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Eco-system Complementarities and Urban Encroachment: A SWOT Analysis of the East Kolkata Wetlands, India

To understand the complex process caused by the plants, microorganisms, soil matrix and substances in the wastewater and their interactions with sunshine in a hot and humid climate, researchers from different corners of the globe are taking keen interest in the functioning of the East Kolkata Wetland (EKW) as a tutorial ecosystem. However, due to excessive pressure of urban sprawl of Kolkata, a densely populated metropolitan city, this system is facing some threats to sustenance over the decades. This paper attempts to illustrate the inherent nature of eco-system complementarities between the city of Kolkata and EKW, threats imparted by the recent urban developments, inadequacy of the regulatory initiatives taken for its protection and would indicate the untapped opportunities as well as weaknesses, by carrying out a SWOT analysis.

Keywords

wetland ecosystem, traditional knowledge, sewage-fed-fisheries, land use change, natural sewage treatment

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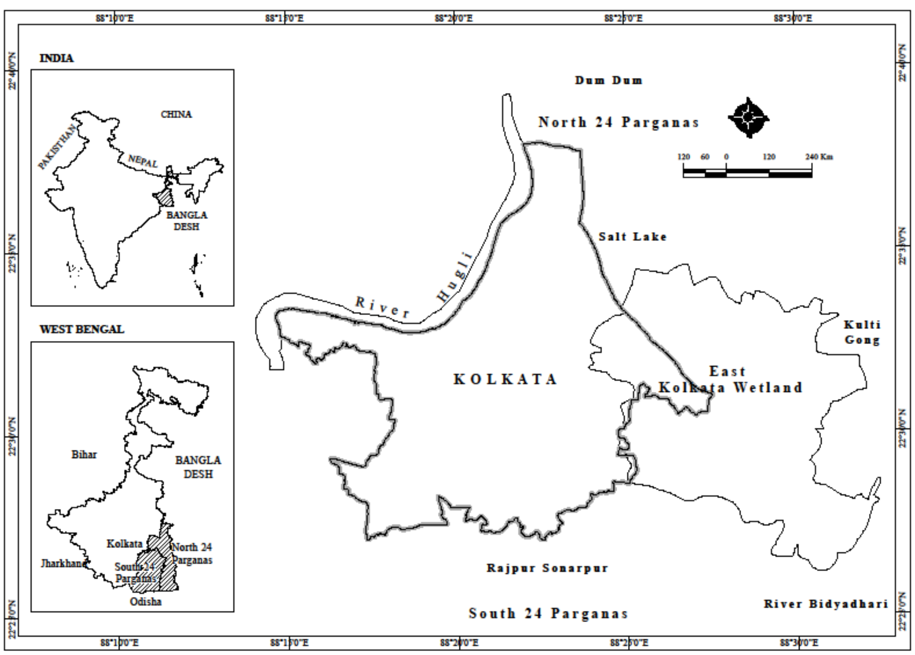
1. INTRODUCTION

Kolkata, the home of 4.5 million people with an additional burden of another 6 million floating day-time population (Census 2011; KMC 2015), is generating 1,112 million liters of sewage per day and facing the challenge of managing, disposing and treating wastewater. The 12,500 hectare wide wetlands spread over 32 *mouzas*[1] with total of 11,085 water-bodies[2] (PAN-GIS 2011)[3] on the eastern fringe of the city, popularly known as the East Kolkata Wetlands (EKW), is serving as a natural sewage treatment plant for more than a century. Nearly 80 percent of city-sewage goes through an intricately designed canal network (CSE 2011) and is the largest of its type in the world (Ghosh 1999) (Map 1). To understand the complex treatment process caused by the plants, microorganisms, soil matrix and substances in the wastewater and their interactions with sunshine in the hot and humid climate, researchers from different corners of the globe are taking keen interest in the functioning of the EKW as a tutorial ecosystem (Furedy & Ghosh 1984; Sarkar 2002; Bunting 2004; Kundu et al.2005; Bunting & Lewins 2006; Hofman 2013). It is a unique case where two apparently unrelated activities – the sewage treatment process and wastewater aquaculture – are connected as well as complementary to each other as a part of an integrated aquatic eco-system. This wetland is a designated Ramsar site where livelihood dependence through wise use practices evolved around sewage fed fisheries and organic waste based farming practices over years.

Map 1. Location Map of East Kolkata Wetlands (Google Earth 2011).



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[1] Rural administrative unit (almost equivalent to village).

[2] According to the official records there are 254 fisheries operating in this area; a fishery may be a conglomeration of water bodies and all water body may not be used as fishery.

[3] A project has been commissioned under the Rajiv Gandhi Chair of the University of Calcutta, India in 2010-11 and PAN Network has prepared the present land-use map by applying GIS technique.

An aggressive urban expansion in the eastern periphery of the city has led to the unplanned conversion of wetlands into urban settlements. After the development of Salt Lake City during the sixties and the construction of Eastern Metropolitan Bypass during the eighties, this eastern hinterland of Kolkata has become well connected with the main city and the spillover pressure of urbanization has made the EKW a hotspot for land speculators and promoters leading to changes in the pattern of land use. If the change occurs to a significant extent then there will be simultaneous threat on the existing sewage and rainwater disposal practices of the city of Kolkata and the livelihood options available to local people through wastewater aquaculture. In fact, if wastewater fishery loses its dominance, the costless treatment of sewage will no longer be viable. In this background this paper attempts to carry out a SWOT (strength-weakness-opportunity-threat) analysis of this eco-service to illustrate not only the status in terms of present benefit, but the concern for future sustainability as well.

2. RESEARCH ISSUES

The analysis has been carried out in terms of a well-designed sequence of research issues:

(i) Exploration and elaboration of the complementary relation between natural treatment of Kolkata's sewage and wastewater aquaculture based livelihood practices in the EKW to ascertain the unique standing of this eco-system as a method of resource recovery.

(ii) An assessment of the total value of the ecosystem services, enumerable and non-enumerable, provided by the EKW to the city of Kolkata, viz., (a) value of the direct benefit for Kolkata, enjoyed due to this opportunity of costless natural sewage treatment and (b) other indirect benefits derived from the sheer existence of this wetland eco-system.

(iii) An assessment of the extent of urban encroachment in recent period.

(iv) The threats to sustenance of the eco-system as a consequence of this physical change in topography leading to changes in the livelihood pattern. An appraisal of interventions initiated by the regulatory authority to retain this eco-balance.

(v) Presentation of the case in a SWOT (Strength-Weakness-Opportunity-Threat) framework.

(vi) Identifying the essential dimensions necessary for designing sustainable policy with effective mechanism to design regulatory instruments for protecting this tutorial eco-system.

3. METHODOLOGY

The methodological details are presented for each one of the relevant questions:

(i) The resource recovery practices have been established by collating and synthesizing facts and figures from different official reports, printed documents and other secondary sources.

(ii) The enumerable benefits mostly refer to the direct and actual usages of the eco-services whose market valuation can be done by applying imputation method through the revealed preference approach. A Cost Benefit Analysis framework has been used here to present an estimate of the opportunity cost of Kolkata from an alternative arrangement of sewage management through the mechanized Treatment Plants (STPs). The non-enumerable benefits are generally associated with the potential but non-market services provided by the eco-system, where existence of the EKW would be considered valuable to keep the option of its future use open to the society. Existing literature, official reports, budget documents, other documents available in printed form or web has been used to estimate the value of these other non-enumerable benefits.

(iii) The temporal growth of urban population in Kolkata and its fringe has been used to establish the increasing pressure on wetlands. On the basis of a GIS map prepared in 2011 on land-use pattern of the EKW, the major changes of water-bodies, agricultural lands, open spaces and other low-lands into urban settlement have been identified.

(iv) Gathering information from official websites of different Govt. and Non-Govt. authorities, existing literature, and direct interview with different stakeholders in the EKW, the threats imparted by the changes in topography have been identified. To study the effect of these changes on the livelihood pattern of the local residents a primary survey has been conducted in 2012 on the employed persons spread over different parts of the EKW, where the stratification is done on the basis of the extent of changes observed in the land-use pattern. Attempt has been made to investigate the changes in the livelihood pattern and the tendency to switch, if any, from traditional to relatively modern vocations, where the traditional vocation refers to all primary activities related to fisheries, agriculture, animal husbandry, etc. and the relatively modern ones are referring to more urbanized vocations. A critical appraisal of vigilance of the civil society, institutional interventions, and legal initiatives in this regard has been presented by collating information from different secondary sources.

(v) SWOT (Strength-Weakness-Opportunity-Threat) method of strategic planning and management has been used in this section where STRENGTHS provide an analysis of the eco-system's advantages over WEAKNESSES which consider areas in which the system is at a competitive disadvantage. OPPORTUNITIES are a list of untapped prospect to exert the system better and finally THREATS explore the external environment that could affect the functioning of this eco-balance.

(vi) Finally, an analysis of possible coordination failure is presented and the possible ways out have been indicated to design a sustainable policy environment.

4. NATURAL TREATMENT OF WASTE WATER AND ECOSYSTEM COMPLEMENTARITY

The EKW provides the city with basic urban service by naturally treating nearly 80 percent of her wastewater. Here wastewater treatment and sewage-fed fishery practices are integrated through a rare type of stage correspondence and Kolkata enjoys an *ecological subsidy* from the EKW comprised wastewater treatment as well as fresh food supply (Ghosh 2004). A number of factors coincided together to create an opportunity for resource recovery in an intricate ambience of wise-use practices that gave the site Ramsar status in 2002.

4.1 Natural Conditions

The wastewater of Kolkata flows through underground sewers to pumping stations in the eastern fringe of the city and is then pumped into open dry-weather-flow channel. The essential factors in the purification process are (a) the hot and humid climate, (b) the shallow ponds, (c) adequate sunshine and (d) abundance of water hyacinth.

a) The geographical location of the EKW, approximately between latitudes 22º25' to 22º40' North and longitudes 88º20' to 88º35' 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) 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 (Raychaudhuri et al. 2008). 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. Sufficient oxygenation is produced to allow for natural elimination of pathogen/ fecal coliform. Thus, reduction of BOD[4] takes place due to a unique phenomenon of algae-bacteria symbiosis occurred through the drawing of energy from algal photosynthesis (Ludwig et al. 1951; Oswald et al. 1953).

c) The solar radiation, which is about 10.46 Mega joule/ square meter 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 percent on an average. This process further helps in the reduction of coli form bacteria up to 99.99 percent (Ghosh 2005).

d) 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[5]. Here the plant roots act as bio-curtains or bio-filters for the passive remediation of wastewater.

4.2 Resource Recovery and Livelihood Practices

Waste recycling in the 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. When the sewage arrives in the pond network through the inlet channels, it is kept standing in the sun, resulting biodegradation of the wastes through an algae-bacteria symbiosis. In fact, retention of wastewater in the ponds before the initial stocking of fish

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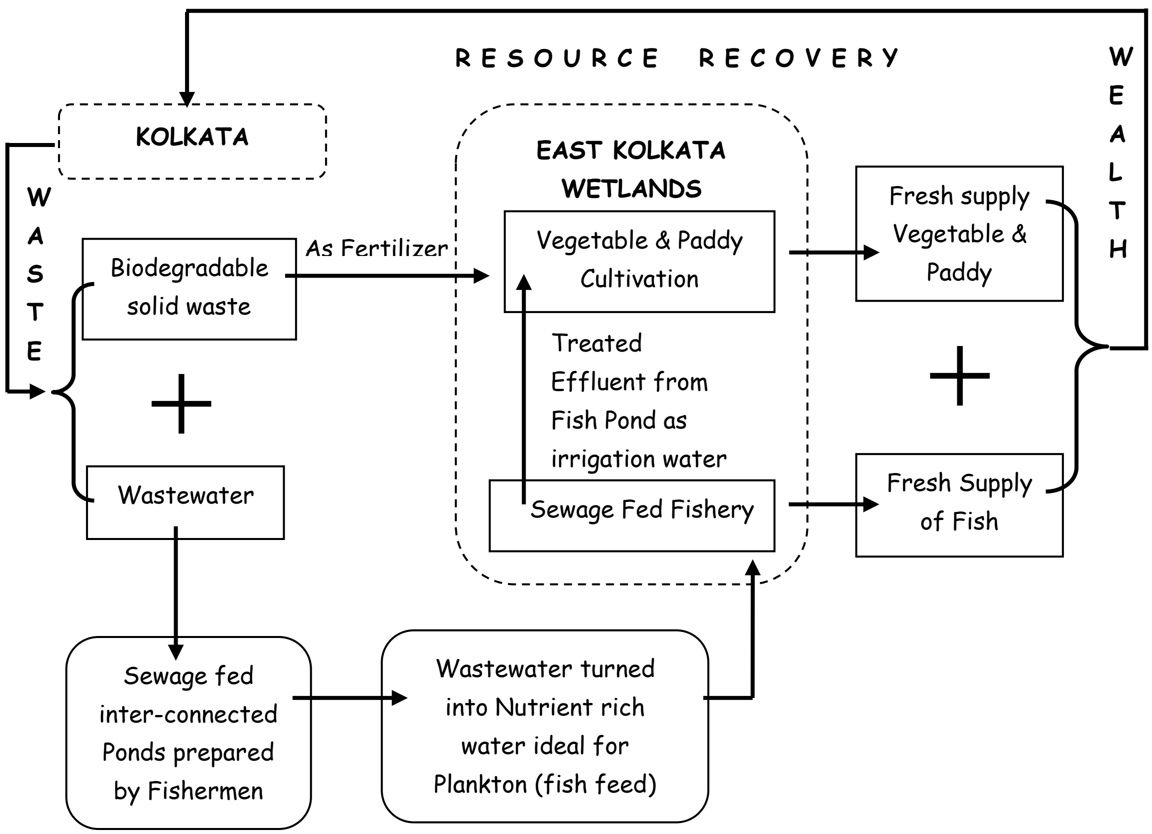
[4] BOD: Biochemical Oxygen Demand

[5] Rhizofiltration: A process in which the plant roots are used to absorb pollutants, mainly metals from water and aqueous waste stream;

for a considerable period of time allows bacteria to work upon the organic waste. The growth of these beneficial bacteria (plankton) is supported by the algae that thrive in these shallow ponds under the ample sunshine. However overgrowth of the planktons becomes a problem for pond management 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. Double dividends are generated through simultaneous attainment of natural purification of waste water and substantial production of fresh water fishes like Indian Major Carps, Silver Carp, Grass Carp, Common Carp, Tilapia, Nilo-tica etc.

The fishermen 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 (Dey & Banerjee 2013a). A series of ponds are needed sequentially for different stages of production: egg pond, nursery pond, rearing pond, stocking pond and harvesting pond, each requires proper inlet and outlet channel management, mostly controlled by natural gravity. The fish farmers of the 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 the EKW was of the order of 18,000 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. On the whole, this resource recovery practices in the EKW provide livelihood support to nearly 0.2 million people (Wetland International 2008). This system of waste recovery is illustrated in Chart 1 showing the complementary relation between Kolkata and the EKW through waste-wealth interconnectedness.

Chart 1. Resource Recovery Practices in the EKW



5. VALUE OF ECO-SYSTEM SERVICES PROVIDED BY THE EKW

The city of Kolkata enjoys a subsidized service of wastewater treatment as well as low cost supply chain of fresh fish, vegetables etc. and the EKW is enjoying traditional livelihood options through wise-use-practices. This section will discuss the **enumerable** benefits derived by Kolkata by saving its municipal cost of treating wastewater and enjoying supply of fresh food at an affordable price. It will also indicate the **non-enumerable** benefits, both actual as well as potential, in terms of provision of other eco-system services.

5.1 Enumerable benefits from EKW

5.1.1 Cost Saving from Sewage Treatment

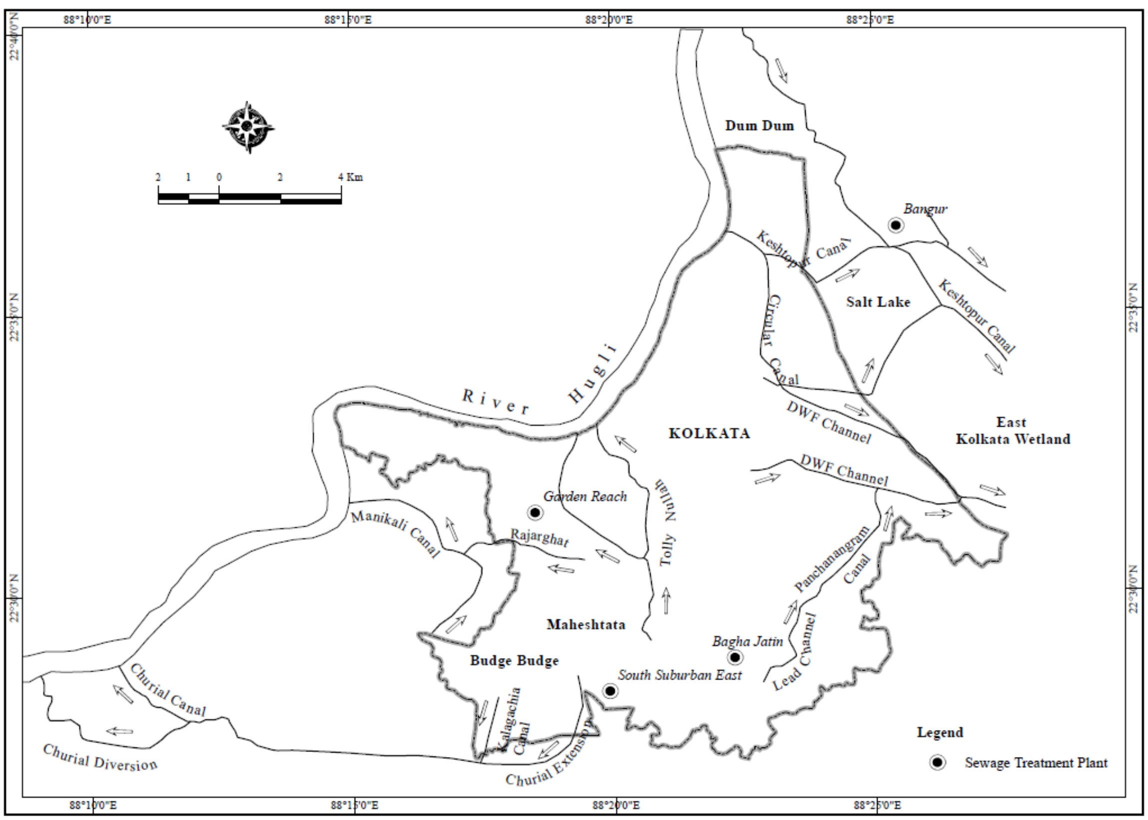
An account of the volume of city sewage since 1875 is reported in Bose 1944 and the situation in 2011 is taken from a document prepared by the Centre for Science and Environment, New Delhi, India. The volume increased from merely 68 MLD[6] in 1875 to 590 MLD in 1943 and further to 1,112 MLD by 2011; i.e., an increase of 2,802 ML per year on an average. Only 50 percent of the city population is covered by sewerage network, which covers 55 percent of the city area. Length of sewerage network is 1,610 km of which 180 km is brick sewer line and the rest is

[6] MLD: Million liters per day;

piped sewer line. Till the initiation of the Ganga Action Plan (GAP) in 1985, there was no mechanical sewage treatment facility available in Kolkata[7]. Under GAP, three Sewage Treatment Plants (STP) were set up in the outskirt of the municipal limit of the city at Garden Reach, Cossipore-Chitpur (Bangur) and in South-Suburban (East) respectively, with total planned treatment capacity of 122.5 MLD. The first two have started working since the end of 1990s and the third one is yet to be commissioned. Another STP has been planned to be set up in BaghaJatin by Kolkata Municipal Corporation (KMC) with a meager capacity of 2 MLD, which has not start functioning yet (see Map 2).

An opportunity cost of this natural treatment facility available for nearly 80 percent of the city sewage can be estimated by extrapolating information from the annual budgetary provision of the municipal authority on Sewerage and Drainage (SD); the Kolkata Municipal Corporation (KMC) has to meet expenditure on the running of the STPs, those of the pumping stations, maintenance of the underground pipelines (1,430 km) as well as the brick sewage (180 km). The responsibility of the up-keep of the canals (261 km length) is vested with the Irrigation and Waterways Department. So, if the EKW fails to bear this burden in the near future, the additional cost commitment for KMC has been assessed below.

Map 2. Location of Sewage Treatment Plants in Kolkata (CSE 2011)



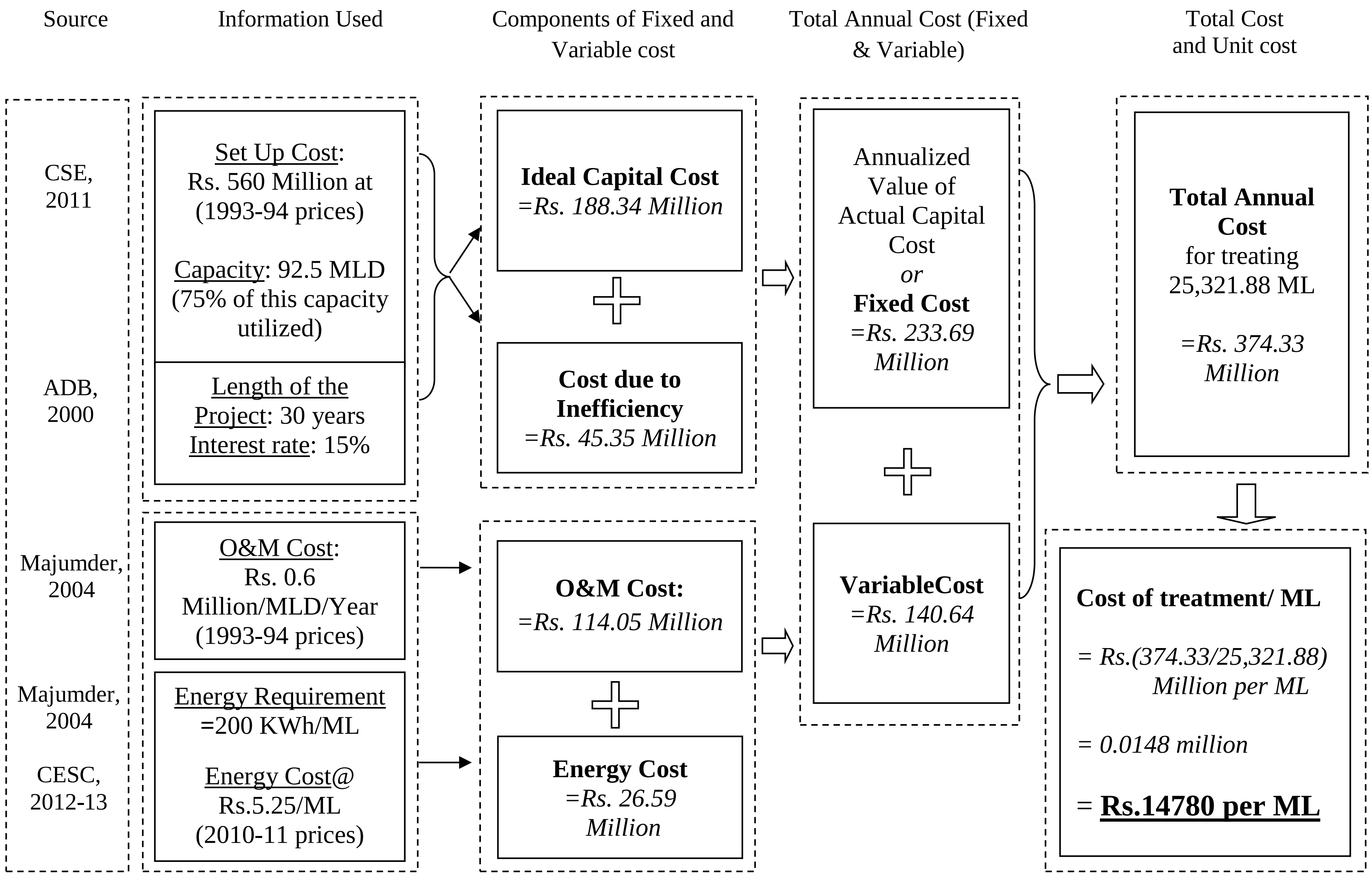
[7] In fact, the river Hugli is the downstream of river Ganga and, hence, cleaning up of Hugli water also came under the purview of GAP.

The treatment of sewage through installation of STPs can be estimated by using information on the annualized value of the fixed cost and the operation and maintenance cost. The per unit fixed cost depends on (a) set up cost, (b) length of the project and (c) the plant-load-factor given by the actual use. Direct information on the set up cost was available for the Garden Reach STP and given the technological similarity of the STP with that in Bangur, in the absence of any information on the set up cost of the later the information available for the former is used as a proxy. The length of the project is taken as 30 years and the information on the actual volume of water treated is taken from the report of Central Pollution Control Board (CPCB), which is the source of information for operation and maintenance cost also (CSE op. cit.; CPCB 2003). The detailed steps followed are summarized in Chart 2.

The estimated cost of treatment for 1 ML of sewerage is Rs. 14,780 or about USD 247. This annual cost of treatment for total sewage of the city, i.e., 405,880 ML would be about Rs. 6,000 million/ year which is equivalent to USD 0.1 billion[8]. Since the EKW is treating 78 percent of that in a natural process, it is providing an annual ecological subsidy of Rs.4680 million to the city of Kolkata (Dey& Banerjee 2015a). The budgetary allocation of KMC on Sewerage and Drainage in 2012-13 was only Rs, 1693.9 million. This is supposed to be utilized for (a) running of the STPs, (b) running of the pumping stations (60 in number, KMC website), (c) maintaining the drainage pipeline and (d) partial maintenance of the canal network. According to the CPCB document (2003), the annual cost incurred by each pumping station is Rs. 0.2 million at 2000-01 prices. So, after suitable price adjustment for inflation, the current commitment for operating the pumping stations would be Rs. 20.80 million. This will leave nearly Rs.1.50 billion for maintenance of the 1610 km long drainage line which is already facing severe clogging problem due to sedimentation and silt. In the absence of this support service from the EKW, the financial provisions appear utterly inadequate and the opportunity cost of this decay of the EKW would be enormous for the city (KMC Budget 2012-2013).

[8] $1.00 is approximately equal to Rs.60.00.

Chart 2. Opportunity cost of Sewage Treatment in STP (Dey& Banerjee 2015b)



5.1.2 Benefits Related to Food-chain and Livelihood

Besides sewage treatment services the EKW provides a number of other benefits to the city of Kolkata by supplying fish, vegetable and other primary products at a very reasonable and affordable price. The city is further generating 4,460 MT of solid waste per day and 95 percent of this is getting disposed at Dhapa dumping ground which is operating as a open dump since 1867 (Furedy, 1987). The people of the EKW are using this waste as manure in producing agricultural products through their ingenious resource recovery practices. The fisheries in the EKW are producing 18,000 MT of fish, vegetable farms are producing 50,000 MT of fresh vegetables and the agricultural lands are yielding 15,000 MT of winter paddy each year. The region thus plays a critical role in ensuring food security of the state accounting for 22 percent of paddy and 44 percent of fish production of the state (KEIP 2013). Moreover, the pisciculture, agriculture, horticulture, floriculture and other related vocations are providing livelihood to nearly 0.2 million of people, who are using the Nature creatively by developing some eco-friendly wise-use practices.

5.2 Non-enumerable benefits derived from the EKW

Besides this direct supply of consumables, the other (unpaid) eco-system services provided by the EKW are related to its ability to control flood, absorb excess Green-House-Gases (GHG) from the air through carbon sequestration, supply clean air to the residents of the city of Kolkata through natural air purification, the use of this eco-system as a natural laboratory for carrying out state-of-the-art experiments on different biotechnological prospects, the potential to develop open space for the city dwellers to be used as walking-trails, entertainment parks and so on.

5.2.1 Flood Control

The low lands of the EKW are storage reservoirs absorbing a major flow of excess rainwater runoff through its storm-water flow channel (SWF) and protecting the city from frequent monsoon flooding. However, what is remarkable is that this area, which is sparsely inhabited by the fish producers, vegetable farmers and agriculturists, has not seen any floods in the last 30 years regardless of the intensity of rain or quantum of flow of water into the wetlands. The water holding capacity of the ponds increase in the monsoon season. The average increases in depth of the ponds during the monsoons range from 10 to 15 cm. which is indicative of the amount of excess water, that each of the fisheries could hold. In addition, a large number of water outlet channels to divert excessive water have been designed by the local residents of the area, which contributes greatly towards averting floods (Sarkar 2002).

5.2.2 Carbon Sequestration[9]

Carbon sequestration in aquatic ecosystems is related to the process of photosynthesis of phytoplankton and algae on the water surface. The energy for the process is supplied by sunlight. Photosynthesis involves the removal of carbon dioxide (CO_2) from the atmosphere and the conversion of that carbon into organic material (carbohydrates) for plant growth and development. Sequestration is the difference between carbon gained through photosynthesis and carbon lost through respiration (Preuss 2001). The potential for carbon sequestration of a water body is related to several intrinsic factors including location, climate, bio-diversity, type of water etc. While the EKW are better known for their socio-economic potential, they support several species of flora and fauna as well. Of the bio diversity of aquatic and vascular flora in permanent or seasonal freshwater systems in India, south of the Himalayas, the EKW support 51.5 percent of diversity at the family level[10]. There is a lot of potential to increase the floristic diversity, which could also be put to commercial use, but little has been done on this front by the concerned authorities. However, there is a potential "cost" of the EKW as a carbon source. Studies have found an average methane emission rate of 29 $mg/m^2/hr$ for specific soil samples from the paddy fields (Chattopadhyay 1994). Also there is a potential for methane emission from the soil around the fisheries though no conclusive evidence is available so far for considering this emission level asa threat. Moreover, it must be kept in mind that the amount of carbon sequestration is directly dependent on the quantity of bio-mass, and the EKW has tremendous potential of increasing this through planting fruit trees. This would not only earn revenues, but also will counter generation of methane and enhance bio-diversity, which contributes to global warming (Raychaudhuri et. al.2007).

5.2.3 Lungs of Kolkata

The EKW is generally referred to as the lungs of the city of Kolkata. When air flows over a water body, the relative humidity of the air increases and water droplets are aerosolised into the air stream. Both the humidity and the presence of water droplets in aerosol form in the air have an important role to play in capturing particles, and removing them permanently from the air stream. In 1996 air samples were collected during the winter months from the Dhapa dumping ground located within the EKW and a village site immediately downwind and the SPM concentration in the air has found to be reduced by 67 percent (DISHA1996). This is indicative of the cleaning efficacy of humidity in the air, a benefit that all residents of Kolkata enjoy round the year.

[9]Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels (https://en.wikipedia.org/wiki/Carbon_sequestration).

[10]The EKW has high fin fish and molluscan diversity, around 20 mammal species, some rare and threatened reptile species (Ghosh et. al. 2011), mediocre floristic diversity (around 100 different plants) in the core area and low avian diversity (more than 40 bird species), which has been declining over the years (CRG 1997, Kundu et al.2008).

5.2.4 Natural Laboratory

The economic contribution of an ecosystem as a "natural laboratory" is usually measured by evaluating the benefits from discoveries and technological breakthroughs made from the ecosystem. The most significant contribution from the EKW, then, is the development of a low cost pond option as an alternate mode of wastewater treatment (Ghosh 1996). This alternate option has been implemented in three municipalities, viz., Garden Reach, Bangur and South Suburban East, within the Kolkata Metropolitan Area (EIP 1996) under the Ganga Action Plan, which aimed at cleaning the river Ganga by ensuring, among other things, that the waste streams from cities do not add to river pollution. However, it would be short sighted to limit the evaluation of benefits to benefits only to sewage treatment. The wetlands have tremendous potential for further discoveries, particularly in the area of biotechnology. For example, the discovery of an enzyme, which could revolutionise the detergent industry, could increase the value of the wetlands significantly. There are several researchers who use the soil, water and biota of the wetlands for further research. The EKW is unique as a learning ground to understand the ecosystems and their interaction in a location that is so close to the city. This is demonstrated by a large number of serious researchers who have visited Kolkata only to learn more about the EKW.

5.2.5 Open Space and Recreation

The dearth of open space in Kolkata is evident when one considers that the *Maidan* (620 hectares), in the heart of the city, occupies more than 61percent of the city's open space. As the nature of work in the city grows more and more sedentary and general health awareness improves, the demand for open space to stretch one's muscles, while breathing fresh air and letting the eyes relax by observing different shades of green, will increase. An option value of the EKW as a walkers and exerciser's paradise, would be a valuable addition to the cramped city of Kolkata. This may involve some modifications in the existing land with pathways being created around some fisheries, but does not involve huge expenditure.

There are scopes for developing low-cost waterfront recreation facilities in the wetland. At present, Nalban, one of the larger fisheries in the EKW, operates as a leisure cum boating resort operated by Bansilal Leisure Parks Limited for the population in and around Kolkata. The possibility of exploiting water bodies for the combined purpose of fishery and tourism are under-explored. Scope of developing water-front sports and entertainment centers deserves serious consideration. The location of Nalban is ideal, being en-route to the largest amusement park in Kolkata, Nicco Park. Besides, there are several other entertainment complexes in the vicinity of Nalban. Other than Nalban, five other fisheries, namely, ChotoParesh, BoroParesh, Gompota, Doltala and NatarBheri, also have potential to serve as leisure resorts, which provide the city dweller access to noise-free open space, cool air from the water body and boating facilities. These fisheries are all accessible by road and not too far away from Nalban making them ideal places for further development.

All these benefits may not be directly enumerable in monetary units, however, that does not constitute a ground for discounting their immense contribution towards sustainable living. The society can be made to pay for these eco-system services which needs careful assessment of the magnitude of different eco-benefits enjoyed so far as *free goods*.

6. URBAN ENCROACHMENT: CHANGING TOPOGRAPHY

Despite all these benefits, it has been frequently alleged that being located on the boundary of an expanding metropolis, EKW faces constant threats from growth and development of real estate around it leading to a significant change in the pattern of land use, despite legal restrictions. In the face of a growing pressure of spillover population from the city of Kolkata the marshy wetlands are continually getting converted into urban settlements, challenging sustainability of the traditional wetland practices. It is important to scrutinize carefully the available records to assess the extent of change in land-use patterns of the EKW in recent time.

6.1 Growing Population Pressure

According to 2011 Census records the population of Kolkata is nearly 4.5 million and that of Salt Lake City and Rajpur-Sonarpur Municipality are 0.2 million and 0.4 million respectively. Mention has been made of these two townships because they are in the eastern part of Kolkata bordering the EKW and are expanding at a mushroom rate over the years. Between 1981 and 1991, the increase in population of Salt Lake City was 202 percent and between 1991 and 2001 the rise in Rajpur-Sonarpur was 460 percent. So, all the bordering areas of the EKW are already saturated making the wetlands more and more attractive from the land-developers' stand point. From the compilation of available records it has been found that between 2005 and 2011 nearly 10 percent of land of the EKW has been converted from wetland to urban settlement. Improved connectivity via Eastern Metropolitan Bypass and a number of newly built up flyovers are making the adjacent wetland areas easily accessible from the main city and that imposes a real threat to this *waste recycling region*. While environmentalists advocate the preservation of the wetlands, land-speculators are exerting increasing pressure for the right to develop areas for residential and industrial purposes. The wetland is bordered by the city of Kolkata to the West, Salt-Lake to the North-West and the new township of Rajarhat to the North-East. Taken together, these factors are making it increasingly difficult to protect the EKW from developers and real estate agents. Public agencies have also shown a tendency to encroach upon the wetland area for various developmental activities such as locating industries, commercial hubs or public utilities (Kunduet al. 2005).

As a consequence, in the EKW the area coverage under water body is continually declining over time. The first land-use map of this waste recycling region was prepared in 1987 and at that time 49 percent of area was under water coverage. However, by 2011 this percentage dropped down to 36.18 percent. Though this area has been designated as an International Ramsar site in 2002, this land conversion continued even in the presence of certain legal barriers and regulatory vigilance. In 1945 (before the reclamation of land for development of the Salt Lake city) fisheries were spread over 58 percent of area under water and this share gradually waned to 49 percent in 1987 (when the first land use map of this waste recycling zone was officially developed[11]) with a further drop to 47 percent by 1994 (according to the baseline document prepared by the Creative Research Group). In the late sixties about 2430 hectare of fisheries were converted into paddy fields. Cultivation also started on the dried up bed of Bidyadhari river (another 250 hectares of land). At that time a number of water bodies had been vested on

[11]In this document, the term 'East Calcutta Wetlands' was legally equated to the 'waste recycling region' and created some confusion as because the wetland area is more extensive than 'waste recycling region' alone.

government as ceiling surplus holdings and the government eventually distributed those among the marginal farmers. Due to lack of capital investment and capacity to undertake risk, small farmers used these *bheris* mostly for paddy cultivation and in some cases have combined both fish as well as paddy cultivation. This led to a rapid shrinkage of water bodies. The fisheries were mostly converted into agricultural land or settlement.

6.2 Change in Land-use: Evidence from GIS Map of 2011

On the basis of GIS maps of the EKW developed by the PAN Network, three types of land conversions have been identified in favor of urban settlements, viz., (a) from water body to urban settlement, (b) from agricultural field to urban settlement and (c) from open space to urban settlement. It is interesting to note that most of the changes have taken place in *mouzas* where the average sizes of the water bodies are either small or at most medium and is definitely below 8,000 square meters. Table 1 reports the association between average size of water bodies and types of changes in land use pattern.

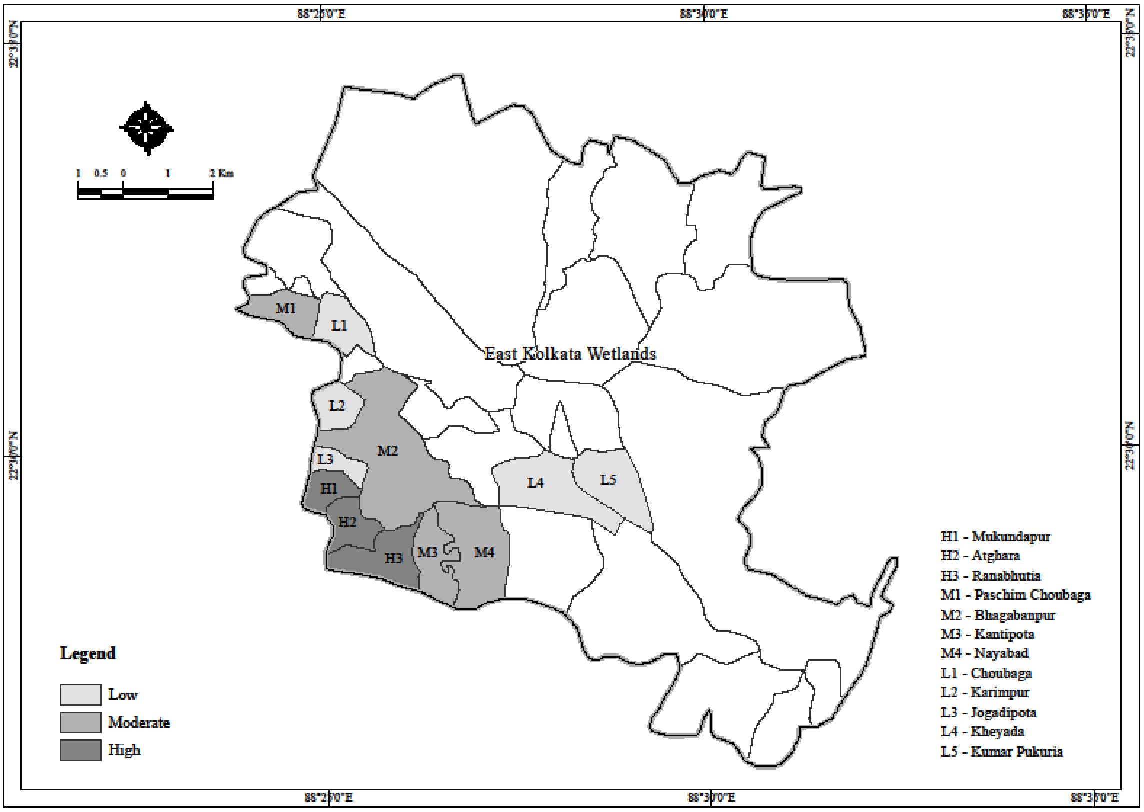
Table 1. Association between the average size of water-bodies and the change in land use (Dey 2012)

	Dimension(s) of change*	Average size of the water body		
		Small ≤30000 sq. m.	Medium (30000 - 80000] sq. m.	Large >80000 sq. m.
Conversion of Wetland into urban settlement	All three (High)	- Atghara - Ranabhutia	- Mukundapur	
	Only two (Moderate)	- Kantipota - Nayabad - Bhagabanpur	- PaschimChoubaga	
	Only one (Low)	- Karimpur - Choubaga - Kheyada	- Jogadipota - Kumar Pukuria	
*Three dimensions of changes are: (i) from water body to urban settlement, (ii) from agriculture to urban settlement and (iii) from open space to urban settlement				

In terms of the pattern of changes we have grouped the relevant *mouzas* into three categories: high, moderate and low change regions[12]. The mouzas in 'high' group experience all three types of changes and those in 'low' group experience change in only one count. The 'moderate' group lies in between. The changes are mostly concentrated in the Western and the South-Western parts which are sharing common border with the city of Kolkata (Map 3).

[12] It should be noted that the mouzas are not classified in terms of extent of change but only the types of changes. In L4 (Kheyada) and L5 (Kumar Pukuria) the extent of change was very low.

Map 4. Pattern of Land-use Change in the EKW (Dey& Banerjee 2013b)



This pattern of land conversion is working against the natural gradient of the EKW and is affecting the efficiency of natural treatment of waste water, obstructing the supply channels of sewage to the fisheries, reducing their natural advantage and down the lane leading to a change in the livelihood pattern of the local people through an interconnected chain of vocational transition. Attempt has been made to thwart this process of land transformation through a series of regulatory checks; however, the conservation of landscape in the core wetland area alone turned out to be inadequate in protecting the delicate eco-balance between the EKW and the city of Kolkata, which is intricately embedded within the synergistic ambience of eco-system services derived from both the locations in an irreversible way.

7. THREAT TO SUSTAINABILITY AND LEGAL INITIATIVES

Conserving the landscape of the wetlands does not necessarily ensure the sustenance of its eco-characteristics until and unless people can retain their dependence on the system for their livelihood practices. In fact the delicate chain of interdependence, once disturbed, will affect the whole system through a multiplier sequence and the initial eco-balance will be almost impossible to regain. The policy makers have partially appreciated this fragility and attempted to protect the core wetland area legally by banning any change in the pattern of land use in the EKW. However, over time the information regarding expansion of the vocational options has become a common knowledge among the local people and they have started showing strong tendency to switch and mix vocations even in the core area. Here the importance of the physical features of the area gets surpassed by the socio-demographic characteristics of the subjects thereby making the legal protection almost futile in nature. This section would explore the actual bottlenecks imposed on the system, change in livelihood profile increasing the severity of the situation, concern of the civil society and the lack of coordination in planning and implementation practices leading to this fiasco.

7.1 Disturbed Ecological Balance

To make the land suitable for urban settlements the first important task is to raise the land by adding more soil into it. If that is done in some parts of the EKW, it is bound to disturb the natural gradient of the wetland which played a crucial role in transporting sewage water from canals to the fish ponds. Moreover, culverts are required to be constructed to develop access roads across canals to connect the new township with the main city. These culverts are obstructing water flows along the canals and leading to an increase in the rate of siltation (KEIP 2010). Though 850 – 900 MLD of sewage is entering the EKW from the city of Kolkata everyday, only 234 MLD is available for aquaculture against the requirement of 869 MLD. Productivity of a fishery mainly depends on the availability of sewage water in the *bheris* (ponds). Due to change in hydrological regimes and heavy silt load in sewage supply, canals have reduced carrying capacity. Heavy deposition of silt in aquaculture ponds also causes bed level to rise and affect natural gradient for waste water supply in fish pond. A survey carried out by Creative Research Group in 1997 indicated that nearly 57 percent of active fisheries were complaining about severe shortage of sewage flow throughout the year and another 24 percent considered it inadequate for most of the year. The situation has worsened since then[13] (Wetland International 2008). To resolve this problem, following the recommendation of the Institute of Wetland Management and Ecological Design (IWMED), the canals were dredged. Instead of solving the problem that has added at least two newer dimensions to it.

Firstly, now the canal bed is deeper than the tank bed and without using motorized pump sets it is not possible to transport sewage water from canal to the *bheris* (ponds). Thus, the process of fish-production has become more contingent on financial affordability than that of traditional knowledge. Though the fisheries are the principal providers of natural sewage treatment facilities, they have very little control over the availability of sewage and the entire system hinges on the supply-side bottlenecks imposed by the city of Kolkata through her sewage management efficiency. This has its follow-up influences on the ecologically balanced wise-use practices that made this wetland ecosystem so unique in nature.

Secondly, the dredged substances extracted from the canal beds are generally dumped along the banks of the nearby water bodies. During rainy season the excess water run-off takes a part of the mud back to the pond and increases its silt-rate. However, digging out the mud is not a very convenient option for the fishermen as that would require postponement of fish-cycle (which is nature determined) or that would keep the pond fallow for one whole season to get back its desirable specifications (which amounts to huge income loss).

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[13] The requirement of sewage for any fishery is estimated by using the formulae $W = (f * d * T/t) * A$, where A: water area of the fishery; T: active period (270 to 300 days, i.e., 9 to 10 months); t: detention time of the sewage (10 days); d: depth of pond (average 1.5 meter); f: dilution factor (0.33); W: Quantity of sewage water required in MLD;

Another important issue is related to the shortage of space for dumping the dredged silt. The Fishermen Cooperative is trying to negotiate with the West Bengal Housing Infrastructure Development Corporation (WBHIDCO) to take responsibility of transporting this sludge and use it as land-fill in the newly developed township in Rajarhat and Bantala area which lie just beyond the boundary of the EKW; however, that negotiation did not materialize till date. A related problem lies in land filling practices adopted by the developers in conversion of low-land into high-land. Generally they are excavating nearby water body and elevating the level of the chosen site. Up to certain level that would help in regularizing the intended depth of the water body used for this purpose. However, excess excavation would increase the depth of it and would make it unfit for shallow water pisciculture. So, that plot would be effectively abandoned and would gradually get converted into another urban plot.

In addition to the increasing gap between demand and supply of wastewater, another problem centers on the intended quality of sewage. As the life style of the people of Kolkata changes the non-biodegradable component in waste is getting increased. So, the desirability of this waste as a source of bacteria-nutrient fish feed and fertility enhancing manure for vegetable farming and paddy cultivation has been questioned by the scientists and social activists (Mukherjee et al. 2013;Aich et al. 2012). So, the fishermen are quite often supplementing purchased feed like leather milk and hotel dust to the sewage. During field visits it is observed that the scrap leather and other tannery wastes discharged by Kolkata Leather Complex in Bantala (situated along the border of the EKW) are boiled, spread on ground for drying, smashed into fine grain and finally packed into bags to be sold as fish feed. Rampant use of such feed is noted in wetland fisheries. In *mouzas* like Hadia and Jogadipota the use of sludge collected from soap factories of Kolkata as fish feed has been noticed. The veteran fishermen opined that this feed would raise the production for a particular season but would ruin the water forever and would make it unfit for further fish-cultivation. They further added that the land cannot be reclaimed either for fishery or for cultivation even after dredging of the pond bed by a foot's depth. Moreover, such excavation would not be permitted by the neighboring pond owners as the rainwater runoff washing that polluted dugout soil would damage other ponds as well. Then the only option left would be to convert this water body into urban land. Thus, the use of non-conventional fish-feed and other deviations from the age-old wise use practices may be influenced by indirect encouragements from the land speculators. A natural fall out of this chemical contamination in the eco-system is changing the profile of the aquatic life. Through the predator-prey food chain affecting the rich bio-diversity of the area (Bhattacharyya et al.2008). Ghoshet al. 2011 observed that, by 2011 there was a sharp decrease in the faunal varieties with an 84 percent fall in avian species.

7.2 Effects on Livelihood Pattern[14]

According to the Management Action Plan document prepared by Wetlands International (2008), 74 percent of the working population in the EKW is drawing sustenance through engagement in fish farming, agriculture and horticulture. The rest of the population seeks livelihood through searching employment within the metropolis and its associated areas. Fisheries related activities include harvesters, carriers, guards, supervisory staffs, unskilled laborers, whole sellers, auctioneers, embankment repairers, and so on. Organic waste based farming involves farm laborer, middlemen and whole sellers. Garbage scavenging is also professionally done by a handful of rag pickers. From a primary field survey conducted in 2001 (Sarkarop.cit.) it was found that more than 80 percent of these people in traditional vocations are engaged in pisciculture and related activities.

To further investigate the occupational pattern on the wetlands a primary survey was conducted by us in 2012. In the sample of 325 responses 110 (33.85 percent) reported engagement in traditional vocations, another 93 (28.62 percent) in modern vocations and the remaining 122 (37.53 percent) in general vocations. Table 2 reports the types of vocations and number of persons engaged in our collected sample.

[14] This subsection draws heavily from Dey & Banerjee (2013b)

Table 2. List of Present Vocations in the EKW (Dey 2012)

Vocation [Persons Engaged]	Sector [Types]	List of Vocation			
Traditional vocation [110]	Agriculture and related [4]	1	Agriculture (on own and other's land)	3	Fruit vender
		2	Agricultural worker	4	Vegetable vender
	Fisheries & related [7]	1	Fishery (Own/Lease/Co-operative Member/*Bheri* manager)	5	Hired labor/ worker at *bheri*
		2	Fish Business/Vender/Auctionnaire	6	Carrying fish/Netting and/or Cleaning/Guarding etc.
		3	Fish Spawn Supplier (*Jhanki*)	7	Fish Feed Making (from Leather scrap)
		4	Making Fish Catching Instruments/Bamboo *pata* & Wooden Parts		
	Others [2]	1	Cowshed (*Khatal*)		
		2	Earthen hut builders (*Ghorami)*		
General vocation [122]	Shops & services [14]	1	Carpenter	8	Beetle Shop (*Pan Bidi*)
		2	Tailor	9	Tea Stall
		3	Bedding Maker *(Dhunuri)*	10	Rice Selling
		4	Salon	11	Petty Grocery (*Dosokorma* Shop)
		5	Laundry	12	Timber Shop
		6	Grocery Shop	13	Gold jewellary shop
		7	Cycle Repairing or Garage	14	Shops (Cosmetics, Bags, Shoe, Watch, Stationary [Monihari], Garments)
	Informal labour [3]	1	Daily labour	3	Plastic waste sorting
		2	Soil excavation		
Modern vocation [93]	Construction related [10]	1	Construction Labour and Helpers of Mason	6	Builders (Business of Brick, Cement, Sand etc Building Materials)
		2	Paris work	7	Hardware Shop
		3	Grill Manufacturing	8	Plumber
		4	Construction Business	9	Electrician/Electric Shop
		5	Land and House Brokers	10	Labour Contractor
	Urban vocations [13]	1	Decorators (Pandel etc. And Interior Decorator)	7	Fast Food Center, Sweet shop, Meat shop and Hotel (for Rice etc. & others)
		2	Housekeeping/ Gatekeeper/ Security	8	Cigar/ Cold Drink supplier
		3	Medicine store and Doctor's clinic (Dentist)	9	CD/Casette Shop
		4	Auto driver	10	Travel Agent (Car Hiring Business)
		5	Driver (Private Cars & Motor Van)	11	Agents (Rose Valley, Insurance Co.)
		6	TV /Radio/Tape Repairing	12	Mobile Recharge Shop
				13	Car Cleaning and Painting
	Other business/ services [8]	1	Furniture Shop	5	Jute Mill Worker
		2	Iron Machine Work (for Cutting and Fitting)	6	Govt. or Other service
		3	Offset Business	7	Worker or Owner Private Company (leather etc.)
		4	Sales	8	Burning Plastic Waste
Total [325]	**Total [61]**				

As per our expectation in the traditional vocation fisheries dominate (22.77 percent of total and 67.27 percent of traditional type) and that again concentrate mostly in the low change area. However, contrary to our expectation concentration of modern vocation is observed in the moderate change area and not in the high change area. Among a few alternative possible explanations the most intriguing one is lying in the definition of general vocations. As has already been mentioned that here we have clubbed different vocations like grocery, eatery, carpentry, tailoring, etc. for which we were not certain about the nature just from their responses. For example, a hair-cutting saloon may vary from a traditional barber's shop to a modern beauty parlor, or a grocery may be a departmental store, a dispensary may be a poly clinic or diagnostic center, and so on. So, what would be a better deciding factor is the length of engagement in this vocation. It is expected that those operating in the area since a long time has not switched into this vocation as a consequence of land use change. Rather they are more close to tradition based livelihood. But the rest is likely to be more urban in nature. As per our expectation in the traditional vocation fisheries dominate (22.77 percent of total and 67.27 percent of traditional type) and that again concentrate mostly in the low change area. However, contrary to our expectation concentration of modern vocation is observed in the moderate change area and not in the high change area. Among a few alternative possible explanations the most intriguing one is lying in the definition of general vocations. As has already been mentioned that here we have clubbed different vocations like grocery, eatery, carpentry, tailoring, etc. for which we were not certain about the nature just from their responses. For example, a hair-cutting saloon may vary from a traditional barber's shop to a modern beauty parlor, or a grocery may be a departmental store, a dispensary may be a poly clinic or diagnostic center, and so on. So, what would be a better deciding factor is the length of engagement in this vocation. It is expected that those operating in the area since a long time has not switched into this vocation as a consequence of land use change. Rather they are more close to tradition based livelihood. But the rest is likely to be more urban in nature.

Thus, we divide the general vocation into two categories and those who are engaged in these trades for more than 15 years are considered veterans and therefore, traditional and those who have joined within last 15 years are considered modern. Fifteen years engagement has been considered as a reasonable cut-off as by that time the pressure of urbanization was strongly felt but the legal barriers were not erected. Out of 122 observations in the general category it is found that 95 respondents have switched vocation over last 15 years. If we consider them to be engaged in modern vocations then the number of respondents engaged in modern vocation would be 188 (i.e., 58 percent) and those in traditional vocation would be only 137 (i.e., 42 percent). This indicates a sharp change in the pattern of livelihood where wetland eco-system and its resource recovery processes guided by the age-old wise-use practices no longer constitute the core of vocational choices.

7.3 Legal initiatives to protect the EKW

The position papers of Calcutta[15] Metropolitan Planning Organization (CMPO)[16] and that of the West Bengal State Planning Board (WBSPB) are evidence of strong objection to the eastward

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[15]British name of the city of Kolkata was Calcutta and, hence, these two alternative names have been used interchangeably in this paper.

expansion of the city since early 60s (Banerjee 2012). Filling up of water body was prohibited under the Town & Country Planning Act in 1979. In spite of that, the Salt Lake City was extended and the Eastern Metropolitan Bypass was constructed on reclaimed wetlands during the 80s, making the core wetland area more accessible as well as vulnerable. The first major resistance came from the civil society in the year 1992. A pressure group called PUBLIC (People United for Better Living in Calcutta) filed a writ petition in the High Court to protect the EKW from urban encroachment and judgment by Honorable High Court ruled in favor protecting this *Waste Recycling Region* from *Developmental* Activities (Dembowski 1999).

In 2006 East Kolkata Wetlands Conservation and Management Bill was passed and 12,571 hectares of land was brought within the wetland boundary. According to this bill not only any new construction within the EKW will be severely penalized but all existing constructions within this area would have to be demolished with immediate effect. In spite of these legal barriers the attempt to encroach has become a perennial problem for the EKW and the East Kolkata Wetlands Management Authority (EKWMA) was formed under the provision of the East Kolkata Wetlands (Conservation and Management) Act, 2006 to resist these violations. However, till date there is no compelling reason to believe in the effectiveness of these regulatory interventions.

Comprehensive planning would combine both internal as well as external approach where the internal one will try to protect the intrinsic strength of the EKW and to correct its weaknesses whereas the external approach will put control over the development and management projects taken up by the city of Kolkata to tap opportunities much better and moderate threats to sustenance imposed on the eco-system. Hence, the following section will place the case of EKW in a SWOT framework for identification of critical aspects essential for sustainable management and planning of the eco-system.

8. SWOT ANALYSIS OF EAST KOLKATA WETLANDS

The eco-system complementarities between the city of Kolkata and the EKW were evolved through a rare co-incidence of a number of natural conditions. Together with the innovative mind of local people, the natural advantages have been put together at their best use of resource recovery practices. This unmatched combination between the city and its Eastern fringe is the inherent strength of the system. The eco-dependence has created a number of opportunities of eco-system services in both enumerable and non-enumerable form. In spite of having such a remarkable balance between the two systems the major weakness of the area lies in 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 break down. In fact the delicate chain of interdependence, once disturbed, will affect the whole system in a multiplier effect and the initial eco-balance will be almost impossible to regain. Existing legal provisions to protect the landscape alone have failed to approach the problem in a comprehensive perspective. Injudicious land use practices and encroachment into the wetlands are threatening the sheer existence of this delicate eco-balance. Table 3 tried to address this issue in a SWOT structure in order to comprehend the eco-system in a holistic frame.

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[16] Later merged with Kolkata Metropolitan Development Authority (KMDA);

Table 3. SWOT Analysis of East Kolkata Wetlands

	Favorable	Unfavorable
	STRENGTH	**WEAKNESS**
Internal	the factors contributing to the strength of this wetland are (i) West-to-East natural gradient of the city of Kolkata; (ii) Hot and humid climate of the region with sufficient rainfall and ample sunshine; (iii) Shallow ponds interconnected through proper inlet-outlet channel spread over wide space; (iv) Rich bio-diversity; (v) Innovative mind; (vi) Rare correspondence between waste water treatment and sewage fed fishery;	the major weakness of the area lies in (i) Fragility of its eco-balance; (ii) Inadequate institutional arrangements to protect use rights (bio-right) of the dependent population; (iii) Lack of awareness in appreciation of this eco-system services; (iv) Indifference of the authority to make the users pay for eco-system services; (v) Absence of integrated approach towards wetland management;
	OPPORTUNITY	**THREAT**
External	The comprehensive development of the area creating opportunities for, (i) Costless natural treatment of wastewater from a metropolitan city making the EKW a tutorial eco-system; (ii) Adopting innovative production practices and marketing strategy strengthening connections with retail supply chain; (iii) Other option values can be explored in a) controlling flood; b) carbon sequestration; c) scope for bio-technological research due to presence of a diverse range of species; d) open(green) space for eco-tourism related activities; (iv) Generation of electricity from non-conventional sources like trapped methane gas in the dumping ground;	the major threats come from (i) Urban encroachment affecting natural gradient and changing the topography; (ii) Ill maintenance of sewage channels raising leakage between desired redistribution of supply of sewage from Kolkata and demand for waste water for sewage fed fishery in EKW; (iii) Weak administration, (iv) Lack of coordination among different nodal agencies; (v) Myopic urban planning of the city of Kolkata without paying much heed to the sustenance of the city caused by the eco-system services derived from the EKW;

Since the EKW is a naturally evolved system with a very delicate but unique and effective internal balance, the strength of the system would be preserved best if it is left undisturbed. The fragility of the system can be protected to certain extent by adopting more comprehensive approach to urban planning whereby not only the spillover population from greater Kolkata would be accommodated here but that will be done under the commitment of protecting eco-balance of the existing system. It has to be ensured that the urban constructions will not obstruct the flow of wastewater in the region, the gradient of the connecting feeder channels will be maintained and the silt removal practices adopted at the canal, channel and pond level would be properly synchronized.

The sewage management practices and the urban development projects of Kolkata have also some definite role to play in this regard. It is observed in this paper that the age-old waste management practices and infrastructure in Kolkata are not much efficient; there is a lot of scope to improve operational efficiency for cost reduction and to guarantee smooth and timely flow of wastewater to the EKW for profitable fish-cultivation as well as organic waste based farming. The non-performance here is affecting the profit prospect of the fishermen and cultivators and a clear tendency has been observed for switching to modern vocations by leaving the traditional livelihood practices. Thus, the external interventions are influencing adversely the internal confidence on the system. The resistance and intervention from the civil society is not always adequate to revive this confidence and the main reason behind that futility lies in the lack of integrated planning where the problems of the city of Kolkata and those of the EKW are to be considered in conjunction without losing focus of the eco-system complementarities. If any one of the systems is considered in isolation then the planning and intervention would be lopsided and ultimately the decay of the delicate eco-system would be inevitable in the near future.

9. COORDINATION FAILURE

The regulator is enacting different legal provisions for the protection of land-use pattern, which are creating confusion among the local people and in the absence of strong political will nothing is getting enforced with appropriate thrust. There is not much coordination between the Kolkata Municipal Corporation (KMC) and the Kolkata Metropolitan Development Authority (KMDA), where the former relies on the EKW for cost-free natural treatment of wastewater and the latter is in charge of urban development and planning. In fact multiple stakeholders (e.g. KMC, KMDA, HIDCO, NGOs, Fishery co-operatives, local residents, eco-tourism developers, real estate agents, and wetland institutes like IWMED, EKWMA) with their own specific agenda are not in harmony and confront each other at times. This complicated web of associations among stakeholders can be perceived as a classic example of coordination failure, which has been delineated in Table 4. Lack of understanding and transparency is constraining the system in achieving its intended sustainability. Everyone is contemplating corrective moves from his/ her own perspective and in the process the retarding influences on others nodes are passing unnoticed. Though the East Kolkata Wetland Management Authority has evolved to manage this complex and challenging issue, the institution does not enjoy any statutory power till date to ensure effective coordination. The effective intervention and related design of implementation mechanism on the part of the designated High-Powered Committee on the conservation of the EKW is yet to claim any strategic presence. Two alternative agenda of urban planning like wastewater treatment and urban growth are apparently lacking compatibility in a holistic frame. Of course, time is still young to take any conclusive position in this regard.

Table 4. Identification of Stakeholders and the Coordination Problem

Body	Perspec-tive	Dept./ party	Purpose/ Responsibility	Challenge	Instrument	Problems
Govt.	Public Management	Irrigation & Waterways	Maintaining Canals which carries the sewage water into the wetlands	Maintenance	Routine Govt. Budget	Dredging done for main canals only, smooth flow of wastewater *(input in fishery)* into branch canals hampered.
		KMDA	Decentralized planning & development across the urban and rural areas	Development	Planned Expenditure	Planning did not take the sewage management issue that may arise from urban invasion into the wetlands
		HIDCO	Plans and executes development projects in the entire Rajarhat Area, Kolkata, West Bengal			Urban Expansion at an immediate vicinity i. changed the landscape ii. Stakeholders of EKW Ramsar conservation site in no way received benefits of New Kolkata Township, either by selling out their property or in terms of getting improved urban amenities.
		Panchayat	Pivotal agency for unleashing Comprehensive Rural Development	Local governance	West Bengal Panchayat Act, 1973	Non-specific
		KMC	Manage wastewater of Kolkata		West Bengal Municipal Act, 1993	KMC has no administrative power i. to maintain canals and sub canals ii. to protect fishery based livelihood, crucial wastewater treatment. No sufficient financial provision for sewage treatment available so far.
	Wetland Management	EKWMA	Maintain the existing land use practices along with its unique wise use practices (According to Ramsar Guidelines)	Conservation and Protection	East Kolkata Wetlands (Conservation and Management) Act, 2006	Lack of Statutory power to stop land conversion
		IWMED	Carrying out studies related to wetland functions & its ecology, wetland mapping etc.	Awareness building	Documentation & Research	Carry out research only, no role in protection
- G	vil Soci	NGO	Mobilization of Local	Conservation &Resistance	Awareness	have some opinion regarding the conservation

		Local Residents	Awareness at Grass Root Level	Conservation and Protection	camps and formation of local groups	issue, however the legal authorities can take action in 'curative' way not 'preventive'
Economic Group	Income Generation	Local Residents	Livelihood Protection	Protection of Private Property Right	Enhanced transparency in documentation	Newer generations not inclined to traditional livelihood are keen on sale of protected land though illegal means.
		Fishery co-operatives	Siltation & Lease Renewal	Stop land filling & ensuring profitability of fishermen	Cooperative resistance	Irregularities in registration procedure
		Real Estate Dveloper	Land Conversion & Acquisition	land filling, changing signature of landscape & profit earning via sale of protected land	Illegal means	Land transfer & sale of land, which is apparently protected area.
		Eco-tourism	Commercial Interest by Protecting the Landscape	Prevent land filling & siltation in respective eco-tourism hubs	Promotion of waterfront activities	Only the landscape can be protected, however protecting *'wise use'* in aholistic manner is not possible.

CONCLUSION

The impression that we have gathered from the foregoing discussion is that the EKW is about to lose its ecological integrity, which mainly refers to the long-term health of the system in terms of interactions among the physical, chemical and biological elements of the eco-system, creating favorable social conditions for sustaining ecological basis of human life. Here none of the stakeholders are approaching the problem from an integrated, comprehensive perspective. The Civil Society is expressing concern over protection of wetland, where that step alone would be insufficient for the conservation of the entire eco-system.

To carry out more intensive investigation in this area for coming up with specific policy suggestions one needs to study the precise effect of this aggressive urban growth on the livelihood pattern of the local residents in the EKW. For that the first requirement would be to collect information on the pattern of time-use of the local people and to list the types of activities undertaken by them. These activities can further be classified as traditional and modern according to their degree of connection with agriculture and allied activities and relatively more urbanized ones. This will help us to study the path of transition in vocational choice, if any. How the residents are gradually switching to the relatively more urbanized vocations and how the different socio-economic as well as demographic factors are playing strategic role in influencing this choice. If traditional activities lose their attractiveness due to eco-degradation then the push factor will lead to the vocational transition. If urban development opens up alternative vocational options then pull factors will be active. So, the ultimate impact will depend on the combined strength of these push and pull factors. Since no corner solution is observed, the final effect is not subject-neutral. This aspect, if properly approached, would help us to identify the most vulnerable group in this entire game and not only economic, but distributive impact of local development policies on specific social and economic classes could also be explored.
Another interesting but related aspect would be the process of transition within traditional activities themselves. As more and more water bodies would be converted into land, a gradual transition from water-linked vocations to land-linked vocations would be noted. However, in such situation there would be contraction of sewage-fed fisheries and the eco-balance of the natural treatment would be affected. So, economic incentives should be designed to encourage people to retain their original livelihood pattern. If the regulators are aware of the comprehensive impact of these aggressive urban developments, then to nullify the negative influences, incentives should be designed to make the traditional practices more rewarding. Their exchange values in the market may not be that high in terms of skill-intensity, but their shadow prices are definitely very high in terms of their contribution to retain ecological balance and natural sustainability.

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