Chapter 6
Wastewater-Fed Aquaculture in East Kolkata Wetlands: State of the Art and Measures to Protect Biodiversity

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Abstract East Kolkata Wetlands (EKW) have been recognized internationally as an important Ramsar Site with its long history of metamorphosis from saltwater area to freshwater aquaculture system fed with wastewater. It has been rendering livelihood opportunity to a large number of people in and around Kolkata through production of cheap protein source of food fish. This large-scale wetland system is utilized for wastewater treatment cum fish farming. The chapter attempts to focus important facts relating to wastewater-fed aquaculture, along with unique features that characterize such wetlands sustainable over the times. Nevertheless, this wetland system is now facing concerns which need to be resolved for benefits of fish farmers and fish consumer as well. Some measures have been addressed for sustainable management of the wetland system that would provide ecosystem service to cater the benefit of protein food production for present and future generations.

Keywords Wastewater · EKW · Aquaculture · Biodiversity

Contents

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6.1 Introduction

The world is now in a critical phase with increasing population over decreasing resources. The developing world as a whole has been predominantly rural but is rapidly becoming urban. In 1975 only 27% of people in the developing world used to live in urban areas, whereas in 2000 it became 40%. Projected prediction suggests that developing worlds will turn to be 56% urban by 2030. The urban populations will face two major challenges: (1) supply of protein foods and (2) disposal of human waste. A study conducted in Kolkata Metro, India, shows that for every 115.6 l of potable water supplied to households, 92.5 l become wastewater. This shows that more is the urbanization; much is the wastewater generation leading to excessive pressure on urban sanitation and threat to open water pollution. The cumulative effect may also threaten biodiversity in general, particularly sustenance of human life. The Millennium Development Goals (MDGs) formulated some measures in terms of respective 'GOALS' to mitigate the concerns as much as in the use of wastewater in agriculture. The important goals with respect to wastewater use in agriculture are as follows:

Goal 1: 'Eliminate extreme poverty and hunger' – fish raised in waste-fed system is contributing to human nutrition through protein supplementation.
Goal 7: 'Ensure environmental sustainability'.

Wastewater treatment through aquaculture in East Kolkata Wetlands (EKW) has been an innovative approach practised by local fish farmers. The recycling of wastewater in aquaculture has its potential of resource recovery in terms of nutrients utility through food chain of fishes. This is a proven and an age-old alternative low-cost sanitation system that is linked to livelihood option and nutritional security of common people. The present chapter highlights the facts and features with respect to concerns and possible measures.

6.2 Facts

6.2.1 Location and Weather

The EKW lies between the river Hooghly on the West and the Kulti Ganga in the East, with geographical location: lat. 22° 25′N–22° 40′N and long. 88° 20′E–88° 35′E. Three major seasons as winter, summer and monsoon are recognized. Temperature ranges between 12 and 40 °C, and rainfall recorded between 150 and 200 cm, with humidity 80% as an average and wind speed ranging from 2.9 to 7.0 km ph. Solar radiation varies between 150 and 250 Langley/day. This tropical location has been suitable for trapping a huge amount of solar radiation that helps in treating wastewater through ecological functions and improving wastewater quality for fish farming.

6.2.2 Genesis

The East Kolkata Wetland is a part of the mature delta of the river Ganga, its tributaries and distributaries. Since the early fifteenth century, the river Ganga changed its main course from the Bhagirathi to the Padma River. This eastward shift in the course of the main flow of the river Ganga brought metamorphic changes in the process of delta building in the lower Gangetic plain. As a result, a number of distributaries and tributaries were cut off from upland flows. The mouths of some small distributaries opened directly into the Bay of Bengal and were influenced by tidal action. One such tidal channel has been the Bidyadhari River that used to deposit silt in this area. Since then, the process of natural deposition and raising the level of the spill area ceased to function, and this incomplete process of delta building did not allow the low-lying areas behind the Hugli levee, to the east of Kolkata, to rise higher. The East Kolkata Wetlands now remain as remnants of the vast stretches of the salt lakes, which once extended beyond the present international boundary of Bangladesh. The land to the east of Kolkata in general slopes to the east and south-east, with the natural drainage in those directions.

6.2.3 Metamorphosis of EKW: From Brackish to Freshwater Aquaculture

Prior to 1830, the low-lying region with saltwater lakes acting as spill reservoirs for the Bidyadhari was utilized for farming of brackish water fish such as bhetki (*Lates calcarifer*), parse (*Liza parsia*), bhangar (*Mugil tada*), prawns (*Macrobrachium rosenbergii*), etc. The area was gradually rendered derelict on account of the receding Bidyadhari spill channel. The poor upflow of the Bidyadhari and the cessation of tidal flow converted the entire area into a vast derelict swamp. The diversion of city wastewater and storm water into the Salt Lakes caused a gradual change in the aquatic environment from saline to nonsaline. This led to the changes in the culture of fish in the region, especially in terms of species. In 1929, a leading fish producer of this region successfully experimented with the process of farming fish in wastewater-fed ponds. Gradually, the wastewater-grown fish became prominent with species such as rohu (*Labeo rohita*), catla, (*Catla catla*), mrigal (*Cirrhinus mrigala*) and exotic ones such as silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) along with tilapia (*Oreochromis mossambicus*), walking catfish (*Clarias batrachus*), etc.

With drying up of the tidal flow, subsequently intake of city wastewater was introduced into this wetland – an innovative approach to keep EKW continuing alive from being wasteland. The intake of wastewater was not only used for fish culture but also used for irrigation of crops and vegetables cultivated in this region. This practice saved the livelihood of thousands of fishermen, which was threatened by the drying up of brackish water fisheries of EKW. In 1992, a case study on the East Kolkata Wetlands was presented in the expert committee meeting of the Ramsar Convention, the only example of 'wise use' of wetland from India, which included one important wetland among 17 other case studies selected from all over the world. That was the beginning of an effort which led to the declaration of the East Kolkata Wetlands as a Ramsar Site, a new dimension in the EKW conservation strategy. The resource-recovery system created and developed in East Kolkata Wetlands by the local innovators through the ages is the largest in the world. It is also the only wetland area by the side of a metropolitan city where the government has introduced development controls to conserve the water bodies and plans to develop it as a unique urban facility for environmental improvement.

6.2.4 Potentiality of EKW

The production of fish in EKW varies from 3.0 to 6.0 tones/ha/year, thereby creating eco job 2 to 2.5 person/ha/year directly and 1–1.5 person/ha/year indirectly. Blending of local wisdom with scientific knowledge of aquaculture, the yield can be increased up to twofold more without supplementary feed and aeration. In this case, the fish pond serves as stabilization pond, and the self-purification capacity enables to reduce the chemical and biological toxicity of urban wastewater. The current land use pattern includes the following:(a) 5852.14 ha corresponding 46.82% of a total land areas used for fisheries and aquaculture, (b) 5852.14 ha as 37.75% of a total land areas used for agriculture, (c) 602.78 ha as 4.82% of a total land areas used for garbage dumping including farming and (d) 1326.52 ha as 10.61% of a total land areas used for human settlement.

6.3 Features

6.3.1 Characteristics of Wastewater in EKW

Wastewater is the main potential ingredients for pisciculture in EKW. The characteristics of wastewater is not uniform round the year, it actually varies not only place to place but also from hour to hour at the same place depending on the climate conditions, availability of water, dietary habits, social customs, etc. The average values of some parameters are given in Table 6.1.

6.3.2 Aquaculture in EKW, Known as LEISA

In EKW the conventional option in wastewater treatment has been replaced by an ecological design of wise use of wetland. The relook of wetland utility aims to reduce pollution and reuse nutrients that have ensured enhancement of food production and livelihood security of the local community through both aquaculture and agriculture. The high organic load of wastewater-fed fishery is degraded by the microbial-algal-animal complex activity that enables organic wastes to recycle into fish biomass through ecosystem dynamics. This ecological process that is the basis of resource recovery from organic wastes has enabled farmers to be capable of growing fish at higher yield with minimal production cost, known as LEISA (low external input sustainable aquaculture).

6.3.3 Different Models of Wastewater-Fed Aquaculture

Based upon the physico-chemical characteristics of wastewater, climatic condition, land availability, etc., different models or designs (Table 6.2) are available for wastewater treatment through aquaculture to achieve the desired reduction of pollutants and harnessing the potential nutrients in economic-driven activities (WHO 2005).

Table 6.1 Physico-chemical parameters of aquaculture ponds of East Kolkata Wetlands (EKW)

Parameter	Raw sewage to fishery	Sewage-fed culture water	Outlet water for agriculture	Effluent standard for inland surface water[a]
Temperature (°C)	32.0	29.27	29.0	40
pH	7.2	7.70	7.5	5.5–9.0
Transparency (cm)	Nil	15	10	10
Total dissolved solid (ppm)	675	455	130.0	2100.0
TSS (ppm)	211	123	65.0	100.00
BOD (ppm)	128.4	25.0	17.9	30.0
DO (ppm)	Nil	3.9	4.5	4.0
Alkalinity (ppm)	273.7	130.0	130.0	83.0
Phosphate (ppm)	2.94	0.8	0.8	0.2
Nitrate (ppm)	3.7	2.41	2.41	0.8
Free ammonia (ppm)	40.0	1.04	0.5	1.2
Lead (as Pb) (ppm)	0.57	Trace 0.09	Trace	0.1
Cadmium (as Cd) (ppm)	032	Trace 0.12	Trace	2.0
Chromium (as Cr) (ppm)	5.80	Trace 0.08	Trace	2.0
Zinc (as Zn) (ppm)	0.56	Trace 0.44	Trace	5.0
Coliform (cfu/100 ml)	$10^{4.5}$	$10^{1.5}$	$10^{1.5}$	<5000 cfu/100 ml
Faecal coliform (cfu/100 ml)	$10^{3.5}$	10^{1}	10^{1}	<5000 cfu/100 ml
Salmonella sp. (cfu/100 ml)	10^{5}	10^{1}	10^{1}	<5000 cfu/100 ml

[a]CPCB, Govt. of West Bengal

6.3.4 Status of Wastewater-Fed Aquaculture in EKW

The total area of EKW comprises 5852.14 ha, including 3200.55 ha for a total perennial aquaculture wetlands, 698.22 ha for a total non-operating area and 1953.37 ha for a total non-functional area. On the other hand, wastewater flow released daily to EKW from Kolkata City accounts 1300 mld (approx.), and wastewater availability for aquaculture is 320 mld (approx).

The wastewater management strategies vary depending upon wastewater availability, carrying capacity of pond, market demand, operational cost, work culture of the workers/member of piscicultural unit, etc. The farmers fill up ponds with wastewater, which is then left for 2 weeks for natural purification and stabilization before introduction of fish. Subsequently, ponds may be topped up with wastewater

Table 6.2 Different models or designs of wastewater utility and their features

Design	Features
Obstructed flow system	Wastewater directly received by fishes; land is not a constraint
Waste stabilization system	Wastewater stored in oxidation ponds in order to suspend organic load and growth of plankton followed by its release to aquaculture ponds
Flow-through system	Wastewater treated through series of ponds and then used for fishes
Dilution of wastewater	If the BOD level of wastewater is more than 50 mg/l, then it is necessary to dilute by adding freshwater
Duckweed culture	In absence of sufficient quantity of water and land to reduce BOD level below 50 mg/l, 'duckweed culture model' is a good option. Duckweed helps in reducing the pollutant level in wastewater and also serves as food for fishes
Effective microorganism (EM)-based system	In extremely land scarce situation, wastewater can be treated by microorganism-based system [consisting of lactic acid bacteria (aerobic and anaerobic), yeast and *Actinomycetes*, etc.

continuously or periodically depending on availability of wastewater and season. Farmers have learned by experience the methods of culturing herbivorous and omnivorous fish such as Chinese carp, Indian major carps and tilapias. Using traditional methods, the quality of wastewater-fed ponds is assessed by observing water colour, light penetration in water and fish surfacing behaviour in the early morning when dissolved oxygen level of pond water declined to their lowest level after respiration of aquatic organisms during the night. This lesson led to conceive the idea of wastewater-fed aquaculture.

6.3.5 Aquaculture Strategies

Farmers of EKW usually adopt a specific aquaculture practice using traditional knowledge by the way of their experiences which is as follows:

- Obstructed flow-through system with multiple stocking and multiple harvesting (Fig. 6.1)
- Water column – 0.6–0.8 m generally, except ponds de-silted when water column is more than 2 m
- Wastewater intake – 50–200 m^3/ha/day (100–200 days/year) due to lack of wastewater
- Species cultured: seven to eight species. *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Labeo bata*, *Hypophthalmichthys molitrix*, *Cyprinus carpio*, *Oreochromis mossambicus* and *Oreochromis niloticus* in different ratios, basically depending upon wastewater availability and water column and size of fingerling at the time of introduction 5–20 g
- Stocking density: 500–1200 kg/ha

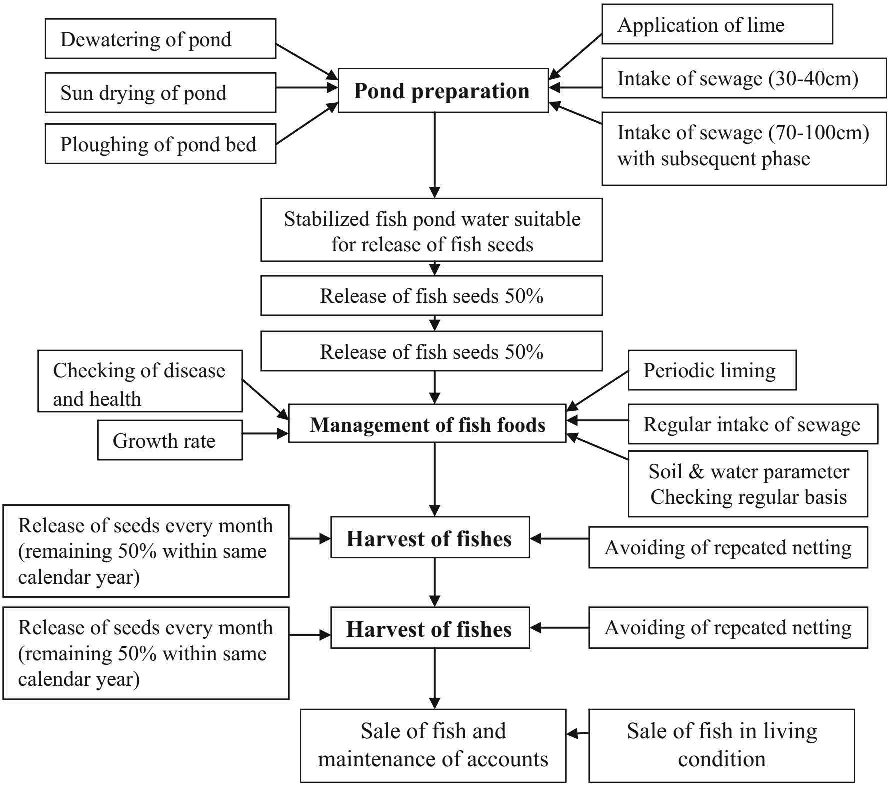

Fig. 6.1 Method of wastewater-fed aquaculture, including multiple stocking and multiple harvesting

- Harvesting throughout the year (100–300 days/year)
- Harvesting size – 50–250 g for IMC and 200 g to 1 kg for exotic crap
- Production: varies from 3–6 tonnes/ha/year depending on availability of wastewater (Table 6.3)

Farmers generally follow a few specific tips for wastewater-fed aquaculture in EKW as:

1. Desired inflow rate of wastewater is 150–200 m^3/ha/day (not 400 m^3/ha/day that may create eutrophication).
2. Added wastewater should not consume more than 1–2 mg/l of dissolved oxygen/ hr.
3. Avoid hot and cloudy day for intake of wastewater.
4. Transparency limit – 25 to 35 cm should be maintained.
5. Algal count – at least 100 million cells/l.
6. Polyculture, multiple stocking and multiple harvesting policy.

Table 6.3 Intake of wastewater and fish yield in East Kolkata Wetlands (WKW)

Different waterbodies	Water depth (m)	Intake of wastewater (%)		Fish production (tonnes/ha/year)
		Gravity flow	Pumped	
1	2	50	Nil	6.00
2	1.5	20	40	5.50
3	1	30	20	4.50
4	1	25	15	4.00
5	0.7	20	10	3.50
6	0.65	20	Nil	3.00

Source: (24-Parganas Fish Producer Association)

6.3.6 Marketing and People Participation

Generally fishes are sold in living condition to get better realization. About 90% of the harvested fishes were marketed in the morning and the rest in noon (Ghosh 2004). There are seven auction centres for sale of fishes. The total quantum of fish sold through these auction centres is 19,135 tones/year, of which more than 80% fish is supplied from EKW. Average sale price varies from Rs. 70–80/– per kg in auction market. A total work force comprises 17,000 people out of almost 72,000 inhabitants residing around 12,500 ha as per 1991 census.

6.3.7 Environmental Benefit

Not only that aquaculture practice in EKW produces fish by utilizing organic-laden water, but also it renders unbelievable environmental benefits to the entire vicinity and its people; otherwise, it creates both aquatic and land pollution that could hamper normal health of residents. The summary of benefits is mentioned below:

- Each hectare of shallow waterbody can remove about 237 kg of biochemical oxygen demand/day.
- Organic loading rate in fishery is 20–70 kg/ha/day. It is a source of nutrients for plankton production, and it reduces the siltation rate in river mouth.
- Support biodiversity.
- Ecological environmental value of EKW is around Rs. 3030 million/year (for flood control, siltation, extensive food chain, livelihood support, carbon sequestration and sanitation).

6.4 Concerns

6.4.1 Poor Infrastructure

Despite a Ramsar Site recognized worldwide as its utility for fish production and livelihood option, still EKW suffers from poor infrastructure for optimal uses of resources. These are:

1. Lack of sufficient wastewater supply from Kolkata Municipal Corporation to the fisheries sector of EKW.
2. Lack of up scaling of aquaculture facilities.
3. Lack of government policy and implementation measure to support wetland practice encourages ecological sound design for environment protection.

6.4.2 Safety of Fish Yield

In aquaculture, a product-oriented practice being, public health concerns have been raised with regard to the suitability for consumption of fish/shellfish from such system. The level of heavy metals, antibiotic residue and microbial counts are reported to be less than the permissible limit.

6.4.3 Threats to Fish Diversity

In EKW, there were as high as 80 species of fish during the 1960s. Later, it was identified 32 fish species. Further, *Jalabhumi Bachao Committee* recently surveyed fish species diversity in EKW during submission of proposal for protection of endangered fishes of EKW and identified 45 species (Table 6.4). The rich fish germ plasm resources of EKW have been suffering from various serious anthropogenic stresses leading to overall exploitation of genetic resources. The reasons which are responsible for such destruction include habitual destruction, over-exploitation, aquatic pollution, disease, introduction of exotics and alien species, lack of awareness about the importance of biodiversity and lack of proper policy implementation to restore it. Out of 45 species, 11 species are generally cultured on regular basis, and 7 new indigenous species were introduced for culture during the last 2 years. Three species of exotic crocodile fish by accident were introduced in EKW, and successful populations are now found in enormous quantity. Some species such as *Nandus nandus* (meni), *Xenentodon cancila* (kakila), etc. were available in EKW in the 1980s, but now these species are not available. In the present scenario, it is essential to conduct a detail survey of EKW for up-to-date information about species diversity and categorize their scale of

Table 6.4 Diversity of fish species in East Kolkata Wetlands (EKW) and their status

Species	Status
Catla catla (catla), *Labeo rohita* (rohu), *Cirrhinus mrigala* (mrigal), *Labeo bata* (bata), *Labeo calbasu* (calbasu)	Commonly cultured Indian carps (5)
Hypophthalmichthys molitrix (silver carp), *Ctenopharyngodon idella* (grass carp), *Aristichthys nobilis* (big head carp), *Cyprinus carpio* (common carp), *Oreochromis mossambicus* (tilapia), *Oreochromis nilotica* (Nile tilapia)	Commonly cultured exotic species (6)
Lates calcarifer (bhetki), *Liza parsia* (parse), *Mystus gulio* (nona tengra)	Brackish water species reintroduced in EKW by some farmer (3)
Ompok pabda (pabda), *Chitala chitala* (chital), *Cynoglossus cynoglossus* [baspah (flat fish)], *Piaractus brachypomus* (rupchanda)	Some farmers introduced to culture in recent years (4)
Pangasius pangasius (pangus), *Mystus vittatus* (tengra)	Traditionally culture by some farmer of EKW (2)
Clarias gariepinus (African catfish/Thai magur), *Pangasianodon hypophthalmus* (hybrid pangus), *Puntius javanicus* (Javaputi)	Some farmers used to culture these species, though they are negative culture species (3)
Amblypharyngodon mola (morula), *Puntius ticto* (tit punti), *P. Sophore* (sarpunti), *Salmostoma bacaila* (chela), *Colisa fasciata* (boro kholisha), *Aplocheilus panchax* (techaka), *Mastacembelus pancalus* (pacal), *Pisodonophis boro* (kuchia), *Notopterus notopterus* (Pholui), *Clarias batrachus* (Magur), *Heteropneustes fossilis* (singhi), *Channa striatus* (shol), *C. punctatus* (lata/taki), *C gachua* (chang), *Mystus armatus* (ban), *Anabas testudineus* (koi)	Species endangered in EKW (16)
Chanda nama (chanda), *C. ranga* (ranga chanda), *Glossogobius giuris* (belay)	Small species available in good number in EKW (3)
Crocodile fishes: *Pterygoplichthys disjunctivus, P. anisitsi, P. multiradiatus*	Accidentally introduced in EKW. From the last 4–5 years, these fishes were recorded in good number (3)

threat as per availability, somewhat in the lines of IUCN, AFS and NBFGR such as extinct, critically endangered, endangered, vulnerable, near threatened, lower risk, remote risk and no risk.

6.4.4 Major Events Causing Concerns to EKW

Aquaculture as well as an entire EKW is under tremendous anthropogenic pressure leading to actual tenure problem. The cumulative effect of these pressures including

Table 6.5 Chronology of major events of concerns to East Kolkata Wetlands (EKW)

Year	Project	Result	Remarks
1896	Cross damming of one of the most powerful tidal-spill channels of the Bidyadhari River	Silting aggravated in the Bidyadhari River	–
1897–1898	Canalization of the Bhagore Khal and construction of the Bamanghata lock to facilitate inland navigation	Further deterioration of the Central Lake Channel	Around 1900 saltwater fisheries existed in the Salt Lakes. In 1904, a warning was given regarding alarming deterioration of the Bidyadhari River
1910	Construction of Krishnapur Canal – shooter route joining the New Cut Canal with the Bhangore Khal	More than 78 Sq. km of the spill area of the Bidhyadhari River was out off	In 1913 a second warning was given. In 1928 the Bidyadhari River was officially declared as dead by the government of Bengal. During 1930, first wastewater feed fisheries was started and proved successful
1940	Wastewater outfall of the city was changed from south-east to east, to the Kulti Gong or Kulti River	This was a necessity as the Bidyadhari River had died	–
1962–1967	Salt Lake reclamation for the extension of the city	Huge conversion of wetland into urban areas. Aggravation of drainage problems of the city during the monsoon	–
1980s	Construction of Eastern Metropolitan Bypass		–

government agencies and private entrepreneur who does not consider its ecological importance due to short-sight short-term planning has led to the shrinkage of these wetlands. The natural state of this low-lying area was interfered with expansion of the city of Kolkata with necessities of drainage and waste disposal and later also reclamation for city extension at different times (Table 6.5).

During 2000, *Jallabhumi Bachoo Committee* was formed with members of 10,000 local people to protect destruction and felling of wetland. One major event they resisted was the formation of Asian Gateway which they won eventually by the verdict of honourable High Court. Another upcoming threat to this wetland is the proposed ‘Eastern Link Highway’. The plan is to start the highway from the Barasat bypass which run through Rajarhat Township and back site of Kolkata Leather Complex and connect with National Highway 117 at Shirakol. If the road goes through the wetlands as it is planned, then the EKW will be at a serious stake.

Table 6.6 Constraints to peri-urban (PU) aquaculture based on the perception of firm managers ($n = 56$)

Constraint	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 problem	30	2.6	5.5
Siltation	23	2.6	5.5
Management problem	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 problem	4	4	13
Inundation during flooding	2	4	13
Declining production	5	4.3	15
Transport pTransport problems	2	5	16

6.4.5 Some Constraints to EKW

In August 2002, Institute of Aquaculture, University of Stirling, Scotland, published ‘Situation Analysis in Peri-urban Kolkata’. The paper summarized some constraints in EKW through response of correspondence of EKW community. The results are summarized in Table 6.6.

6.5 Measures

It is realized that conservation measures are essential to protect such important wetlands from further degradation (Ghosh 2005). Conservation is to be encouraged for the existence of species that includes some steps such as identification, cataloguing and prioritization of species as per their RED data categories. Some measures are to be taken as:

6.5.1 In Situ Conservation

In situ conservation of fish can be done through the maintenance of fish germ plasm resources in their natural habitat or man-made ecosystem in which they occur. Major advantages of in situ conservation include (1) continued co-evolution wherein the wild species may continue to co-evolve with other forms, providing the breeders with a dynamic source of resistance that is lost in ex situ conservation, and (2) national parks and biosphere reserves may provide less expensive protection for the wild relatives than ex situ measures. In situ conservation can be achieved through the following practices: (1) ranching, (2) protected areas (sanctuaries, biosphere reserves, etc.), (3) conservation aquaculture, (4) threatened or endangered species designation and (5) restoration of damaged and degraded habitat.

6.5.2 Ex Situ Conservation

The threatened species are conserved outside their natural habitats. The two main pillars of the ex situ conservation programme are (1) live gene bank or resource centre and (2) gamete bank. A mini gene bank with cryopreserved milt of several threatened and commercial species presently exists at the National Bureau of Fish Genetic Resources (NBFGR), Lucknow, India. Other ex situ conservation programmes include tissue banking, registration of germ plasm,and DNA barcoding.

6.5.3 Some Specific Recommendation for Enhancing Fish Biodiversity in EKW

With a view to save the world's largest wastewater recycle region, it is urgent to adopt proper and balanced methodologies for enhancing fish diversity (Ghosh and Ghosh 2003). The endangered species of EKW can be divided into two broad groups, viz., (1) candidate species having economic importance for culture and (2) fishes having ornamental values. Out of the 27 endangered species in EKW, 15 species can be selected as candidate species for culture and the remaining 12 as ornamental fish, especially for export. Besides culture of economically important fishes, standardizing and transferring the captive breeding and seed rearing technology of ornamentally valued small fishes of EKW are common among fishers. This will open a new avenue of employment in EKW and also play a role in restoration of fish biodiversity. Some measures are:

1. As most of the endangered fish species in EKW are smaller in size, mesh-size regulation during harvesting of fishes from grow-out pond is a suitable option

for protection against random catching of endangered fishes. Mesh size should be more than 4–5 cm for harvesting of marketable fish.

2. Total restriction on use of insecticide, pesticides and other harmful chemicals in pisciculture in EKW.
3. Strict monitoring to restrict the entry of heavy metals and other harmful chemicals in city wastewater and thus reducing the pollution load of incoming wastewater to the fisheries of EKW.
4. Over-removing of earth from the bed of pond by Rajarhat New Town Authority be restricted, and it should be limited as per suggested cutting depth of 0.80 metre (average).
5. Restrict fragmentation of bigger pond into small ponds.
6. Restrict unapproved exotic species culture and if so should be declare as punishable offence.
7. During liberation of fish seed, certain unwanted and exotic variety of fishes are coming from different places of West Bengal and entering into EKW system. Establishment of a fish seed centre within EKW can resolve this problem.
8. Protect existing natural habitat of endangered species of EKW. Government should take initiative to declare some bio-protected zone for endangered species.
9. Captive breeding and seed production of endangered fishes of EKW.
10. Awareness amonglocal people related to EKW regarding importance of endangered species for biodiversity and environment. Policymakers and implementer agencies also be educated about the biodiversity importance for our world.

6.5.4 Marketing Chain in EKW

The postharvest scenario in the fisheries unit in EKW and its distribution system play an important role in completing economic cycle. Daily harvested fish is brought to auction centre usually in the morning and also in noon/afternoon through carriers/packers. Generally quantity of fish carried by carriers per consignment is 12–16 kg live fish or 20 kg dead fish. The rate of carrying fish by carriers is varying between Rs. 4.00 and Rs. 7.50 per kg depending upon sale price of fish, distance, etc. Farmers have no free access to sale the product where they get maximum; they have to engage carriers for selling fishes. Out of total production, the fisher/producer sells 97% and 3% disposed of by way of subsistence payment to labourers, consumption by residential staff and charity/donation made during festivals. The operating chain may be represented diagrammatically as follows (Fig. 6.2).

In auction market, the aratdars (i.e. kata owner) charge commission to seller as well as from buyer (wholesaler/retailer). The commission is charged as a percentage of cash sales, and the rate varies between 1% and 2% for buyer and 2% and 5% for seller. The peak business month is between April and September; remaining months are lean period of culture and production. More than 19,235 tonnes of fish per year are sold through seven auction centres of this region. Out of the entire fish

Fig. 6.2 Marketing chain in East Kolkata Wetlands (EKW)

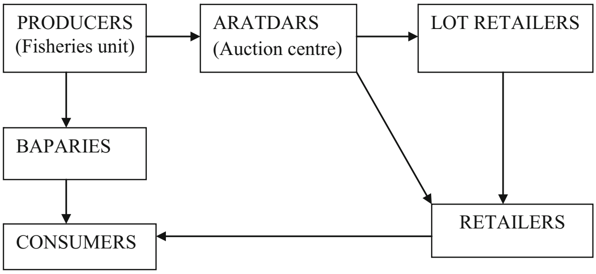

Table 6.7 Auction centre and total quantity of sale/centre/day

Sl. no.	Auction market	Nos. of stalls	Police station	Total quantity of fish sold (kg/day)
1.	Bamanghata	60	Bhangor	9000
2.	Bantala	55	Bidhannagar	11,000
3.	Chowbhaga	75	Teljala	6750
4.	Krishnapur	54	Rajarhat	8100
5.	Gangajoware	25	Sonarpur	3250
6.	Chingrighata	42	Tiljala	12,600
7.	Garia	25	Garia	2000

sale through these centres, more than 15,592 tonnes (>81%) from EKW and the remaining of about 19% fishes come from adjoining area of EKW. The locations of the auction market are at seven strategic points catering to diverse retail market mentioned in Table 6.7.

Major fish supplies to Kolkata City from EKW are mainly through aratdars. The aratdars in their turn put the fish for auction to retailers and lot retailers. The lot retailers take the fish to retail market and put the same for auction again to a section of retailers. A portion of the daily supply (very small) also goes directly to retailers from the collectors or 'beparies' who purchase the fish at fishing sites. The retailers purchase the fish and sell the same to consumers in market.

Due to monopolistic control of fish trade in different stages by a handful of middleman, the producers receive low prices for their products while consumers have to pay high prices for what they purchase. In general the producer in recent year gets around Rs.70.00/kg (average) of live fish, but in fish market, consumer purchases it not less than Rs. 120.00/kg. The middleman consume 40% margin, whereas the producers hardly get margin during course of production. Day by day the economic viability of fish production in EKW is reducing due to higher production cost in compare to selling price. It is the middlemen who are absorbing the margin of profit by depriving the producers.

6.5.5 Measures for Protection of EKW

Some recommendations for maintaining good ecosystem health and quality fish (Saha 2004):

1. Follow site selection and standard design norms (site specific).
2. Follow guidelines for use of domestic wastewater in aquaculture.
3. Follow management practice of wastewater feed aquaculture.
4. Use settling ponds, before intake of wastewater to culture ponds, and velocity of outflow water from settling ponds should be 'silting velocity'. It is observed that disease is less in obstructed flow system compared to flow-through system.
5. Treat seed of fishes before liberation in ponds (dip treatment with NaCl solution at 2.5% for 3–5 min, formalin treatment at 250 mg/l, group treatment with $KMnO_4$ (at 5 kg/ha for 48 h). Outsourced seed first should be released in a hapa/pond and keep for 2–3 days, and after treatment, it may be released to grow-out pond.
6. Avoid overstocking.
7. After every crop, sun-dry the pond bed if unit is small (below 1 ha), once in a year for big pond (below 10 ha) and once in 4–5 years if size of the pond is above 10 ha. Plough the pond bottom and apply lime after drying.
8. Apply lime in regular interval especially during change of monsoon.
9. Application of chlorine at 1 ppm or iodine in regular interval.
10. Regular inspection of soil and water quality parameters, fish health and growth.

Different measures and incident to protect wetland and fisheries in EKW:

1. PUBLIC (People United for Better Living in Kolkata) is responsible for 1993 Kolkata.
2. Fisheries department, Govt. of West Bengal, formed institute of wetland management and ecological design during 1987–1988. This was the first step to highlight EKW in international level.
3. *Jallabhumi Bachoo Committee* (10,000 member local people) movement during 2000 against extension of urbanization and implementation of different project in EKW and finally won over such step.
4. Government's declaration of 'East Kolkata Management Authority' in 2002 for the conservation and sustainable uses of EKW.
5. Fisheries department, Govt. of West Bengal, has organized 8 fisheries co-operatives and 24 fish production groups in EKW to improve physical structure and culture of fish through different government programme and soft-term loan, viz., NCDC loan etc.

6.5.5.1 Physical Improvement of EKW

Physical improvements of EKW were started on and from 1999 to support fisheries units and waste recycle region.

1. In 1999, HIDCO de-silted Nalban Fisheries as trial basis to till up low-lying area of Rajarhat Township. Since 1999 to up to date, HIDCO (2003) (West Bengal Housing Infrastructure Development Corporation Ltd. 2003) de-silted more than 150 lakh cum earth from approx 800 ha fish pond.
2. The West Bengal housing board constituted a committee under notification No. 86/HI/NTP/IM-3/99(pt) dated 18 February 2003 for 'physical development of bheries within EKW and waste recycling region (WRR)'. The committee suggested design of fish pond and wastewater supply (72 million litre/day (mld) to the northern part of waste recycling region (WRR) from New Township, Rajarhat. Accordingly works on wastewater supply structure are under process. This will feed wastewater where wastewaters supply from KMC in very low. 600 ha of pisciculture area of EKW will be benefited and existing production will be enhanced by 60 to 100%. The committee also estimated an expenditure of Rs. 251 crore for physical development of much required 2500 ha piscicultural area of EKW (USAID, INDIA 2006).
3. In 2007 EKW Management Authority de-silted different wastewater feed feeder canal, as a result the existing area are getting more wastewater related to Vidhyadhar Channel No. 1 and 3 and new area (which was previously converted to agri-land from fishery) came under piscicultural activities due to supply of wastewater.
4. Under MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) scheme through South 24-Parganas District Administration the EKW Management Authority de-silted 3 km of Bidhyadhari Fishery Feed Canal (Bantala to Saintala).

Requirements to enhance production from EKW (Ghosh 2007):

1. Inflow of wastewater is required at 320 million litres a day (mld) at existing condition of piscicultural area and will be required at 869 mld in the future after enhancement of water column to 1.5 m for the entire piscicultural area of EKW. This needs to be ensured first. In dry season GTS level 9 needs to be maintained after Bantala site and in rainy season use proposed pumping system for feeding wastewater to piscicultural units.
2. De-silt all feeder canals and strengthen all dykes of fisheries to support 1–2 m water column.
3. Infrastructure, viz., road, electricity, freshwater supply, etc., needs to ensure better operation and scientific culture.
4. Technology up-gradation along with species diversification is required for quality fish production based on market demand.

5. Refresher training of fisher/producer of EKW.
6. Financial support and insurance facility which are lacking required utmost.
7. Land policy should be on stream lined.
8. Overall management and work culture; for that support from local leader to farmer/producer community is essential, besides government support.

6.6 Conclusions

FAO estimated that an additional 40 million tonnes (world demand) of aquatic food will be required by 2030 just to maintain current level of consumption. Recycling and reusing of water is one of our prime necessities to cater future demand of freshwater and food. WKW is a striking example of low external input sustainable aquaculture and agriculture site. Sewage is well known as a readily available biodegradable nutrient-rich resource, and aquaculture provides an opportunity for not only converting this waste into valued protein food but also a biological means for wastewater treatment which is most important in the context of current freshwater scarcity scenario.

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