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Ecosystem Services for Disaster Risk Reduction: A Case Study of Wetland in East Delhi Region, India

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Abstract

Ecosystem services are the benefits that societies receive from the nature. These may be in the form of regulating, provisioning, supporting or cultural services. Wetland being one of the most productive ecosystems provides these services at no cost. These ecosystems also contribute to reducing disaster risk by serving as natural protective barriers or buffers and, thus, mitigating hazard impacts. But many such wetland ecosystems are tremendous stressed due to anthropogenic pressure. Wetlands on the fringes of river channels in the city are looked upon as a resource for different land use planning. The capital Delhi manifests all the ills that a river system (Yamuna) can possibly face, made the city more vulnerable and disaster prone as evident from frequent incidences of flood, water crisis and disease outbreak. Rapidly increasing urbanisation with limited integration of values and functions of floodplains in developmental planning has led to their fragmentation. This study is an attempt to assess the present state of ecosystems, its services particularly in reducing the risk of water and climate related disasters like flood, drought and epidemics in East Delhi and part of National Capital Refion

Index terms—

1 I. Introduction

etland ecosystems are crucial to our natural wealth. They provide us with services worth trillions of US dollars every year entirely free of charge making a vital contribution to human health and well being **??**Ramsar Convention, 1971). Wetlands are one of the most productive ecosystems of the world which along with supporting unique flora and fauna provides range of ecosystem services **??**MA, 2005). Wetland ecosystems contribute to reducing disaster risk by serving as natural protective barriers or buffers and thus mitigating hazard impacts (Gupta & Nair, 2012). Well managed ecosystems can provide natural protection against common natural hazards, such as landslides, flooding, wildfires, storm surges and drought (Rieux et al., 2009). Ecosystem decline increases Disaster risk both by reducing the ability of an ecosystem to act as a natural buffer, as well as by reducing people's resilience by reducing their bases for a) Ecosystem Services of Wetland Natural systems are humanity's "life-support system" providing essential "ecosystem services" for existence and socio-economic well being **??**MA, 2005). Decline in ecosystem services influence the resources available to the people and, hence, lead to increasing vulnerability to hazards, and thereby decrease their resilience against disasters. The conservation and restoration of ecosystems such as forests and wetlands plays an essential role in reducing disaster risks such as flood, drought and storm (Wetland International). The Fourth Assessment Report of IPCC (2007) while reporting about the increased frequency and intensity of disasters due to climate uncertainties, suggested for strengthening ecological systems as part of adaptation and mitigation strategies **??**IPCC report, 2007).

Ecosystem services are the benefits that individuals and communities obtain from ecosystems. These include "regulating services" such as regulation of floods, drought, land degradation and disease, along with "provisioning

services" such as food and water, "supporting services" such as soil formation and nutrient cycling, and "cultural services" such as recreational, spiritual, religious and other non-material benefits (Table 1). Integrated management of land, water and bio resources promotes conservation and sustainable use. This provides the basis for maintaining ecosystem services, including those which contribute to reducing disaster risks. Restoring wetlands on crop fields resulted in a net increase of ecosystem services in the Mississippi Alluvial Valley in US including green house gas mitigation, nutrient mitigation and waterfowl recreation and therefore net benefit to the society (Jenkins et al., 2010). Wetlands consist of characteristic assemblages of species that interact with each other and their environment. Some coastal ecosystems including mangroves forests, coral reefs and salt marshes, help to reduce the risks associated with coastal hazards such as storm surge and coastal flood. Such ecosystem also provide a host of associated services which may be lost if natural systems are replaced by built structures (McIvor et al., 2012). A study conducted by the scientists at the University of Delhi and Duke University has shown that coastal villages in Orissa with the widest mangrove belts suffered fewer deaths as compared to those with narrower belts or no mangroves in the devastating Super Cyclone of 1999 (Das et al., 2009). The interactions within and between the biotic and abiotic components of wetland ecosystems provide various ecosystem services to the human society. Some of the ecological functions provide direct economic benefits whereas others provide indirect support and protection to an economic activity. The State of Louisiana has adopted policy guidelines for using natural wetlands to assimilate nutrients in secondarily treated municipal effluent, thus utilizing ecosystem services of natural wetlands. In addition to water quality improvement, wetland assimilation provides additional ecosystem services, including increased vegetative productivity, surface accretion, and carbon sequestration (Young KO Et Al., 2012). The floodplain wetland system provides several ecosystem services, key being regulation of hydrological regimes, groundwater recharge, water quality improveement, support to biodiversity and life support system, effective in flood control, waste water treatment, reducing sediments loads, low input sustainable agriculture, fisheries development, tourism and valuable for educational and scientific interest and recreational benefits. River floodplains have been reported as potential sites to mitigate extreme events in the hydrological cycle (Mitch et al., 2000).

Wetland ecosystems are under tremendous pressure due to various anthropogenic activities. Notwithstanding the high value of the ecosystem services that wetlands provide to humankind, wetlands continue to be degraded or lost due to the effects of agricultural intensification, irrigation, water extraction for domestic and industrial use, urbanisation, infrastructure and industrial development and pollution **??**Russia et al., 2013). Wetlands on the fringes of river channels in the city are looked upon as a resource for different land uses. Studies show that the value of converting Thai mangroves to shrimp farms, draining freshwater marshes for intensive agriculture in Canada, and operating unsustainable fishing practices on coral reefs in the Philippines, was between 60% and 75% lower-in the long term-than the benefits from wetland conservation and sustainable use (www.ramsar.org). Wetland ecosystems of Yamuna river corridor in Delhi are one such live example. The capital city faces all the ills that a river system can possibly be faced with (Yamuna Jiye Abhiyan, 2007) and made the city more vulnerable and disaster prone.

Under the UNDP's Disaster Risk Management Programme in India, Disaster Management Plans were developed. However, these plans focussed primarily earthquake and fire hazards and on structural interventions. Non-structural interventions are limited to training, awareness generation and interventions focusing on ecosystems have been lacking. Since Delhi is predominantly urban ecosystem approach for livelihood resilience and disaster mitigation has not received attention in the past.

This study is an attempt to assess the role of wetland ecosystem in East Delhi and the services provided by these systems. An analyses of ecosystems role in reducing the risk of water and climate related disasters like flood, drought and epidemics has been undertaken.

2 Global Journal of Human Social Science

Volume XIII Issue IV Version I Delhi, the capital city of India lies between 28.380 N and 77.120 E in latitude and longitude respectively. The River Yamuna (Figure 1), a major tributary of Ganges, is one of the key natural infrastructures of Delhi city. The total length of the river in the city is 50 Km between its entry at Pala and exit at Raipur. Its floodplains extends to an area of 94.84 km2comprising forests, agriculture land, settlements and lakes/ponds and can hold lot of water-about 2 billion cubic meters. The maximum width of the active floodplain is observed near Okla. where a large quantum of water is brought through Hindu cut. Despite high urban stress, the floral diversity of the floodplains is rich including 74 species of macrophysics and 90 species of phytoplankton. Faunal diversity encompasses 62 species of zooplankton, 55 species of benthos, 36 fish species and 131 bird species (wetland International-South Asia).

Delhi region has suffered major floods during years **??**924, **??**947, **??**967, **??**971, **??**975, **??**976, **??**978, **??**988, **??**993, **??**995, **??**998

3 Methodology

the wetland. Transect walk as suggested by de Zeeuw (2004) helps understanding natural resources, present land use pattern, vegetation, changes in the physical features and cropping systems, etc in villages, and public resources, land use, social differentiation and mobility in urban communities. A questionnaire based survey was

carried out to have perception of communities living on the fringes of wetland on disasters faced by them and ecosystem services provided by the wetland. Experts view (academicians, ecologist, practioners, and bureaucrats who are versed with the study site) on the integration of ecosystem services and DRR were also taken. Scoring was done (on the basis of number of hazards addressed by one ecosystem service) for analysing the ecosystem services and DRR aspects addressed and based on the scores importance were attached as high (4-5), medium (3) and low (<3). In this study five is the highest score.

4 a) Ecosystem services of wetland of East Delhi

The availability of water near Okhla throughout the year helps to maintain minimum water level required for functioning of the floodplain. The surplus water during monsoon percolates down and helps to control floods and maintain moisture regimes during lean period. Bioaccumulation of key nutrients in floodplain helps to reduce pollution stress, and thereby, leading to development of rich biodiversity habitat. Okla. Bird Sanctuary (notified in 1990 by UP Govt.) situated in Gautama Buddha Nagar is rich in avifaunal diversity and presently inhabits more than 145 bird species include 22 species of resident water birds, 44 species of resident terrestrial birds, 43 species of migratory water birds and 26 species of terrestrial migratory birds. The sanctuary covers rich aquatic, semi-aquatic and terrestrial habitat where more than 25 species of aquatic plants, 110 species of terrestrial plants including herbs, shrubs, climbers, grasses and trees have been recorded (Divisional Forest Officer, Gautama Buddha Nagar, UP, 2012). Table 2 provides the list of some of flora and fauna of the region respectively. Tourism has increased in the sanctuary including foreign tourists. The park is adding considerable revenue to the district. From November, 12 to March, 13 the income generated from the park was approximately nine laths Indian rupees. Communities residing in the floodplain derive their basic needs like water for drinking, irrigation and domestic purposes from the floodplains of Yamuna. For drinking purpose hand pumps are available and water depth is found to be 10-15ft. Bore wells are used for irrigation. Agriculture and labour are the sources of livelihood of the communities. The floodplain is very fertile and supports lots of cultivation of vegetables, horticulture and floriculture. Vegetables commonly grown are beans, cauliflower, cabbage, bottleguard, lady's finger, onion, potato, spinach, corn and bitter guard. It was surprising to find out that cultivators used urea, diammonium phosphate (DAP) and other chemical fertilizers in their fields. Community didn't complain about diseases caused by water. However, dengue outbreaks have been reported after monsoon and floods in the entire city.

The key services from the wetland ecosystems in East Delhi are as follows: In 2010, the city witnessed one of the worst floods due to heavy rainfall. The flooding was gregarious due to the development within the natural course of the river. Yamuna water entered Delhi after being released from Tajewala and Hathnikund barrages up North, the water had lesser area to accommodate itself on the floodplain since a chunk of the floodplain-the size of the Commonwealth Games Village-was no longer available to the river that earlier remained for centuries.

5 (Source: Yamuna jiyeAbhiyan)

As evident from the figure 2, the bed in the west between the ring stream has been lost due to construction and developmental activities. A tour through the Yamuna flood plain gives the glimpse of encroached wetland. Indraprastha thermal power plant was established on the bank of the river to discharge waste generated directly into the flowing water. Memorials of our several leaders and politicians had been built in the floodplain between Nigambhod Ghat and Rajghat. Millennium Bus Depot (Asia's biggest depot) which was constructed during Common Wealth Games remained flooded for almost three months in 2010 because of no drainage system. Ironically, it happened just before a month for games to commence.

6 Ponds, near Bahaullah drain have disappeared due to bridges and flyovers and have now been converted into parks full of water hyacinths showing atrophic condition.

The important lung space of the city has been lost converting it into heat island.

Many marginalized communities depend upon the ecological services provided by the wetland to meet their day to day requirements (table 3) and figure **??**. species diversity and also the duration of stay of migratory species has lessened. The reason is non availability of tree species for nesting and food. The species that have not been sighted in the sanctuary from last 5-6 years are paradise flycatcher, Egyptian vulture and great spotted eagle.

Unplanned urbanization has drastically altered the drainage characteristics of natural catchments by increasing the volume and rate of surface runoff. Drainage systems are unable to cope up with the increased volume of water and are often encountered with the blockage due to indiscriminate disposal of solid wastes. Twenty prominent sewage and drainage system that carries the untreated loads of in and around Delhi is increasing the vulnerability of the sanctuary. Total quantity of sewage generated in Delhi is around 2,871 MLD whereas the capacity of sewage treatment plant is 1,478 MLD only. The figure clearly indicates that 1,393 mld of untreated sewage is directly discharge into the river (Source: wetland International-South Asia). Table 4 reveals role

of floodplain in addressing various hazards and in disaster risk reduction. Disaster Recovery Plans are in place prior to hazard events that accelerate disaster recovery. engage communities in the recovery process and minimize impacts/ Ecosystem approach to DRR is widely advocated as second paradigm shift in disaster management, as it directly links with the livelihood of the people and sustainability of their resources (Gupta, 2012). This calls for emphasis on natural resource management, ecosystem services, land-use and adaptation to climate change within the strategies of disaster prevention, preparedness and post-disaster relief and recovery process (India's National Policy on Disaster Management, 2009, section 5.1.6). Most of the floodplains have been encroached for developmental projects. However, there are opportunities available for developing ecosystem approaches for reducing disaster risks due to climate change in Delhi and nearby areas. Table 5 presents an effort to assess and rate the ecosystem services in DRR framework.

7 Opportunities and Challenges of Integrating Ecosystem Approach in Disaster Risk Reduction

Table 5 shows that each of the ecosystem services addresses one or more DRR aspects. Out of 14 ecosystem services by the wetland of East Delhi four are highly important (E1R, E7P, E9P and E11S), one holds medium importance (E8P) and rest are of relatively low importance. The scoring and importance attached does not discourage the other ecosystem services provided by the wetland rather it gives the priority for such services that can be integrated in the DRR framework. The YAP I launched in 1993 addressed the issues of pollution control and integrated development of river system. The main components of the plan include interception, diversion and treatment of sewage, low cost sanitation, river front development, construction of electric crematoria, forestation along the riverbanks and community participation. With inception of YAP II and leaving aside the present political issues, YAP could be seen as one of the opportunities and platform for key management interventions with the support of Government of India.

Environment Impact Assessment of development projects: EIA is an anticipatory mechanism for assigning quantitative values to the parameters indicating the quality of environment before, during and after a major activity, project or incident, thus allowing measures to ensure ecological compatibility and economic efficiency in decision making. EIA, in pre disaster prevention and mitigation phase helps in precise decisions regarding planning risk reduction and choices of mitigation methods, technology and locations for activities.

Alternate power generation: Renewable energy (hydro and solar) usage should be increased to lessen the loads on thermal power plants. Government should subsidized and support renewable energy resources. Weeds in and around wetland can also be used in generation of befouls, lot of research can be taken on this topic.

8 Restriction on indiscriminate withdrawal of groundwater:

Indiscriminate use has led to over extraction of the groundwater over past few years. Yield of deep aquifer has decreased due to increased demand of water and blooming of tube wells. There is a need to regularise on groundwater usage from deep aquifers as rate of discharge is not equal to rate of extraction.

Legislations and its enforcement: India is one of the leading countries in the world in terms of environmental legislations and policies but enforcement is very poor. Sound implementation will help to check the ecosystem degradation by putting ban on negative environment practices by human beings.

Awareness generation and community involvement: Awareness generation programme at school level and also involving community at large will bring about attitudinal change regarding the conservation and protection of environment. Role of higher education and research institutions in promoting awareness is equally important besides the policy environment for facilitating a more sustainable approach.

Mainstreaming disaster management plans: Ecosystem approach cannot be looked in isolation and needs to be mainstreamed with disaster management plans at policy level because challenges of water, climate-change and increasing pressure over the finite land have intricately woven the natural geoenvironmental processes to aggravate and turn into disasters.

Corporate Social Responsibility and self responsibility: Corporate should come up with an approach to take ECODRR as an initiative for protecting environment and contributing in sustainable and inclusive growth of the country. Similarly onus lies on each and every citizen and take responsibilities towards disaster free India and should not only depend on Government schemes and programmers.

Further Research: Researches on why the river morphology of Yamuna is changing at some places can be undertaken to have more holistic understanding of the floodplain behavior.

9 VI.

10 Limitations and Challenges

The Integration of ECODRR approach has also certain limitations. Following are the key points: ? Infrastructures have already been developed on the floodplain, and, hence major chunk of wetland has already been encroached.

11 Conclusion

Wetlands on the corridor of Yamuna are rapidly diminishing due to anthropogenic activities and have become one of the most threatened ecosystems. Pressure for conversion of wetlands for developmental purposes is very high especially in case of urban riparian wetlands. These wetland ecosystems provide many tangible and intangible benefits on a sustainable basis not only to the urban society but also to the associated dependent ecosystems. River floodplain can be consider as a tool for mitigation of flood waves or extreme low only if a management and structure respect this natural function **??**Pithart et al., 2007). Recognizing the importance of wetland ecosystems, the National Environment Policy of India (NEP, 2006) contains an unambiguous assertion of the need for a holistic view of wetlands, which looks at each identified wetland in terms of its causal linkages with other natural entities, human needs, and its own attributes. The ecosystem approach to disaster risk reduction advocates for sustainable ecosystems management as strategy to reduce exposure and vulnerability, through hazard mitigation or regulation as well as enhancement of livelihood capacities and resilience.

12 VIII. Acknowledgements

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1

Figure 1: BFigure 1 :

[1]

[2] Ecosystem Services for Disaster Risk Reduction: A Case Study of Wetland in East Delhi Region, India

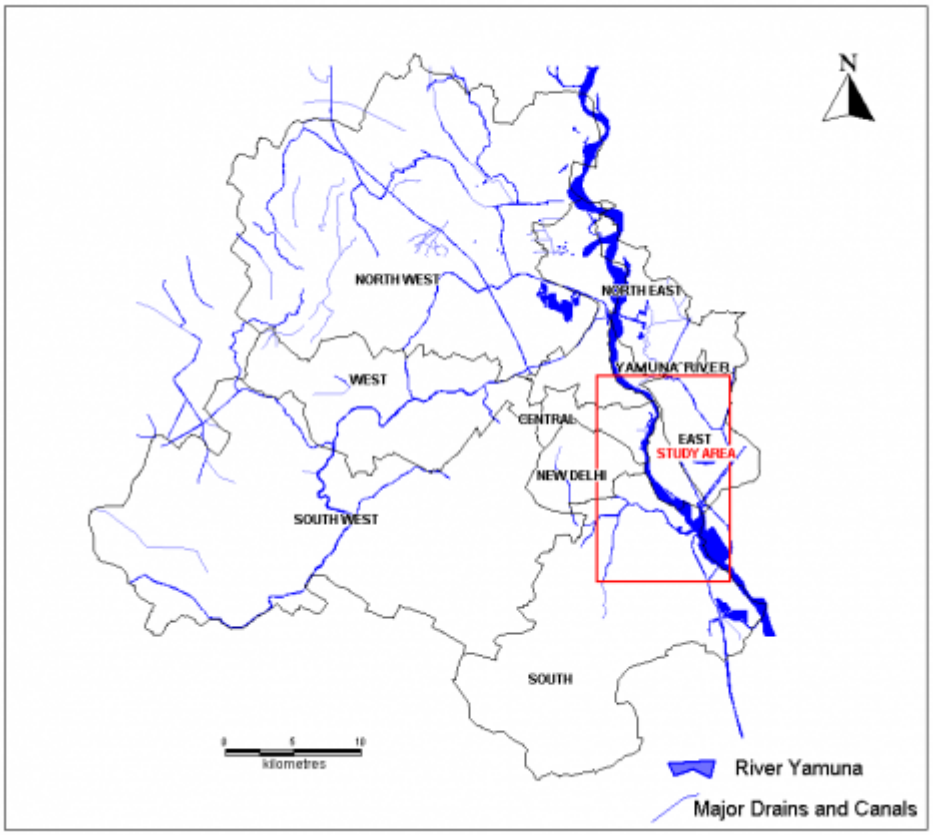
N
NORTH WEST
NORTH EAST
YAMUNA RIVER
WEST
CENTRAL
EAST
STUDY AREA
NEW DELHI
SOUTH WEST
SOUTH
kilometres
River Yamuna
Major Drains and Canals

Figure 2:

Figure 3: BFigure 2 :

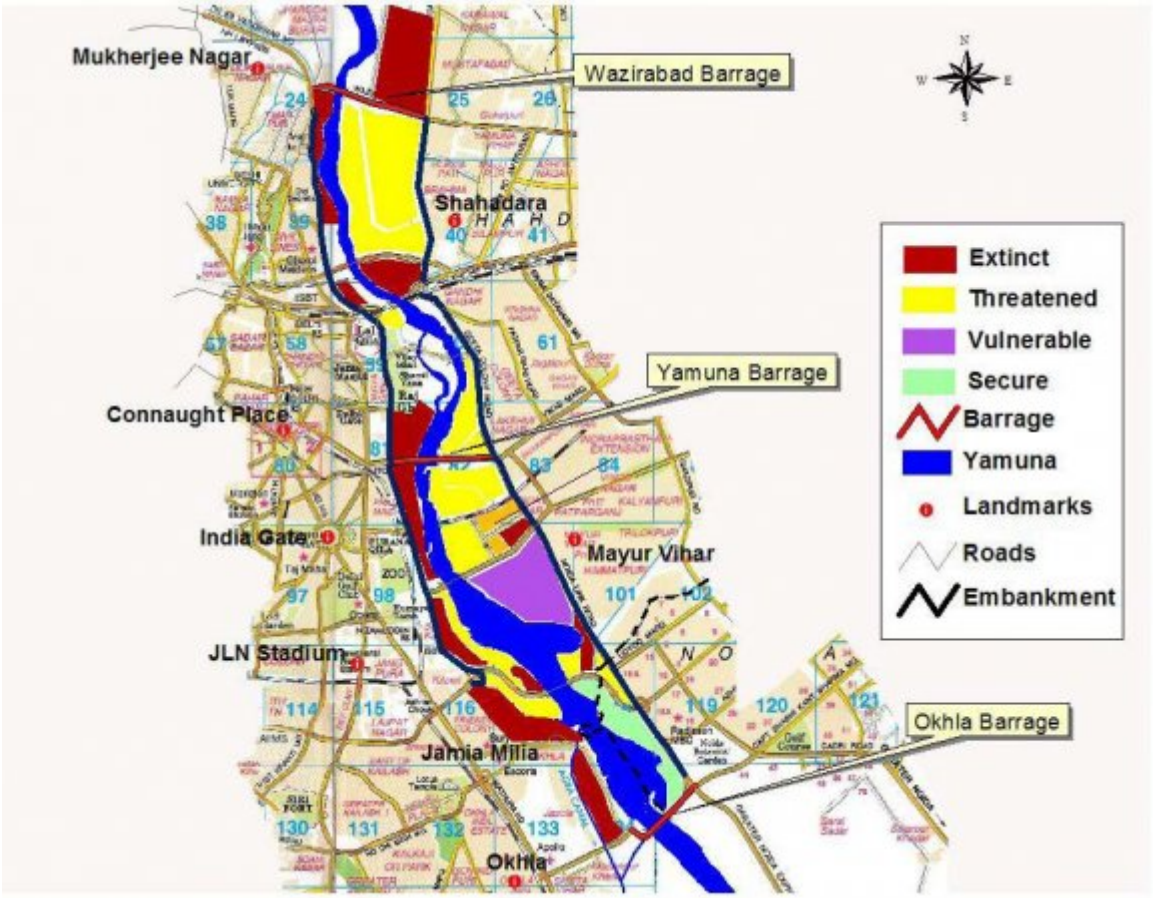
Mukherjee Nagar
Wazirabad Barrage
Shahadara
Yamuna Barrage
Connaught Place
India Gate
Mayur Vihar
JLN Stadium
Okhla Barrage
Jamia Milia
Okhla
Extinct
Threatened
Vulnerable
Secure
Barrage
Yamuna
Landmarks
Roads
Embankment

Figure 4:

Cattle Egret a residential Bird of the Okhla Bird Sanctuary

Typha grass used by the villages for thatched roof and making mats

Water Hyacinth used as organic Fertilizer and bio-fuel

Vegetables and Fruits gown in the flood plains

Shallow aquifers in the flood plains serves as a source of potable water ,domestic use and agriculture

Control Floods and addresses water scarcity by storing excess water

Figure 5:

1

Services	Comments and Examples
Provisioning	
Food	production of fish, fruits and grains
Fresh Water	storage and retention of water for domestic, industrial, and agricultural use
Fibre and Fuel	production of logs, fuelwood, peat, fodder
Biochemical	extraction of medicines and other materials from biota
Genetic materials genes	for resistance to plant pathogens, ornamental species, and so on
Regulating	
Climate Regulation	source of and sink for greenhouse gases; influence local and regional temperature, precipitation, and other climatic processes

Figure 6: Table 1 :

2

Fauna	Flora
Pavo cristatus	Argemone Mexicana
Columbia livia	Calatropis procera
Paser domestica	Commelina benghalensis
Cercomola fusca	Tribulus trestis
Culicicapa ceylonensis	Eclypta alba
Luscinia svecica	Azolla pinnata
Megalaima zeylanica	Phyla nodiflora

Figure 7: Table 2 :

	Ecosystem Services		Explanation
			Regulating
	E1	Storing excess water during heavy rainfall	Safe passage of excess waters in the city
Year	E2	Ground	Source of surface and ground water which is much needed to
2013	E3	water	meet the city's growing needs of water for domestic, industrial
	E4	recharge Disease regulation Carbon Sequestration	and uses. Helps in control of water borne diseases Act as an essential carbon storage and thus help in climate change mitigation
2	E5	Shelter	Provides a potential shelter belt against advancing land degra-
20	E6	belt	dation Regulates thermal currents in the city where summer
2		Thermal	temperatures are today
42		regulation	
Volume	E7	Livelihood	becoming unbearable with every passing year in the context of
XIII	E8	Support	climate change and global warming. Provisioning Production
Issue	E9	Fisheries	and sell of vegetables and fruits like water chestnut, lotus root,
IV		Water for	green vegetables are key means of sustenance particularly for
Version		drinking,	slum dwellers Hardy and tolerant fish species found in the river
I		domestic	stretch except in upstream of Wazirabad barrage where still
		purpose	major and minor carps are found The fish species found are
		and	rohu, katla, mrigal, channa, singada etc. Source of drinking
		irrigation	water to major part of the city. Also provide water for irrigating crops Supporting
D	E10	Support	Vegetation such as water hyacinth and different grass species
D		heavy	like Typha,
D			
D			
)			
(		nutrient load	Phragmites carca, Lamphrophyla etc. are found that take up nutrients
Global	E11	Sediment	received from the nearby drainage and thus help in controlling
Jour-	E12	retention	water pollution Organic fertilizers are made from the water
nal	E13	and accu-	hyacinth after processing. Also bio fuels by briquetting have
of	E14	mulation	been made. Cultural Okhla Bird Sanctuary in Gautam Buddha
Hu-		of organic	Nagar provides a source of recreational activities. More than
man		matter	145 species are reported from Okhla out of this about 50% are
So-		Recre-	migratory birds, 36% are resident birds and rest are vagrant
cial		ational	sightings. A variety of both native and exotic species of plants
Sci-		Educa-	are found in the sanctuary Source of formal and informal
ence		tional	education and training, Many school children visit the bird
		Aesthetic	sanctuary along with researchers and scholars. Wetland provide scenic beauty

[Note: BEcosystem Services for Disaster Risk Reduction: A Case Study of Wetland in East Delhi Region, India]

Figure 8: Table 3 :

4

	Addressing Hazard	Comments
H1	Flood	Addressing flood hazard by means of spread and passage of flood waters during the monsoon every year and exceptional floods once every decade or more (1978, 1988, 1995, 2010).
H2	Epidemics	Addressing epidemics like dengue and malaria
H3	Drought	Addressing meteorological drought in the capital by supplying water for irrigation during lean period
	Reducing Vulnerability	
V1	Physical vulnerability	Reducing physical vulnerability by providing buffer to build in infrastructure like irrigation system, municipal water supply, sanitation and drainage by checking land degradation both to the people as well as of the ecosystem
V2	Economic vulnerability	Reducing economic vulnerability by providing stable source of income from fruits, vegetables and fisheries
V3	Livelihood vulnerability	Reducing vulnerability of local people who are dependent on wetland for their livelihood like vegetables and fruits along with addressing issue food security. Also reducing vulnerability of the people who are dependent on fisheries for their livelihood support
V4	Environment Vulnerability	Reducing environmental vulnerability by checking water scarcity, providing suitable environment for fish breeding, taking nutrient loads from the drainage system etc. around the city.
	Increasing Capacity	
C1	Governance	Strengthens knowledge and policy environment which in turn helps strengthening governance and hence increasing the capacity to address disaster in a holistic way. It helps traditional DM professionals and engineers recognise DRR benefits of ecosystems
C2	Society and economy	Communities are engaged in diverse and environmentally sustainable livelihoods resistant to hazards.
C3	Land use management and structural design	Effective land use and structural design that complement environmental, economic, and community goals and reduce risks from hazards.
C4	Risk Knowledge	Leadership and community members are aware of hazards and risk information is utilized when making decisions.

5

	Ecosystem Services	DRR aspects addressed	Scoring	Importance
E1R	Storing excess water during heavy rainfall	H1, V1, C3,C5	4	High
E2R	Ground water recharge	V4	1	Low
E3R	Disease regulation	H2	1	Low
E4R	Carbon Sequestration	V4	1	Low
E5R	Shelter belt	V1	1	Low
E6R	Thermal regulation	V4	1	Low
E7P	Livelihood Support	V2, V3, V4, C1, C2	5	High
E8P	Fisheries	V2, V3, V4	3	Medium
E9P	Water for drinking, domestic purpose and irrigation	H3,V1, V4, C3	4	High
E10S	Support heavy nutrient load	V4	1	Low
E11S	Sediment retention and accumulation of organic matter	V1, V4, C1, C3	4	High
E12C	Recreational	C1	1	Low
E13C	Educational	C4	1	Low
E14C	Aesthetic	V4	1	Low

Note: R, P S and C stands for regulating, provisioning, supporting and cultural services of ecosystem respec
a) Opportunities of integration of ecosystem services in
DRR aspects and interventions
Yamuna Action Plan (YAP):

Figure 10: Table 5 :

VII.

Figure 11:

[Secretariat and Gland] , Ramsar Secretariat , Gland .

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