

Impacts of urbanization and encroachments in urban wetlands: A case study of Ganga riparian wetlands of the city of Patna

Abstract

Urbanization is the increase in the proportion of people living in towns and cities due to the migration of people from the rural area. The development in urban areas causes wetlands loss of more than 60%. In fact, urbanization is an inevitable trend of human society, and necessary for modernization. At the same time, it has a severe impact on the wetlands ecosystem. Wetlands were estimated to occupy around 8.6 million sq. km, which is 6.4% of the surface of the earth, out of which about 4.8 million sq. km are found in the tropic and sub-tropic regions. In the 19th century, it was found that approximately 50% of the world's wetlands are lost. Some of the major anthropogenic activities leading to loss of the wetlands are urbanization, drainage for agriculture, and water system regulation. The construction and development activities due to urbanization like excavation, filling, draining, and so forth, are the major destructive methods resulting in a significant loss of wetland spatial extent. The wetlands are under tremendous pressure and need effective measures for their rejuvenation. This present study enumerates the different causes and impacts of urbanization on wetlands by taking the example of Patna's urban character.

1. Introduction

Wetlands are characterized by the interaction between the terrestrial system and the aquatic system. The wetlands could be considered as the world's most productive ecosystem. Wetlands provide many functions and services within local watersheds along with economic values in communities. Indeed, the Wetlands offer habitat for numerous birds and other wildlife and provide recreational opportunities. The wetlands ecosystem changed a lot in watershed due to the effects of urbanization.

The health of urban wetlands can be recovered in terms of water quality by eliminating pollutants, reducing flood damage by checking and storing excess water coming from flood and insulating shorelines from erosion through absorbing storm surges. Urban reformation applies remarkable effects on the architecture and operation of wetlands, chiefly through modulating the hydrological and sedimentation regimes, and the dynamics of nutrients and chemical pollutants. Multiple investigations have reported the fading of indigenous species in urban settings (Faeth et al. 2005; Clergeau et al. 2006). Environment of urban areas can also promote the infiltration of invasive species, which further add up to loss of indigenous biodiversity (Shochat et al. 2006). A lot of changes in the wetlands ecosystem is due to change in the watershed and effects of urbanization.

1.1 Impacts of urbanization on wetlands

The urban wetlands, whether coastal, riparian, or lacustrine estuarine, the impacts are caused due to intervention in its watershed. Firstly, the creation and evolution of wetlands are repressed by hydrological cycle. The living and chemical properties of wetlands are impacted by hydrological regimes, Hence the process of production and convergence of runoff altered significantly in the watershed of urban areas. This results in the degradation of wetland's function on runoff regulation and maintenance of ecosystem productivity. Secondly, there are a large number of pollutants including sediment loadings, heavy metals, nutrients, bacteria, and so on in urban surface runoff, which cause an important impact on the wetlands water environment, aquatic organisms, and wildlife habitats. The urban reformation also minimizes the aboriginal species of the plants and enhances newly introduced species of plant. Moreover, the drinking water can be polluted and then causes health problems in humans. Thirdly, urbanization induced climate change that impacts hydrology of wetlands, quality of water, hydrological cycle, energy balance, biogeochemical cycle, plant species, and the ecological operation of wetlands (Zheng, 2008).

1.2 Direct impacts on urban wetlands

The direct impacts can be considered as the activities that are directly located on-site of wetland area. These could be land-use change from wetlands to non-wetlands activities, agriculture, construction activities, encroachments, dredged filled or drained, solid waste disposal, water, and soil water disposal grazing, industrial waste disposal, water transport, tourism activities, etc. All the activities increase sedimentation, hence affect the depth of wetland or main waterbody, which increases flooding in urban areas. The activities like wastewater disposal, use of fertilizers in agricultural practices increases eutrophication which is a form of water pollution. It fosters the proliferation of algae (algal bloom) and other plants in the water, after overcrowding crops up and these plants species compete for sunlight, oxygen and space. The definition of the eutrophication can be given as the mechanism by which a waterbody achieves a high level of nutrients, particularly phosphates and nitrates. This initially promotes aquatic plant growth, but later plants disappear leaving the stage to algae blooming. When the algae die and decompose, elevated amount of organic matter and decaying microorganisms diminish the available oxygen in water, inducing the death of other organisms, such as fish. The activities, such as grazing also affect habitat loss of floral and faunal biodiversity (Figure 01). The collection of wetland products like fish, lotus seeds, water chestnuts, etc. also increases direct pressure on wetlands, hence disturbs the wetlands ecosystem. Taking account of a cultural and religious point of view, the immersion of idol or other religious offerings also degrades the aesthetic value and increases sedimentation.

1.3 Indirect impacts on urban wetlands

Indirect impacts are caused by increased stormwater and pollutants generated by urbanization within a wetland’s contributing drainage area or watershed area that stress the wetland ecosystem community. It is caused mainly by non-point sources of pollution due to different activities in an urban watershed. Since the wetlands are often placed at the low point of topography of a watershed, they are frequently influenced by activities in upland areas. The indirect impacts could be through carrying of pollutants by a surface flow of stormwater to main wetland streams, pollution of wetlands water through pollutants entering through biogeochemical cycles. The population density in the urban watershed of wetlands also caused decreased recreational activities and tourism activities in wetland sites, impacting disturbance in migratory and local birds. As wetlands are known for biodiversity in terms of migratory birds, the impact of urbanization also decreases the total number of birds visited.

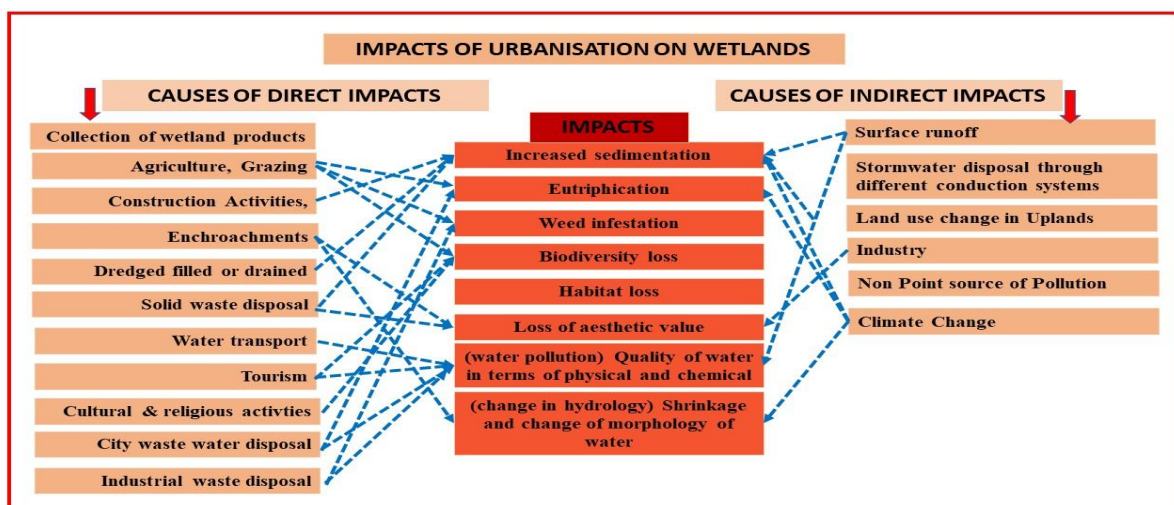


Figure 1: Impacts of Urbanization on Urban Wetlands

Source: Barman, 2020

2. Methodology

The methodology adopted for the study is a literature study, site visit, and analysis. The observational data is collected in the form of notes, photographs, and drawings. The collected data is analyzed and correlated with literature studies.

2.1 The study area

Patna is the capital and the largest city of Bihar with cartographic co-ordinates as 25.6°N 85.1°E, with a mean elevation of 174 ft. (53 m). The population of Patna was 1.68 million in 2011, which makes it the 19th most populous city in India. Patna is one of the earliest dawn of civilization in term of tradition and history. The modern city of

Patna is located on the South of Ganges. The city is approximately 35 km (22 miles) in length and 16 to 18 km (9.9 to 11.2 miles) wide. The important feature of the geography of Patna is the location at the junction of the rivers; it has a slender strip of slightly high land around 8 km in breadth along the South of Ganga and has very productive soil and alluvial arable plains in the remaining portions. The Ganga river, in Patna, has meandered and migrated northwards in the Patliputra area (Sahu and Saha, 2014). This migration has resulted in the deposition of the earth on the south [right] bank of the river and created a massive space of a few hundred hectares between the line of urban reformation and the operating river passage. The detailed study area is selected a riparian wetland stretch of Ganga in the city of Patna. A detailed study has been conducted in a stretch in the urban fringe of Patna city which is also proposed for riverfront development under smart city mission.



Figure 2: River Ganga in Patna

Source: Google Map

2.2 Observations and analysis

The city of Patna is spread alongside the river Ganga from west to east. Through its course of time, the river edges have been developed in Ghats due to religious and cultural impacts. The city beautification projects including the construction of Ganga Driveway, bridges, Ghats, etc. have been coming up as a result of urbanization. The stretch of the Ganga in Patna has never been considered as the part of Riparian ecosystem. Due to urbanization and development projects taking up in Patna Ganga Riparian, wetlands are in tremendous anthropogenic pressure and degraded conditions. The area around the stretch of Ganga river and its southern bank of Patna is mostly surrounded by government institutional buildings, residential buildings, convention, public halls, market areas, colleges, transport transit points, and commercial markets. The linear stretch of riverbank has transformed the adjoining urban fabric in a similar fashion of linear low-rise development. The Bans Ghat, Buddha Ghat, and collectorate Ghat are 3 places of public activity while the rest stretch is bounded by different public institutions and few residential areas. There are many direct and indirect causes of impacts of urbanization. There is also unauthorized development of colonies along the bank near the Bans Ghat and Collectorate Ghat

which are polluting the environment of the river. The floristic survey of the proposed site witnesses scattered growth of grasses (mainly weeds), rooted hydrophytes, emerging hydrophytes, shrubs in an undisturbed area where human movement is absent and trees leaning over river water. Commonly seen shrubs and grasses are Congress grass, Lantana, Eipatorium, Solanum, and Datura. This is mainly due to better survival rates, higher seed production, and fast-growing in comparison to other herbs. The species of grasses reported along the banks are Cyanodon dactylon, Achyranthes aspera, Saccharum sponticum, Vetiveria zizanoides, Ludwigia parviflora, Rungia repens, etc. These are primarily documented above the water level, in an unperturbed area. Rooted hydrophytes are reported along the banks, where the water level is less than a foot of water has receded after flooding.

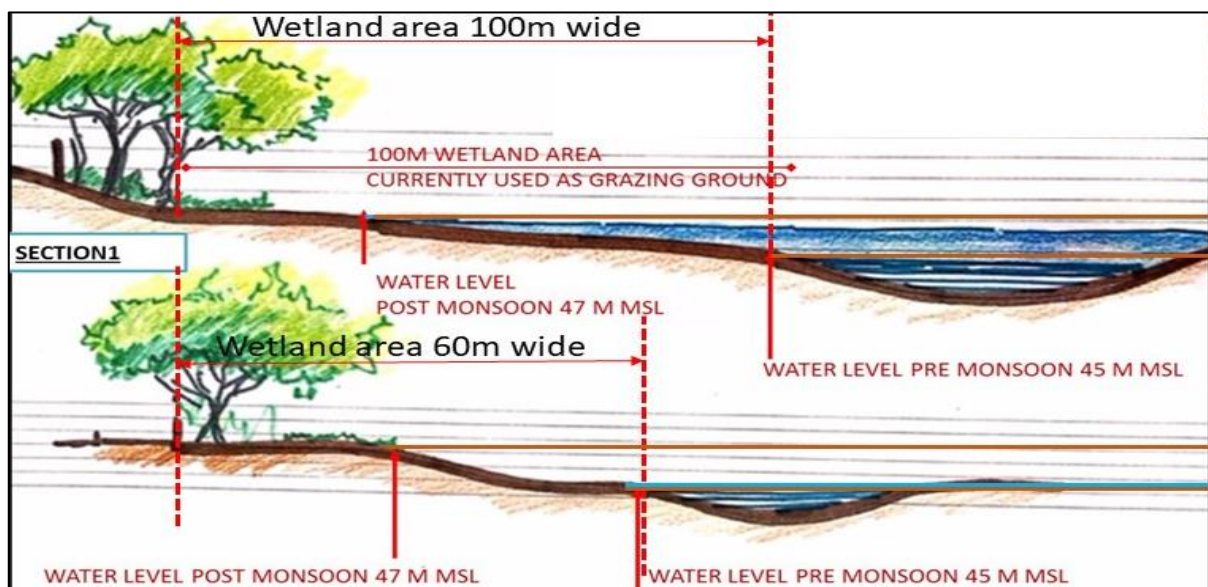


Figure 3: Wetland distribution of Patna, Sections at different stretches of Study Area Bans Ghat to collectorate ghat

3. Results

3.1 Direct impact of urbanization in ganga riparian wetlands

The main direct causes of Impacts of Urbanization in Patna are basically land-use change, religious and cultural, massive construction activities of both ghats and encroachments, grazing, agricultural activities, solid waste disposal, waste and sewer water disposal.

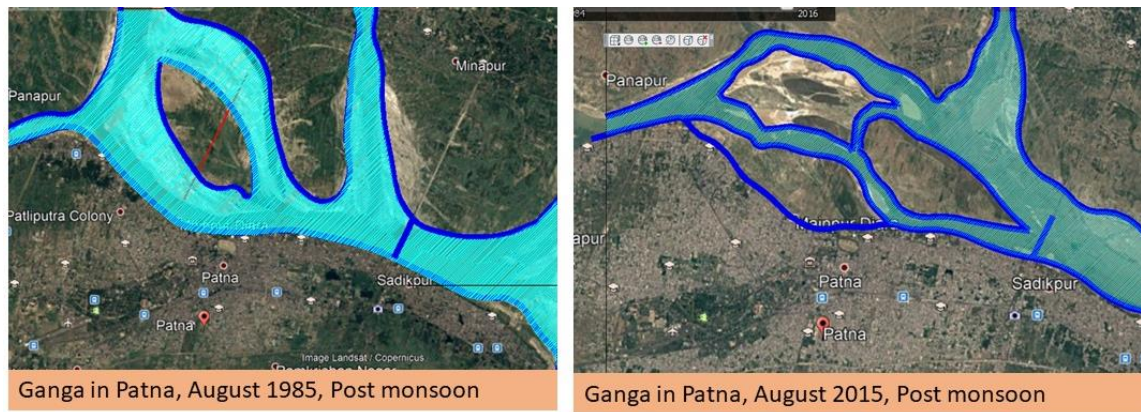


Figure 4: A comparative study of Change in wetland size in 30 years showing wetland shrinkage

Source: Barman, 2020

3.2 Land use change for water bodies and urbanization

As the city is very old with historical importance, the fringe along the city is all occupied with residential and government institutional buildings. This impacts the river with day to day activities, which causes partly biodiversity and habitat loss to floral and faunal biodiversity. The existing river bank is bounded on the southern end by public buildings and unauthorized settlements, which creates a close boundary to the riverfront that is not accessible to general citizens. On the northern end, Lokanayak Ganga Path or Ganga Driveway is situated, which is a planned 21.5 kilometer-long (13.4 mi) road expressway across the river Ganga between Digha and Deedarganj in Patna. There is a big stretch of wetland between these two sections of the river which is serviced by a small stream of Ganga diverted near Digha Ghat. The water level is quite low in the summer season while during monsoons the flow is high.



Figure 5: Encroached settlements, River edge, Waste water disposal and residential settlement

Source: Barman, 2019

3.3 Collection of wetland products, grazing and agricultural activities

The part of wetlands beyond Bans ghat is being used for extensive agricultural purposes. The use of fertilizers and other agricultural processes increasing siltation in the river Ganga main channel which may cause a flood-like situation. The increased agricultural activities also affect biodiversity and increase weeds like water hyacinth

(Jalkumbhi) in those areas. It is also noted that due to agricultural activities the migratory and local birds do not get free space for feeding and breeding.

Encroachments are a predominant activity found all along the stretch. The construction of temporary structures by bamboo can be found all along the stretch and a few of them are permanent buildings also. (Figure 6) The encroachments also enhance solid waste, sewerage, and wastewater disposal activities along the wetlands zone. The water near this fringe is observed grey in color and with reduced transparency.



Figure 6: Section showing different segments along wetland, degraded scenario of the Wetland

Source: Author

3.4 Solid waste disposal

It is also observed that part of the riparian wetlands has also become garbage dumps or solid waste disposal sites for people living in nearby fringe areas. The Patna Nagar Nigam in general does not practice garbage collection by going for individual door-to-door collection in adjoining areas of the riverfront area. The residents, institutions, and shopkeepers of these areas throw their garbage at the identified points along the main Ashok Rajpath road. There is a dumping of solid waste on road by mobile vendors for the absence of community bins and regular waste collection. Further, there are dairy units and settlements along the ghats, who dispose of their waste directly into the river.

3.5 Wastewater and sewerage disposal

There is a severe problem with drainage in the city. There are closed drains along the main arterial road of Ashok Rajpath while open drains in internal roads. The small local drains are also present in few places which get clogged in monsoon. The drains get choked and overflow due to encroachment on roadsides. This results in water logging in adjoining areas during rainy seasons. The major issue is the flow of untreated drain water directly into the river with all the waste of nearby areas. There is an old sewerage system existing in the area with linkage to public buildings, households, and shops. There is a lack of public toilets and urinals for the local

vendors, shopkeepers, and commuters in the zone. Disposal of raw sewage from settlements and slums along the river bank is very common including the open defecation along the edge.

It is also noted that the stormwater drains (Nallah) of the city also carries wastewater from a few parts of the city and due to lack of sewerage system it disposes of in the river itself. The greywater falling into the river is observed to be a prominent phenomenon near Bans Ghat.



Figure 7: An wetland of Ganga formed at a distance from 500 m from southern River bank in study area, it is thriving to sustain due to sedimentation of construction activities

Source: Barman 2019

3.6 Development and construction activities

The construction of the Ganga Expressway is currently creating the most destructive impact on these riparian wetlands. The huge sedimentation of construction activities



Figure 8: Construction of expressway causing narrowing of channel and wetland

Source: Barman 2019

has divided the mainstream and the character of wetlands is getting lost. Due to which, shrinkage of wetlands along with main waterbody shrinkage is also observed. This can be also noted that the main course of Ganga is now swiftly moving away from its banks in the stretch of Patna city. The construction activities have caused a threat to its biodiversity also. It could also be observed that the river Ganga has already shifted 2.5 – 3.5 km from most Ghats in Patna in recent years due to man-made interference (Figure 5).

3.7 Religious and Cultural Activities

As Ganga is considered as the holy river in Hindu religion and the city inhabitants remain engaged with the river for different religious activities. The disposal of religious offerings and gatherings are also causing degradation to the wetlands.

4. Discussion and conclusion

As the wetland ecosystem provides various services to mankind, the cost of replacing the lost ecological services of wetlands can be expensive, assuming they can be replaced at all. The community that loses wetlands services may need to invest in costlier drinking water treatment, stormwater management, and flood control infrastructure. Retaining and conserving its existing ecosystem is always a better solution than investing in infrastructure. The present status is not a site-driven or localized concern, but it is a story of every urban wetland. A collaborative effort should have been made to avoid the adverse impact of urbanization to wetlands and it should be a primary concern for policymakers. Wetlands should be used to provide solution inside the urban and peri-urban background that can alleviate risks from climate change, support production of food for an expanding population, and stimulate income through tourism and recreation (Ramsar, 2013).

All the development should be oriented towards conserving and restoring the wetlands ecosystem. The socioeconomic profile and culture of the region is also a predominant local cause of different degradation pattern. There is a need for an interdisciplinary decision-making system to address these problems, which can be adopted at a very wide range of academic disciplines that do not generally mingle with each other – herpetology, hydrology, botany, ecology of landscape, conservation biology, management of wildlife, management of storm water, toxicology, and wetlands etc. The upcoming development works could be focused on wetlands restoration and conservation with biodiversity and habitat establishments. As wetland plants play an important role in remediating contaminants causing pollution, adopting phytoremediation techniques through the ecological design process may balance the ecosystem and give a sustainable ecological solution. These techniques could also be seen as a purpose of designing habitat corridor, biodiversity regeneration through environmental design processes with collaborative design interventions by a landscape architect, ecologist, environmental planners, environmental engineers, and many more. After all, a healthy wetlands ecosystem could be a healthy lifeline for urban dwellers. There are many examples of wetlands restoration and wetlands conservation in riparian wetlands like - Weiliu Wetland Park in China, Yanweizhou Wetland Park in Jinhua. Such examples can be studied and reviewed for further development activities and policymaking. “Handbook for Integrating Urban Development and Wetland Conservation, (2018)” by Ramsar also

gives guidelines for such kind of development which can be easily followed for a better future and mankind.



Figure 9: (A) Yanweizhou Park: A resilient Landscape, (B) Weiliu wetland park

Source: Topos, 2015; Landazine, 2019

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