CHAPTER III

Kolkata’s Urban Development and Emergence of East Kolkata Wetlands

3.1 Preface:

East Kolkata Wetlands is one of the rare examples of a man made eco-system engaged in resource recovery practices, which is both efficient as well as environmentally sustainable. It has gradually transformed from *nona bheris* connected with tidal forces into a popular sewage fed fishery area over a span of two hundred and fifty years. It is fascinating to note that the present eco-system has emerged due to urban planning by British rulers. A number of factors coincided together to create a rare opportunity of treating wastewater from the city via sewage fed fishery practices. In fact, this correspondence has culminated into a typical livelihood pattern in terms of a set of interdependent vocations in the area that has made the eco-system of Kolkata and that of EKW complementary to each other.

The discussion in the present chapter is organized as follows: section 3.2 summarizes the history of emergence of EKW along with development of waste disposal by Kolkata, section 3.3 briefly discusses the special structural features of the wetlands to create an opportunity of treating wastewater through unique stage correspondence between this waste treatment process and the practice of sewage-fed fisheries. Section 3.4 elaborates the traditional knowledge based livelihood practices; consequent on this typical wise use practices a complementary relation has come out between the city and its fringe and EKW earned recognition as an International RAMSAR site. Section 3.5 elaborates on the specific nature of this mutual dependence of the two systems and finally section 3.6 concludes the chapter by indicating the fragility of this internal balance and raises concern about its sustainability due to the invasion of myopic urban growth.

3.2. Evolution of Wastewater Disposal System of Kolkata:

3.2.1 Wetlands in the East: The Earliest Account:

The earliest known account (1748) of East Kolkata Wetlands portrays this as a marshy salt lake. Mouth of river Bidyadhari opened into Bay-of-Bengal through river Matla and
influenced by tidal actions, created salt-water lakes as spill-reservoirs of the tidal channel.

These salt-water lakes were used for brackish water pisciculture to produce Bhekti, Parse, Bhanger and Prawns and the annual production was around 14.8 tonnes/ sq.km. (Ghosh & Sen 1987).

**Illustration 3.1: EKW in the early Nineteenth Century (1827)**

*Salt Water Lake, east of Calcutta, crowded with boats, with the city in the distance*

At that time Bidyadhari was used for dual purposes: until early twentieth century Bidyadhari was the main drainage line for the city of Calcutta¹ and that was a major transportation route for commerce from the North-East hinterlands of Bengal like Assam, Chandpur, Khulna, Dhaka or Barisal, etc. In early 1770 Major William Tolly, Chief Engineer of the city, was permitted to excavate the Tolly's Nullah (the silted up bed of Adi Ganga) at his own cost so as to collect toll (tax) from the cargo boats. In the year 1776, the Tolly's Nullah was completed which connected Bidyadhari (near Shamukpota) and river Hugli (near Hestings) resulting in diversion of the headwaters of Bidyadhari and a consequent rise in the siltation rate in the lower reaches of the river (Bose 1944) (Illustration 3.1).

¹ British name of the city of Kolkata was Calcutta and, hence, these two alternative names have been used interchangeably in this paper.
3.2.2 The Drainage problem and development of sewage disposal system:

Though the natural elevation of the city of Calcutta is six to seven meters along the levee of the river Hooghly and only 0.26 meter at the existing wetland sites, in 1803 the city drainage was artificially directed into river Hugli against the natural slope. That led to annual flooding of the city during monsoon rains and pollution of the river Hugli (Ganga) that used to provide drinking water to the city. To develop an advanced system for the disposal of the city sewage and excess rainwater, in 1803, the then Governor General of India, Lord Wellesley appointed an expert committee. The committee recommended construction of underground drainage through a network of West to East canals into the salt-water lakes, river Bidyadhari, Matla and ultimately to the Bay-of-Bengal to take advantage of the natural gradient of the city and to avoid contamination of water of river Hugli, which was then the principal source of drinking water.

It was, however, not until 1855 that Municipal Commissioners recommended the adoption of this scheme (popularly referred to as Mr. Clark’s scheme) to the Government. Ultimately, the project took off in 1859 and it took almost 16 years to complete the first phase of the drainage scheme with construction of underground sewer, canals, sluices, bridges, etc. A dumping ground was constructed at Dhapa for managing solid waste. This area was connected to the city with railway line for transportation of solid waste and with the construction of Dhapa Lock in 1883 the first phase of the project came to an end (Bose 1944). In 1880, a nineteen years’ lease was granted to one Bhabanath Sen for cultivation, fisheries and unloading of garbage-wagons in this area. The cultivable lands were let out in small parcels and settlements grew up. The solid waste had been dumped in a planned sequence to develop a landscape along with water-bodies between them. The water-bodies provide sources of irrigation for agriculture.

3.2.3 Decay of river Bidyadhari and wetlands as a savior:

Emergence of a new urban eco-system: Though the initial design of this sewerage and drainage network was highly innovative and consistent with the natural gradient of the area, since these canals were popular routes of cargo transportation also, cutting of some additional channels to enhance commercial benefits obstructed the natural flow of waste water to Bidyadhari, raised her siltation rate and ultimately in 1928 the river was declared
dead. Sewage outfall of the city was changed from South-East (Bidyadhari) to East (Kulti River). Tidal flow of saline water in *nona bheries* (saltwater lakes) stopped and gradually there was a change in the aquatic environment from saline to non-saline water\(^2\). Thus, once profitable *nona bheries* turned into non-productive, fallow and stagnant swamp.

**Sewage fed Fisheries:** It was found that a restricted volume of sewage discharge-into the lake was favorable to fresh-water fish culture. Since late 1920s, attempts were made to cultivate fresh-water fishes like *Carp* in the lakes with a small quantity of sewage used as food; in 1929, a landowner, Bidhu Bhushan Sarkar, discovered that the output of *Carp* cultivation could be raised manifold by letting in small doses of sewage into the swampy area (Bose *op. cit*, Chattopadhyay 1990). Draining of the excess sewage from the ponds became possible only after the construction of storm-water-flow (SWF) channel from Bantala to Kulti in 1940. Within a short time, the whole area was converted into a fresh-water aquaculture system\(^3\). In the new aquatic environment, the most prominent fish species are Rohu, Catla, Mrigal, Silver Carp, Grass Carp, Common Carp, Tilapia, Catfish, etc. By 1945 annual fish production also increased to 84 tonnes/sq. km.

3.2.4 **Canal Network: Disposal of wastewater into wetlands:**

In 1934, a new plan, credited to city engineer B N Dey, was conceived and completed in 1943. It was decided to discharge the sewage and storm water by two separate channels. Then dry-weather-flow (DWF) channel was constructed on the Northern side of the SWF Channel and in 1943, the out-fall system was changed from Bidyadhari to Kulti Gung (river) which is ultimately drained by river Raymangal into the Bay of Bengal (IWMED, 1997). Since then the wetland has become a very popular place for wastewater fisheries. Map 3.1 shows the layout of the canals and channels in EKW around 1943, which was meant to be used for both sewage management and fish-cultivation.

\(^2\) The changes in salinity in the fisheries were from 800-1200ppm in Nona Bheris to about 500-600 ppm in sewage fed fisheries.

\(^3\) Though the whole process of sewage stabilization through *Algae-bacteria Symbiosis* was in the domain of traditional knowledge source at least since late 1920s, this unique practice was first documented under formal knowledge source by Ludwig, Oswald and Lynch only in 1951 (Ludwig and Oswald 1951)
Map 3.1: General Layout of the feeding and drainage channels in EKW (1943)

Source: Bose 1944

Map 3.2: Canal Network –East Kolkata Wetlands

Source: Extracted from the GIS map prepared by PAN Network, 2010
After some local farmers started exploiting sewage as a resource to cultivate fish and vegetables, a secondary network of canals were constructed throughout the peri-urban interface to connect ponds and plots (Map 3.2). In fact, in EKW the natural treatment of waste and the practice of sewage-fed fishery are having a strong complementary relationship that is going to be elaborated in the following discussion.

3.3. **Wastewater Aquaculture: An Instance of Unique Complementarity:**

3.3.1 *Natural Conditions and Natural Treatment:*

Wastewater treatment is a combination of *unit operation* and *unit process* designed to reduce the various contaminants in wastewater to an acceptance level. When untreated wastewater is directly discharged into natural water bodies like river or lakes, it undergoes self-purification or natural treatment by five successive actions of (i) dilution, (ii) oxidation, (iii) reduction, (iv) sedimentation and (v) sunlight (Basu 2015). The wastewater of Kolkata flows through underground sewer lines to pumping stations located in the eastern fringe of the city. It is then pumped into open dry-weather-flow (DWF) channel spread over wide wetlands, locally known as the *bheris*.

The essential factors in the purification process (a) the hot and humid climate, (b) the shallow ponds, (c) adequate sunshine and (d) abundance of water hyacinth collectively created an excellent opportunity for natural treatment of wastewater.

(a) **Climate:** The geographical location of EKW, approximately between latitudes 22°25’ to 22°40’ North and longitudes 88°20’ to 88°35’ East, provides it with a hot and humid climate throughout the year with average rainfall of 1600 mm (90 per cent of which from June to October), which makes the area a natural incubator for a diverse group of microbes with rich presence of bio-diversity (Aich & Kundu 2010).

(b) **Shallow ponds:** The water purification process takes place in the water bodies, locally known as the *bheris*, which are shallow, flat bottomed lagoon type of ponds that vary between 50 and 150 cm in depth and can be as large as 0.4 to 0.5 sq. km. in size.

---

4 It involves contaminant removal by physical force like skimming and sedimentation.
5 It involves contaminant removal by addition of certain chemicals like alum and microorganisms like bacteria; for example coagulation, chlorination, filtration and activated sludge process.
The shallowness of ponds gives a better ratio between pond volume and pond surface than a deeper pond and creates more favorable condition for photosynthesis process to take place. Due to this low-depth there is full vertical circulation of water to the surface where algal blooms occur. So, sufficient oxygenation is provided to allow for efficient BOD and pathogen/ fecal coliform reduction. Reduction of BOD takes place because of a unique phenomenon of algae-bacteria symbiosis (Ludwig et.al. 1951, Oswald et.al. 1953) where energy is drawn from algal photosynthesis (Illustration 3.2).

Illustration 3.2: Algae Bacteria Symbiosis

(c) **Adequate Sunshine:** The solar radiation, which is about 10.46 Mega joule/ sq. m. per day, is sufficient for this photosynthesis to take place. The solar energy is trapped by a dense population of plankton which plays a significant role in degrading the organic matter. The cumulative efficiency of BOD reduction from the waste water is above 80 per cent on an average. This process further helps in the reduction of coli form bacteria up to 99.99 per cent (Ghosh 2005).

---

6 BOD: Biochemical Oxygen Demand
(d) **Bio-filters**: Water hyacinth plays a special role in the working of this complex ecosystem. Its main function is to take up heavy metal ions from the surrounding water, known as rhizofiltration. Here the plant roots act as bio-curtains or bio-filters for the passive remediation of wastewater.

### 3.3.2 Process Correspondence: Crucial role of sewage fed fisheries:

**Fish as Ecological Manipulator**: When the sewage water arrives in the pond network through the inlet channels, it is kept standing in the sun, which results in biodegradation of the wastes through an algae- bacteria symbiosis. In fact, retention of wastewater in the ponds before the initial stocking of fish for a considerable period allows bacteria to work upon the organic waste. The algae that thrive in these shallow ponds under the ample sunshine support the growth of these beneficial bacteria (plankton). However, the overgrowth of the planktons becomes a problem for aquatic environment since they cause algal bloom. It is at this critical phase of the ecological process that the fish plays an important role by grazing on the plankton (Illustration 3.3).

#### Illustration 3.3: Fish as an Ecological Manipulator

- **Wastewater Aquaculture**: The sewage treatment process in EKW is a rare example of a parallel connection of two originally independent eco-systems to create a symbiotic

---

7 Rhizofiltration: A process in which the plant roots are used to absorb pollutants, mainly metals from water and aqueous waste stream;
network. In general, wastewater treatment and aquaculture appear to be two unrelated activities, but here both are connected and complementary as a part of an integrated aquatic eco-system. The natural gradient of the city from West to East takes almost entire city sewage to the wetlands without any additional cost.

In a typical wastewater treatment plant under engineered method initially wastewater is passed through grit chambers for preliminary treatment. All the physical impurities (e.g. floating bodies, larger solids) are removed essentially by skimming and sedimentation in primary treatment in sedimentation tank. Secondary treatment involves chemicals or biological organisms\(^8\) to remove the dissolved minerals and colloidal particles from the sewage water. The purification process is almost complete after this stage and the wastewater is almost purified by all previous steps. However some harmful pathogens still exist in the wastewater which is has to be disinfected in tertiary treatment procedure. Chlorination, ultraviolet ray treatment or ozone treatment are some of the methods used in disinfection process (Basu \textit{op. cit.}).

The exclusivity of East Kolkata Wetlands eco-system prevails in the fact that the sewage, otherwise considered as pollutant is being used as an input by the fishermen. The local people have searched out this process right. Five types of ponds are needed over the entire process of fish production: egg pond, nursery pond, rearing pond, stocking pond and harvesting pond, each requires proper inlet and outlet channel management, which is mostly controlled by natural gravity. The passing of sewage water through these different sequences of ponds are basically equivalent to the bio-physical process of a typical wastewater treatment plant through grit-chamber, sedimentation chamber and so on (EPA 2004, Basu \textit{op. cit.}, Yan \textit{et. al.} 1998). The physical appearance of these inter-connected \textit{bheris} seems like a mirror image of sequence of chambers used in wastewater treatment plant. Chart 3.1 summarizes this unique alliance of wastewater treatment and sewage-fed fishery practices integrated through a rare type of stage correspondence.

\(^8\) Organic matter is used as nutrient for the biological microorganisms (for example, activated sludge process). Fine suspended matter is filtered (for example, trickling filter).
Chart 3.1: Correspondence between the processes of sewage treatment and fish production

Requirements for typical wastewater Treatment Plant:

- **Inlet (raw sewage)**
- **Preliminary Treatment**
  - Grit Chamber
- **Primary Treatment**
  - Sedimentation Tank (Sludge)
- **Secondary Treatment**
  - Biological Treatment (Aerobic)
    - Activated Sludge Basin (trickling Filter)
    - Sludge (to Anaerobic Treatment)
- **Setting**
  - (Biological floc)
- **Disinfection**
  - Outlet (to stream)
  - Sludge (to Anaerobic Treatment)
  - To Landfill

Requirements for Sewage-fed Fishery & Garbage Farming:

- **Natural Conditions:**
  - Hot & humid climate
  - Shallow Ponds
  - Sequential flow of sewage

- **Favourable for:**
  - Photosynthesis
  - BOD & Coliform Reduction
  - i.e. natural incubator

- **Process:**
  - Algae Bacteria Symbiosis: *(Solar energy trapped)*
  - Plankton Growth *(Good)*
  - Overgrowth of algae *(Bad)*
  - Fish acts as Ecological Manipulator

- **Inlet (raw sewage)**
- Egg Pond
- Nursery Pond
- Rearing Pond
- Stocking Pond
- Harvesting Pond
- Sludge Garbage farming
- Outlet (to Stream)

Source: Author’s understanding
When the sewage arrives in the series of interconnected bheris, it is kept standing in the sun, which results in biodegradation of the wastes through an algae-bacteria symbiosis opening a opportunity for ‘Natural Treatment’. While preparing ponds for aquaculture the elaborate procedure helps removing all kinds of impurities for wastewater. Through their traditional knowledge gathered from years of experience the local fishermen have converted the most unfavorable non-productive sewage disposal swamp into a profitable area for pisciculture. They know exactly how to excavate the ponds to the correct depth, clean the water by spraying kerosene, lime and khol, mix the right quantity of sewage, allow optimal time for conversion of the waste into fish feed, when to add spawns, how to protect the embankments through water hyacinths, and so on.

The fish farmers of EKW have developed such a mastery of these resource recovery activities that they are easily growing fish at a yield rate which is 2 to 4 times higher than that obtained from normal ponds and their production cost is also unmatched by any other freshwater fish ponds of this country. The volume of annual fish production from sewage fed fisheries of EKW was of the order of 18000 metric tons in 2008 which used to meet nearly one-third of total fish demand of the city (Wetland International 2008). Besides wastewater fisheries, the other connected activities in the area include paddy cultivation by utilizing fish pond effluents, organic waste based farming of vegetables, poultry and animal husbandry. Thus, the cumulative social and economic gain from such sustainable management in an eco-friendly way is crucially contingent on the livelihood dependence of the local people on these traditional vocations, especially fisheries (Yan et.al. op. cit.).

Kolkata is enjoying ecological subsidy (Ghosh 2004) where wastewater treatment is possible without incurring much added cost. The pivotal role is played by the wastewater pisciculture contained in an intricate ambience of wise-use practices that conferred RAMSAR status on EKW in 2002. Double dividends are generated through simultaneous attainment of natural purification of waste water (nearly 80 percent reduction of BOD on an average) and substantial production of fresh water fishes like Rohu, Catla, Mrigal, Silver Carp, Grass Carp, Common Carp, Tilapia, Catfish, etc. (Ghosh op. cit., Chattopadhyay op. cit.).
3.4 Traditional Knowledge based Livelihood Practices:

The unique correspondence between this waste treatment process and the practice of sewage-fed fisheries has been discussed in the previous section. In fact, this correspondence has culminated into a typical livelihood pattern in terms of a set of interdependent vocations in the area that has made the eco-system of Kolkata and that of EKW complementary to each other. Waste recycling in EKW involves four principal resource recovery practices, viz., sewage-fed fisheries, paddy cultivation by utilizing fish pond effluents, organic waste based farming of vegetables and freshwater aquaculture. So, if the livelihood practices in EKW undergo drastic changes then that may affect the option of natural sewage treatment available to Kolkata. The typical wise use practices related to wetlands have been talked about in following section.

3.4.1 Preparation of Pond Bed:

The pond preparation begins with draining out water through locally made sluice gates or by pumping out the water into the canals. Its bottom is allowed to be dried up completely. If there is a excess sludge, then the land has to be dug up at a depth of 8-9 inches and brought on top to dry. This thorough drying is important to eliminate the possibility of any foul smell retained in the fish. The sides are generally dug down deeper and the middle of the pond remains shallow. Another channel\(^9\) about 6-8 inches deep inside the pond bed is excavated leaving a gap of few feet from the bank of the bheri (Illustration 3.4).

**Illustration 3.4: 6-8 Inch deep Channel Excavated in Pond Bed**

![Illustration 3.4: 6-8 Inch deep Channel Excavated in Pond Bed](source: Dey & Banerjee, 2013a)

\(^9\) This dug out sludge from this channel rich in organic components is used as fertilizers in the agriculture as well.
Raw sewage is now allowed to enter the pond and ‘Mahua khol’ (grounded oil cakes) is applied to the pond bed. The colour of water mixed with ‘Mahua khol’ turns black and muddy, and subsequently Calcium Carbonate (CaCO$_3$) or ‘Chun’ is applied to filter the water. Bio-chemical reactions gives the pond water a crystal clear appearance. Sufficient time is allowed to the remaining dirt particles to settle down in the pond bottom. After 4-6 days using ‘Moi’ the water is mixed up a number of times to ensure sufficient aeration in pond water (Illustration 3.5). This step is crucial to ensure the growth of millions of planktons which prepare the water rich in nutrient for fish spawns. The remaining solid waste or sludge in water gets deposited during mixing of water with ‘Moi’ in that 6-8 inch deep channel cut at the time of pond preparation.

**Illustration 3.5: Air Circulation in water using ‘Moi’**

3.4.2 Managing Wastewater Supply:

When sewage water is transported through main canals from the city of Calcutta, may not reach all the *bheris* through them. Criss cross narrower sub canals which have been excavated and maintained by the local fish farmers can be a rare example of complete understanding and co-operation among the stakeholders. The sewage here is like a ‘public good’ or ‘common property resource’ and each nodal person connected through this network is entitled to get the access of sewage water for cultivation purpose. In general, there is informal agreement among the fishermen and agricultural farmers when and how much sewage can be drawn from the stream of canal. The concordance among

---

10 A special kind of bamboo sieve (*pata*) aligned vertically on pond bed with weights attached on both sides at the bottom.
all the stakeholders ensures that, no one is deprived of this crucial supply of resource (input) for their livelihood.

The wastewater is allowed in the pond through sluice gates into the pond. An angular bamboo pata coupled with net is attached with each opening. It is to strain out all major debris coming through the wastewater. However since fish always have a tendency to swim against the flow, the sieve ensures that no fish is missed out into the sewer canal. While preparing the pond water only senior members with years of experience takes the responsibility of taking the judgment regarding how to manage the nutrient supply by judging exactly what amount of sewage is to be allowed into the pond and when to drain out water (Illustration 3.6).

The waste coming from the city of Kolkata is a crucial resource for these cultivators who wisely use the wetlands ensuring the ‘resource recovery’.

**Illustration 3.6: Managing Inlet & Outlet**

Source: Author
3.4.3. **Embankment Protection:**

Protection of pond banks is ensured in a unique way. Bamboo/Goran poles are fixed at a distance of 4 meters from the pond bank, tied with one another by GI\(^{11}\) wires (Illustration 3.7). A 3-4 meter wide band of Water hyacinth\(^{12}\) (collected from the freshwater ponds) is placed between pond bank and the wire. These plants work as natural buffer to save it from waves causing consequent erosion replacing costlier alternatives like stone, brick or concrete walls needed for bank protection. In fact, water hyacinth plays multiple roles acting as good shelter for fishes from the scorching heat in summer days, the roots working as excellent absorbent of solid waste present in sewage, as a good breeding ground for common carp and *Tilapia*\(^{13}\) or *Nilo tica*\(^{14}\) and sometimes these are used as food by fishes (Ghosh, op. cit.).

**Illustration 3.7: Embankment using water hyacinth**

Source: Ghosh 2005

---

\(^{11}\) Galvanized Iron  
\(^{12}\) Locally known as ‘Kochuri pana’  
\(^{13}\) *Tilapia mossambica*  
\(^{14}\) *Tilapia Nilotica*
3.4.4 Using Ecological indicators:

The preparedness of pond water for receiving fish spawns are judged by examining its color, smell and taste. A small amount of fish spawns are put into pond water and after suitable interval water is collected in a transparent glass bowl to check condition of those spawns. If the spawns are found surviving well the water is considered ready\textsuperscript{15}. Thus preliminary cleaning, sedimentation, disinfection of the sewage water is implicitly done while preparing ponds for aquaculture without incurring additional cost to the municipal authorities. Chart 3.2 sums up the sequence of stages of pond preparation.

\textbf{Chart 3.2: Stages of Pond Preparation}

\begin{itemize}
  \item Draining out water by Motor Pump from ‘\textit{Bheri}’
  \item Drying up pond bed
  \item Ploughing up pond bed
  \item A channel of 6 to 8 inch deep excavated border-wise leaving a gap of a few feet from the bank
  \item Sewage allowed into the pond
  \item Application and mixing of ‘\textit{Mahua Khol}’
  \item Application and mixing of ‘\textit{Chun}’ or Calcium Carbonate
  \item Mixing water using ‘\textit{Moi}’
  \item After few days, embankments using water hyacinth is attached
\end{itemize}

Source: Dey & Banerjee 2013a

Generally, the full length process is repeated every year in case of hatcheries and Nursey ponds as these are more vulnerable to any kind of pollutant. But in case of larger \textit{bheris}\textsuperscript{15} In formal knowledge plane the test is called ‘bio-assay’ test.
which are used for rearing or stocking purpose, it is repeated every 3-5 years depending on the size. For large bheris if dried up completely for excavation, the fish cultivation may be postponed for a year or so. The high opportunity cost compels the fishermen to perform the task at an interval of 10-12 years or more. So, until and unless it is mandatory for them to dry up this pond they do not opt for complete draining out of water. Nevertheless, the application of ‘Mahua Khol’ and ‘Chun’, Mixing of water using ‘Moi’ goes on.

Though tilapia and nilo-tica are widely grows without any hassle like hatching, sequential transfer of fish through a series of ponds etc. Other species like Indian major carps (IMC) and common carps need to be harvested following specific procedures.

3.4.5 Supply of Spawns

IMC spawn are usually purchased from specialized hatcheries in Naihati or Bankura. These are sold on per bowl basis, a bowl contain about 50,000 spawns weighing around 100 grams. The eggs are available from mid-March to mid-April and lasts till mid-August. The price varies widely over the season due to variation in quality and market demand ranging from Rs. 500-600/bowl in the beginning to Rs. 50-100/bowl by the end of season.

At the time of pond preparation the fishermen need to get in touch with the hatcheries in advance to place the order. Since the sewage fed fishery is horizontally sequenced and there is always scope of transferring the yield into a wider space, 10 bowls of spawn is required for a bigha of nursery pond with depth of water no more than 1.5 ft. However, in vertically integrated single pond fishery only a bowl of spawn can be accommodated in a pond of a bigha wide. The spawn suppliers and ‘Jhankis’ themselves take the pain of delivering spawns to EKW farmers as these tiny lives are vulnerable and only continuous supply of oxygen can keep them alive. For IMC, in a year around 3 times eggs are applied to the pond in 3 consecutive months starting from early April to early June.

---

16 Fertilized egg 3-4 days old.
17 Locally called ‘bati’
18 Bengali month ‘Chaitra’
19 Bengali month ‘Shravan’
20 Specially trained spawn suppliers, who continuously shuffles water.
3.4.6 Stages of Fish cultivation:

After procurement of eggs\(^{21}\) from hatcheries initially they are put in the nursery pond\(^{22}\), from there sequentially shifted to the rearing pond\(^{23}\), stocking pond\(^{24}\) and finally to the harvesting pond\(^{25}\). Whole fishery area is partitioned as per convenience to cultivate fish in horizontally integrated aquatic system. The area, depth and number of ponds go on increasing while moving from one stage to the other. Illustration 3.8 demonstrates the idea of partitioning scheme adopted by fishermen in EKW. The right time of transferring fishes from the lower to the higher stage is decided on the basis of long standing practices and traditional wisdom which is mostly related to the size of the fish and its rate of growth (as an illustration see table 3.1).

**Illustration 3.8: Partitioning Scheme for the water body**

![Partitioning Scheme for the water body](image)

Source: Author’s understanding from Field Interview

\(^{21}\) For a fish farmer who is rearing eggs of river-bred fish like IMC (Indian Major Carp), the fishermen purchase fish spawns from hatcheries in Bankura, Nadia etc. and in case of Common carp or Golden fish the farmers themselves hatch the eggs in ‘Hapa’ or egg pond.

\(^{22}\) Locally termed as ‘Antur Pukur’

\(^{23}\) Locally termed as ‘Lalon Pukur’

\(^{24}\) Locally termed as ‘Palon Pukur’

\(^{25}\) Locally termed as ‘Dhaul’
Table 3.1: The Process of Fish Production in EKW through Pond-sequencing

<table>
<thead>
<tr>
<th>Pond Type</th>
<th>Stage of Production for IMC</th>
<th>Size wise names</th>
<th>Rearing Time*</th>
<th>Inlet information (Average)</th>
<th>Number of the pond ideally required**</th>
<th>Average Size of the pond ideally required**</th>
<th>Average depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery Pond</td>
<td>1</td>
<td>Fish Spawn (2-3 days old)</td>
<td>15-16 days (maximum 20 days)</td>
<td>50000 spawns per bowl (100 gm per bowl)</td>
<td>0.002 gm. per piece</td>
<td>Not specifically identifiable</td>
<td>1 (10 bowl egg is applied in this size pond)</td>
</tr>
<tr>
<td>Rearing Pond</td>
<td>2</td>
<td>Dhani-pona (20 days old)</td>
<td>1 month</td>
<td>30000-50000 per kg.</td>
<td>0.02-0.03 gm. per piece</td>
<td>2-3 mm.</td>
<td>10 times</td>
</tr>
<tr>
<td>Stocking Pond [stage I]</td>
<td>3</td>
<td>Early Fry</td>
<td>1.5 months</td>
<td>250-300 per kg.</td>
<td>3.5-4 gm. per piece</td>
<td>2.5-3 cm.</td>
<td>150 times of dhani-pona</td>
</tr>
<tr>
<td>Stocking Pond [stage II]</td>
<td>4</td>
<td>Fingerlings</td>
<td>2 months</td>
<td>100 -150 per kg.</td>
<td>7-10 gm. per piece</td>
<td>5-6 cm.</td>
<td>2 times of early fry</td>
</tr>
<tr>
<td>Harvesting Pond</td>
<td>5</td>
<td>Chara-pona</td>
<td>2 months</td>
<td>25-30 per kg.</td>
<td>35-40 gm. per piece</td>
<td>12-13 cm.</td>
<td>4 times of fingerlings</td>
</tr>
<tr>
<td>Final Catch</td>
<td>6</td>
<td>Pona</td>
<td>--</td>
<td>8-10 per kg. (in 4 months) 1 per kg (8-9 months)</td>
<td>100-150 gm. (4 months) 1-1.5 kg (8-9 months)</td>
<td>15-16 cm.</td>
<td>3 times of chara-pona</td>
</tr>
</tbody>
</table>

Source: Dey & Banerjee 2013a
Sometimes the fishermen’s co-operatives do not get this much of land as stated in table 1. However since the entire process is horizontally integrated ponds used in each stage may not be required simultaneously rather sequentially. The boundaries of hatcheries and nursery ponds are purely temporary and built as per seasonal requirement. After completion of the initial stages of fish production, they are sometimes merged with stocking ponds in order to get larger area coverage for rearing fish. In a way they manage the space consuming mechanism of fish cultivation by using same land for alternative purposes. Alternatively, smaller farmers specialize in cultivating spawns to a typical size (say fingerlings) and sold alive to other cultivators who have larger space capable of completion of stocking and harvesting part of the process.

The beauty of the eco-system lies in the fact that, here all the different kinds of livelihoods are integrated in chain of interdependent vocations. The effluents from pisciculture ponds are used for irrigating the adjacent paddy fields and horticulture farms. In fact, nursery ponds are so shallow that in dry season (winter) wastewater does not reach the ponds following natural gravity. However after one round of fishery earlier in the year the pond bed is fertile enough for agricultural use. In small pockets after the fishery stage is over, often winter paddy or vegetables are cultivated. The irrigation water comes from the treated effluent of fish ponds and the soil fertility is restored.

3.4.7 Preparing pond for second or third round:

Once the pond is prepared can be used at least three to four times without repeating the rigorous procedure. After a round of cultivation, some tiny insects\(^ {26}\) grow in water. A small dosage\(^ {27}\) of kerosene mixed with Gammexane powder is poured on water creating a thin layer of the mixture on water. This block the oxygen supply in the pond and the insects can no longer survive without oxygen. The layer of kerosene evaporates within a day and the remnants are cleaned by mosquito net.

In a season three consequent rounds of cultivation of IMC, first couple of ponds remain empty. In this spare time common carp\(^ {28}\) is hatched. Mid of February to mid of April is

\(^{26}\) Locally known as ‘haspoka’

\(^{27}\) each bigha of bheri a liter of kerosene is sufficient.

\(^{28}\) Syprinus, Grass Carp, American Rohu etc.
ideal for breeding of common carps. To prepare the pond, a new set of water hyacinth collected from other fresh water ponds nearby (which are not sewage fed) are used to prepare embankments replacing the old set. Healthy mature fishes are caught from existing ponds. Male and females are sorted. Now, male and female fishes are transferred in 1:3 ratio into the bheri. For a few days, they are fed with ‘Mahua khol’ or ‘Mustard khol’. Oxygen supply is raised with the help of some water shuffling machines or ‘Moi’ to keep the fishes active and healthy. Fishes lay good quality eggs\(^{29}\) in the roots of water hyacinth and within a night they are fertilized. These water hyacinths are cautiously collected and transferred into another pond already prepared for Nursery. After a few days the spawns become observable in size and water hyacinth is shuffed well into the water so that the spawns are detached from the roots. The following procedures are identical to that of IMC.

### 3.4.8 Optimizing Nutrient Sharing:

Decades back the biodegradable sewage water from the city used to be so rich in nutrient that no additional feed/ fertilizer was required for cultivation of fish, paddy or vegetables. However in recent past the farmers have been complaining about lesser quantity of feed\(^{30}\) in the wastewater compelling them to arrange for additional feed. In the larger bheris, fish feed like grounded oilcakes (Mahua or Mustard) are now applied. However larger fishes in general eat up all the stuff at a go banning the smaller fries to get the required nutrition. To solve this problem, a triangular bamboo frame placed in the middle of the pond. It works like a sieve allowing smaller fishes to access of the first share of food first and larger fishes get it later.

### 3.4.9 Resource Recovery Practices:

The regular mixing of waste water with the pre-existing pond water requires the draining of excess water from these fish ponds. This excess water is used for irrigation in the adjacent agricultural fields. Again when the waste residues and accumulated water are discharged from the ponds to prepare pond bed for another breeding-rearing cycle the

\(^{29}\) The eggs pretty much look like pearls or ‘sabudana’ or Sago.

\(^{30}\) Locally called as ‘Khorak’
sludge is used as fertilizer for vegetable farming. In dry season these shallow watery and marshy lands are utilized for paddy cultivation. Thus, fishery and agricultural activities have become complementary processes. The two eco-systems namely city of Kolkata and EKW is complementary in nature (Chart 3.3) and the major livelihood in this area centres around fishery and farming along with other associated vocations.

**Chart 3.3: Complementarity between Kolkata and East Kolkata Wetlands**

The uniqueness of this eco-system lies in the fact that the sewage, usually considered as waste is being used as an input by the fishermen. Besides natural water treatment services EKW is providing the city of Kolkata food, shelter and livelihood for a large section of population. It seems that the waste is being used as a resource, which gets transformed.
into consumable food products through both visible and invisible processes embedded in the system. The visible parts come with farming and fishing activities whereas the invisible part lies within the very process of Algae-Bacteria symbiosis, which transforms wastes into nutrients.

3.5 Mutual Dependence - Kolkata and EKW:

Waste recycling in EKW involves three principal resource recovery practices, viz., sewage-fed fisheries, paddy-cultivation by utilizing fish pond effluents and farming of vegetables using organic waste as fertilizer. The fish farmers of EKW have developed such a mastery of these resource recovery activities that they are easily growing fish at a yield rate which is 2 to 4 times higher than that obtained from normal ponds and their production cost is also unmatched by any other freshwater fish ponds of this country. The volume of annual fish production from sewage fed fisheries of EKW was of the order of 18000 metric tons in 2008 which used to meet nearly one-third of total fish demand of the city (Wetlands International 2008). The treated water discharged through outlet channels from fish ponds are used for irrigating the paddy fields and horticulture farms. They depend on organic wastes dumped by the city of Kolkata as manure for producing fresh vegetables. Overall, this resource recovery practices in EKW provide livelihood support to nearly 0.2 million people (Wetland International op. cit.).

3.5.1 Wise Use of Wetlands - RAMSAR:

These wetlands have saved the city from incurring the construction and maintenance cost of wastewater treatment plant. The wetland forms an urban facility for treating the city's waste water and utilizing the treated water for pisciculture and agriculture, through the recovery of nutrients in an efficient manner. The ponds act as solar reactors and complete most of their bio-chemical reactions with the help of solar energy. Theses age old livelihood practices are tacked with the sewage treatment facility received by Kolkata in an integrated way making the site as International model for multiple use wetlands. For these wise use practices on 19th August,2002 the ‘East Calcutta Wetlands’ has been designated under RAMSAR Convention as wetland of International importance. In fact, the RAMSAR Information Sheet describes the system as "one of the rare examples of
environmental protection and development management where a complex ecological process has been adopted by the local farmers for mastering the resource recovery activities” (RIS 2002).

3.5.2 Complementary Eco-systems:

From the thermodynamics point of view, any product in the world will inevitably turn into waste in the end; yet every ‘waste’ is bound to be a ‘resource’ that is useful elsewhere in the biosphere (Ma & Wang, 1989 cited in Yan et.al. op. cit.). On the basis of the circulation principle, the whole circulation of ‘products’ and ‘wastes’ should be taken into account to discover their potential uses and effects, turning the useless into the useful according to its nature while treating the ‘waste’. There are no differences between resources and waste in the combination (Yan et.al. op. cit.). This system of waste recovery illustrated in Chart 3.4 shows the complementary relation between Kolkata and EKW through waste-wealth interconnectedness.

Chart 3.4: Resource Recovery Practices in EKW

Source: Banerjee & Dey 2015
The mutual dependence of the city of Kolkata and East Kolkata Wetlands is a unique evidence of this waste to resource conversion where wise use practices has evolved around sewage fed fisheries and organic waste based farming over the century.

3.6 Overall Assessment:

Kolkata is generating 1112 million liters of sewage (CSE 2011) and 4460 metric tons of solid waste per day (Das & Bhattacharya 2013). Only 15% of this huge amount of wastewater gets treated through sewage treatment plants and a major portion of the rest (nearly 78% of total) goes to the wetlands located at the eastern side of the city, popularly known as East Kolkata Wetlands (EKW) through an intricately designed canal network for natural treatment (Wetlands International 2008). During the process of treatment the bacteria rich waste water gets converted into algae and produce planktons which is a source of nutrient-rich fish feed. The wetland provides about 150 tons of fresh vegetables daily, as well as some 10,500 tons of table fish per year (RIS op. cit.). It provides livelihood support to more than 0.2 million people (EKWMA & WI 2010) and is recognized as a highly dependable food supply chain for the residents of Kolkata.

However, since the development of Salt Lake Township and the construction of Eastern Metropolitan Bypass, the connectivity of EKW with the main city has improved and the pressure of urbanization is leading to conversion of some of the water bodies into urban settlements. This practice is disturbing the age-old eco-balance and the eco-system based livelihood in the area, creating big environmental threat for the city herself. Since the major weakness in this arrangement lies in the fragility of its eco-characteristics, if one economic and/or ecological agent of the system gets disturbed, a spiral of disequilibrium influences would be released and ultimately the whole system will collapse. Chapter 4 presents the recent threat of urban encroachment affecting the protected eco-system and talks about the possible consequences of this encroachment.
## APPENDIX 3.A.1

Photographs on Wise Use Practices from the Field

<table>
<thead>
<tr>
<th>Photo 3.1: Drying up ponds (Channel submerged in water)</th>
<th>Photo 3.2: Excavation of pond bed</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image" /></td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Photo 3.3: Ploughing up Pond Bed</td>
<td>Photo 3.4: Embankments of Water Hyacinth</td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Image" /></td>
<td><img src="image4.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Photo 3.5: Inlet (triangular Bamboo made sieve)</td>
<td>Photo 3.6: Outlet (through pumps)</td>
</tr>
<tr>
<td><img src="image5.jpg" alt="Image" /></td>
<td><img src="image6.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Photo 3.7:</td>
<td>‘Moi’ folded in bamboo sticks</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><img src="image1" alt="Photo 3.7" /></td>
<td></td>
</tr>
<tr>
<td>Photo 3.8:</td>
<td>Bamboo <em>pata</em> used for preparing ‘Moi’ &amp; Triangular Sieve</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><img src="image2" alt="Photo 3.8" /></td>
<td></td>
</tr>
<tr>
<td>Photo 3.9:</td>
<td>‘Jhanki’, the spawn supplier (suffling water in the container to ensure constant oxygen supply in spwans)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><img src="image3" alt="Photo 3.9" /></td>
<td></td>
</tr>
<tr>
<td>Photo 3.10:</td>
<td>Using Ecological indicators to judge the water quality</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><img src="image4" alt="Photo 3.10" /></td>
<td></td>
</tr>
<tr>
<td>Photo 3.11:</td>
<td>Duck house placed over pond</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><img src="image5" alt="Photo 3.11" /></td>
<td></td>
</tr>
<tr>
<td>Photo 3.12:</td>
<td>Droppings of ducks used as fish feed</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><img src="image6" alt="Photo 3.12" /></td>
<td></td>
</tr>
</tbody>
</table>

Photo Credit: Dr. Dhrubajyoti Ghosh
<table>
<thead>
<tr>
<th>Photo 3.13: Net Pulling</th>
<th>Photo 3.14: Harvesting of fish</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="http://www.downtoearth.org.in/coverage/everybody-loves-waterbody/40203" alt="Net Pulling" /></td>
<td><img src="http://everitas.univmiami.net/?attachment_id=441" alt="Harvesting of fish" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Photo 3.15: Rowing in effluent irrigated paddy fields</th>
<th>Photo 3.16: Fish pond effluent irrigated paddy fields</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="http://www.downtoearth.org.in/coverage/everybody-loves-waterbody/40203" alt="Rowing in effluent irrigated paddy fields" /></td>
<td><img src="http://everitas.univmiami.net/?attachment_id=441" alt="Fish pond effluent irrigated paddy fields" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Photo 3.17: Organic waste based farming (mixed farming)</th>
<th>Photo 3.18: Cauliflower cultivation (organic waste based)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="http://www.downtoearth.org.in/coverage/everybody-loves-waterbody/40203" alt="Organic waste based farming" /></td>
<td><img src="http://everitas.univmiami.net/?attachment_id=441" alt="Cauliflower cultivation" /></td>
</tr>
<tr>
<td>Photo 3.19: Fish Carrier</td>
<td>Photo 3.20: Auction market in <em>Bantala</em></td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td><img src="image" alt="Fish Carrier" /></td>
<td><img src="image" alt="Auction market in Bantala" /></td>
</tr>
<tr>
<td>Photo 3.21: Variety of Fish in Auction market</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Variety of Fish in Auction market" /></td>
<td></td>
</tr>
<tr>
<td>Photo 3.22: <em>Bheris</em> used for Eco-tourism</td>
<td>Photo 3.23: Boating in eco-tourism park</td>
</tr>
<tr>
<td><img src="image" alt="Bheris used for Eco-tourism" /></td>
<td><img src="image" alt="Boating in eco-tourism park" /></td>
</tr>
</tbody>
</table>