. co-operative (not registered) 5. owner-worker participatory 6. leased-lane 7. leased-land with joint management 8. vested/CMC land 9. sublets vested/CMC land 10. incorporated company 11. Government undertaking 12. own & leased (vested)
5	Holding size	5	1. <1 bigha 2. 1-25 bigha 3. 25-50 bigha 4. 50-100 bigha 5. >100 bigha
6	Fragmented	6	1. yes 2. no 3. na.
7	Water source	7	1. sewage canal 2. jhils and ponds 3. sewage canal & underground water 4. rainwater 5. rainwater & underground water
8	Irrigation method	8	1. gravity (without using pump) 2. pump 3. gravity and pump 4. na.
9	Garbage use	9	1. used

			2. not presently used 3. na.
10	Fish feed	10	1. mustard cake, mohua cake and lime 2. leather milk and others 3. hotel dust and others 4. mustard cake, mohua cake, lime and others 5. no feed used 6. na.
11	Fertiliser	11	1. only chemical fertiliser used 2. chemical & organic fertiliser used 3. no fertiliser used 4. na.
12	Seed	12	1. own produce 2. bought from market 3. both 4. na.
13	Fish stock supply	13	1. bought from agents 2. bought directly 3. both 4. own spawn & from market 5. na.
14	Type of fish stocked	14	1. spawn 2. hatchlings & fingerlings 3. both 4. na.
15	Fish disease & pests	15	1. severely affects 2. moderately affects 3. not affected 4. na.
16	Medicine & pesticide use	16	1. potassium permanganate & lime 2. other chemicals & medicines 3. none 4. pesticides 5. na.
17	Crops grown	17	1. major produce Indian major carp 2. major produce tilapia 3. mixed species 4. paddy 5. vegetables 6. paddy and vegetables 7. na.
18	Labour type	18	1. permanent 2. casual 3. casual & permanent 4. na.
19	Labour gender	19	1. male 2. male & female 3. na.
20	Unionised labour	20	1. yes 2. no

21	Financing	21	1. bank loan/ loan from Government/ co-operatives 2. private loan/ credit 3. dadan or advance 4. personal savings 5. private loan/ credit & dadan or advance 6. private loan/ credit & personal savings 7. dadan or advance & personal savings 8. private loan/ credit & dadan or advance & personal savings 9. na.
22	Assistance from Government, NGO, etc.	22	1. yes 2. no 3. na.
23	Land development	23	1. for 2. against 3. unsure
24	Fish cultivation problems	24	1. uncertain sewage water 2. labour problem 3. declining production 4. electricity 5. transport 6. poor seed quality 7. poaching 8. siltation 9. disease 10. financial 11. law and order 12. degraded sewage water 13. management problems 14. risk of land developers 15. bad roads 16. inundation 17. no problem
25	Vegetable & rice cultivation problems	25	1. inaccessibility/ garbage transportation 2. insects 3. seasonal water shortage 4. price fluctuation 5. high fertiliser/pesticide price 6. health problems of workers 7. poaching 8. adverse chemical affects 9. degraded garbage quality 10. lack of finance 11. seasonal inundation of fields 12. problem of land security 13. no problem

Notes: