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Water Urbanism- Integrating Urban Wetlands into Urban Landscape for Sustainable Development

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ABSTRACT

Currently, cities across the world account for around 80% of global economy. The obvious result of this exponential growth is the expansion of urban areas to accommodate increasing demographic shift. Owing to the changing lifestyles, most of the urban areas, transition areas and ru-urban fringe areas are witnessing steady increase in the unscientific and unplanned consumption of natural resources (land, water, minerals and vegetation) leading to degradation of the natural environment of the urban areas in turn impacting negatively the wellbeing of the urban communities. Among all the natural resources, urban areas and water share a vital relationship. In this context, the paper discusses the interconnected demand and supply of ecosystem services especially related to water in an urban environment. Further, urban wetlands provide a vital resource to adequately cope with the growing water demands in urban areas. Water supply and waste water as well as storm water management systems are impacted by planning decisions.Hence, integrating wetlands into urban landscape through scientific urban planning is need of the hour for promoting sustained development. In this regard, the urban planners need to closely collaborate and communicate with the hydrologists, policy makers, developers and the local community at large to understand the physical as well as socio-economic systems of the region in order to formulate a comprehensive urban development plan that strongly considers environmental resource -impact relationships.Against this background, the paperdiscusses prominent case study examples that involve innovative strategies and proposes recommendationsat various levels for developing integrated urban and wetland planning for urban areas.

1. Introduction

Currently, cities across the world account for around 80% of global economy. The obvious result of this exponential growth is increasing population and the unscientific expansion of urban areas to accommodate this demographic shift. This trend is altering the natural landscapes of the cities posing critical challenges to the living conditions and increasing demands for natural resources.The situations and the projections that prevail in the contemporary cities indicate that the cities in
future will be far more diverse in their socio-cultural and economical domains leading to diverse lifestyles. Owing to the changing lifestyles, most of the urban areas, transition areas and ru-urban fringe areas are witnessing steady increase in the unscientific and unplanned consumption of natural resources (land, water, minerals and vegetation) leading to degradation of the natural environment of the urban areas in turn impacting negatively the wellbeing of the urban communities.

I. WATER AND URBAN AREAS

Urban areas and water share a crucial relationship. Historically, human settlements have grown and thrived as cosmopolitan metropolis due towater sources (the most vital element), fertile lands as well as productive plains that border these water sources. This feature highlights the cohesiveinterdependence between natural and manmadeenvironment. In this sense, human settlements are combination of biotic and abiotic systems evolving as a response to water concerns which include hydrology, terrain, drainage, etc.

A. Urban Evolution and Urban Ecosystems

Universal drivers such as demographic growth, natural disasters and shifting socio-economic structures reflect the evolution of urban eco-systems over a time period. In thisregard, interconnected demand and supply of ecosystem services especially related to water also evolve in the due time.

Degrees of combination of geology,geo-morphology,climatic conditions, soil types and hydrology primarily provides framework of possibilities for people to dwell, farm, build shelters and circulation networks and eventually water supply and management systems. Gradually, this framework is being viewed less constraining and as a result it is altered significantly owing to the advancements in technology, engineering and construction. Tracing the urban evolution, especially in areas that are undergoing rapid urban development stages, support in moderating theunpremeditated consequences of unscientific urbanization.

B. Water and Social Equity

Water, being a finite and irreplaceable fundamental resource is critical for socio-economic development and sustainable ecosystems. It is only renewable if only managed efficiently and equitably. Water serving as the crucial link between society and the environment is a key enabler in strengthening the resilience of socio-economic and environmental systems in the context of unpredictable changes.

Socio-economic instruments, climatic conditions, habitual water usage patterns of the urban dwellers, technical adoptions and efficiency of public supply services profoundly decide the amount of usage of urban water.

C. Different Sources of Water in Urban Areas

Secured supply of clean water is not only the most fundamental aspect for the vitality and functioning of the urban areas, but an important aspect of planning and managing urban areas.Water, in the broadest sense is both artery and vein to urban communities as it has been used to cater to the needs as well as to carry away the rejects.

Urban area's water demand-supply is managed through natural (ponds, lakes, rain water,streams, rivers, springs,etc.) and manmade (wells, tube well, hand pumps, canals, dams, etc.) sources.

These sources can be further classified as surface and subsurface sources as mentioned below:

- Surface sources: Ponds and lakes, Streams and rivers, Storage reservoirs.
- Sub-surface sources: Wells and tube wells, Springs

There are several main sources of drinking water in Indian urban areas that substantially support the water requirements (Refer Table I).

TABLE I. MAIN SOURCES OF DRINKING WATER IN INDIAN URBAN AREAS

Sl. No.	**Source**	**Percentage**
1	Tap water from treated source	62%
2	Tap water from un-treated source	8.6%
3	Tube well	8.9%
4	River / Canal	0.2%
5	Tank/lake/pond	0.4%
6	Hand pump	11.8%
7	Covered well	1.7%
8	Un-covered well	4.5%
9	Spring	0.2%
10	Other sources	1.7%

Source: Census 2011, Ministry of Home Affairs,GoI

The demand for water in urban areas is primarily influenced by:

- Population growth and density
- Socio-economic conditions of the urban dwellers
- Climatic conditions
- Technological choices
- Development and cost of water services

D. Water Concerns in Urban Areas

Urban areas of present era face challenges associated with adequately accommodating huge population growth while balancing scarce and finite natural resources, in particular water. Water is not only critical for sustaining life in urban areas; it also significantly transforms geophysical structure and ecological systems.The intensifying demand for land is

increasingly being addressed by draining, filling and building upon on the water bodies and the wetlands. Increasing living costs, land prices, transportation costs, labor costs coupled with severe climatic conditions directly influence the quality, quantity, demand-supply and management of the water in urban areas (Refer Table II).

TABLE II.IMPACT OF URBANIZATION ON WATER RESOURCES

Sl. No	**Issue**	**Remarks**
1	Unregulated urban development & construction	Accelerated development & construction activities exposes bare soil to accelerated erosion contributing tons of sediment to the streams. Sedimentation clogs streams and reservoirs severely restricting their capacity to contain floods.
2	Waste disposal in streams & other water bodies	Sewage and industrial waste is disposed by discharging into streams & other water bodies. The degree of the waste treatment & the amount of waste effluent in relation to the amount of water available for dilution greatly impacts the resulting pollution.
3	Unscientific landfills	Water leaching through the solid waste and sanitary dumps (which carries both chemical and biological contamination) pollutes ground water resources.
4	Degradation of recreation & aesthetic value	Aesthetic values & recreational potential of water bodies is prone to exponentialreduction owing to haphazard development of waterfront real estate.
5	Storm water runoff	Storm water runoff leads to severe pollution as the rainfall flushes contaminants from urban streets.

6	Encroached development on flood plains	Much of the urban growth is by encroachment upon flood plains resulting in the increased flooding hazards.

All these aspects strongly resonate the fact that the hydrology (water resource management) should be factored in and be the primary base for urban planning as well as to make informed decisions towards the comprehensive development of the urban areas.

II. WATER RESOURCE MANAGEMENT – AN IMPORTANT TOOL IN URBAN PLANNING

Water resources in urban areas are bound to be altered by the accelerated urbanization process. But a comprehensive planning and management process supported by adequate hydrologic data can aid in mitigating the disastrous effects of rapid development. There is a pressing need for conventional functional-economic approaches to planning to be broadened in scope through the inclusion of the natural resources of the urban areas.

Several aspects including the need to make urban water systems resilient to climate change, reiterate the fact that urban water management must be an integral part of sustainable urban planning that addresses vital dimensions of an urban area (Refer Table III).

TABLE III.INTEGRATION OF DIFFERENT DIMENSIONS FOR URBAN WATER MANAGEMENT

Sl. No.	**Dimension**	**Attributes**
1	Environmental	-Wetland conservation -Prevention of pollution -Reuse of wastewater
2	Political	-Public information for water services -Land and water rights -Carrying capacity
3	Social	-Collective action for water management -Livelihood enhancement -Water supply connection
4	Economic	-Water metering and tariff -Incentives for efficient water usage -Penalties
5	Science and Technology	-Climate change impact evaluation -Hydrological information system

		-Supervisory control and data acquisition

Water supply and waste water as well as storm water management systems are impacted by land use decisions. To formulate a comprehensive landuse plan which is environmental and resource oriented, the urban planner (who is trained in the landscape architecture, transportation, urban economics, social sciences, policies, etc.) need to closely collaborate and communicate with the hydrologist (who is trained in physical sciences). Thus urban planner needs to understand the physical system of the region in order to develop and evaluate landuse plan that strongly considers resource -impact relationships (Refer Figure 1).

Among the several sources of water for urban areas, wetlands provide a vital resource to adequately cope with the growing water demands.Wetlands not only provide a natural means of cleaning wastewater (as they absorb pollutants), they support rich bio diversity, replenish water, reduce flooding (as they store flood waters and maintain surface water flow during drought or dry periods), sources oflivelihoods and offer the much required urban lung (green) spaces.Hence, integrating wetlands into urban landscape through scientific urban planning is need of the hour for promoting sustained development.

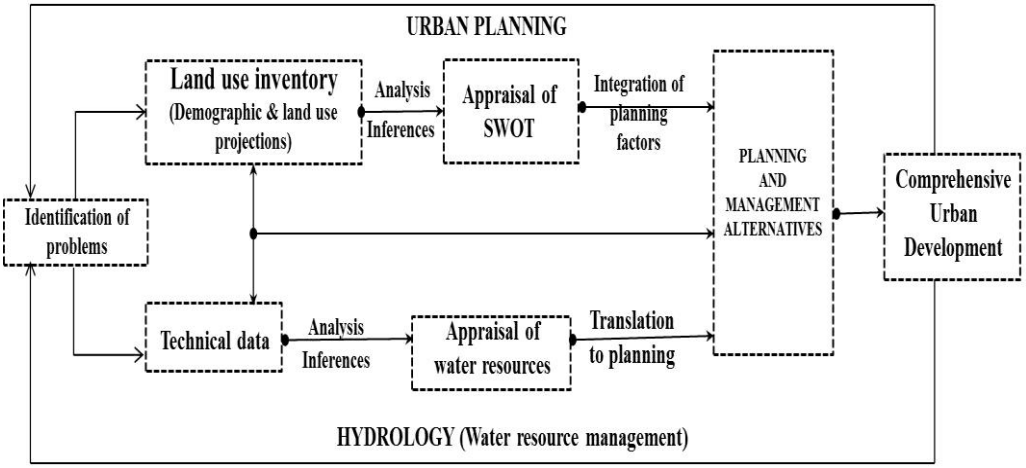

Figure 1: Urban planning process highlighting the interdependence and interrelation of urban planning and hydrology

III. WETLANDS - A CRITICAL URBAN WATER RESOURCE

Wetlands, also referred as Earth's kidneys (as they filter water) are the vital links between water and land. Simply put, wetlands are areas of land where water covers the soil and are saturated with water either seasonally or permanently. Wetlands are dynamic aquatic ecosystems and exist in every climatic zone (from tropics,polar regions, high altitudes to dry regions) across the world. There are even underground wetlands.Common names for wetlands are mudflats, mires, floodplains,swamps,deltas,fens,marshes,mangroves, lagoons, bogs, etc.

A. Types of Wetlands

Wetlands may be either natural or constructed and the water within them may be flowing or static which could be freshwater, brackish (partly salty) or saline (very salty). There are different types of wetlands based on their locations,topography, climatic conditions,soil types, water chemistry (salinity)and vegetation (Refer Table IV). These different types of wetlands also attribute to their diverse functions. (Refer Table IV). Large wetlands may also contain several smaller wetland types.

TABLE IV. TYPES OF WETLANDS

Sl. No.	Main category	Sub-category	Functions
1	**Marshes** Marshes are normally permanently saturated and can be either saline or fresh water.	**Tidal marshes** Tidal marshes are found along the coastlines and are affected by changing tides.	-Recharge groundwater. -Moderate streamflow (this is especially important function during droughts). -Presence of marshes in watershed slows and stores water helping in mitigating floods. -Filters water through the sedimentation of pollutants.
		Non-tidal marshes These marshes occur along streams and are usually freshwater, but can also be brackish.	

2	**Swamps** Swamps are fresh water wetlands dominated by woody plants	**Forested swamps** Forested swamps are often inundated by flood water (slow moving or still water) from streams & rivers. **Shrub swamps** These swamps have often waterlogged soil and are dominated by shrubby vegetation.	-Flood protection. -High in productivity. -Support rich bio-diversity. -Rich deposits of alluvial soil from floods. -Timber from the swamps can be sustainably harvested for various purposes.
3	**Fens** Fens are peat-forming wetlands that receive nutrients from sources other than precipitation.	_	-Prevents & reduces the risk of floods. -Improve water quality. -Less acidic & higher nutrient values. -Support diverse flora & fauna.
4	**Bogs** Bogs are characterized by spongy peat deposits, acidic waters & a thick layer of sphagnum moss.	**Bogs through terrestrialization** Bogs can form as sphagnum moss growing over a lake or pond & gradually filling it. **Bogs through paludification** Bogs can form as sphagnum moss layers dry land preventing water from leaving the surface.	-Prevent downstream flooding by absorbing precipitation. -Support rich bio-diversity

B. Wetlands in Urban Areas

A large proportion of values associated with most types of wetlands are due to their water related services. Urban wetlands, either natural or constructed are one of the most productive ecosystems and significantly provide numerous ecological, social, and economic benefits often referred as 'Wetland Ecosystem Services'(Refer Table V).

TABLE V.WETLAND ECOSYSTEM SERVICES

Sl. No.	Domain	Services
1	**Bio-diversity**	Wetlands are one of the most productive habitats and shelter wide range of bio-diversity because of their unique location between water & land, freshwater & salt.
2	**Water security**	Wetlands regulate water quantity and help in groundwater recharge.
3	**Pollution filters**	Wetlands act as filters for pollution and thus improving water quality.
4	**Flood & drought regulation**	Wetlands function like natural sponge absorbing the excess water and thus help in regulating floods and the adverse impact of droughts &storms. This aspect successively reduces socio-economic damage to urban assets.
5	**Resilience to storms**	Wetlands contribute to land formation by controlling soil erosion and sediment transport consequently increasing resilience to storms.
6	**Fertile land**	Wetlands are important sources of food (For ex: rice paddy systems & rice-associated bio-diversity) as they support nutrient cycling & regulate pest. They also support harvesting of several commercially significant fish species, papyrus, reeds, etc.
7	**Climate**	Soil of wetlandhelps in sequestration of carbon for

	change adaptation	several hundreds of years aiding in adaptation to climate change.
8	**Historical, scientific, recreational & cultural values**	Across several cultures, wetlands are integral part of valuesassociated with historical, religious, archaeological and human development. They are also recreational places for several engaging activities.

C. Significance of Wetlands in Addressing Urban Water Demand

Urban areas through their range of consumptive and non-consumptive activities generate water footprints.Urban wetlands are less dynamic than natural ones and are capable of purifying urban water efficiently and cost effectively.Theyact as natural rainwater buffers and are overflow areas for lakes, ponds, streams, rivers, etc. The quality of the run-off is significantly improved by the plant life of wetlands which eliminates biological pollutants. Urban wetlands offer an alternative to conventional rain water processing since they are highly economical as compared to high-tech purification plants.Urban wetlands can be used to improve the quality of surface water. Urban precipitation and surface run-off from urban areas can be processed in urban wetlands to eliminate solid substances, heavy metals, nitrates and phosphates.

D. Current Conditions of Wetlands in Urban Areas

Increased anthropogenic pressures resulting from progressive unjustifiable urbanizationare causing degradation and severe threats to the wetland functioning. It is estimated that from 1991 to 2001, India has lost around 40% of its wetlands to accommodate the growth magnitude and increasing demands for food and water of the swelling demography.

In comparison to upland areas, the relatively flat terrain coupled with water and other resources associated with wetlands are easier to urbanize while attracting unregulated economic activities resulting in the degradation of wetlands. Rapid urbanization and the subsequent increase in the demand for the land are leading to encroachment on wetlands. This particular aspect is resulting in a progressive loss of wetlands through infilling, drainage as well as conversion of wetlands to accommodate development activities.

IV. INTEGRATING WETLANDS INTO URBAN PLANNING

It is pragmatically proven fact that only wetlands deliver most of the ecosystem services (rain water drainage, air filtration, micro-climate regulation, sewage treatment, noise reduction, recreational as well cultural values) as compared to seven ecosystem types (forests, wetlands,lakes,cultivated lands, street trees, parks). Therefore, it is highly essential that the urban development is planned and managed through recognising the potential of urban wetlands essentially as water management infrastructure.

Urban wetlands impart multi-faceted significant ecological and socio-economic values. Several urban wetland ecosystem services are related to water purification, provision, regulation and replenishment of ground water to address the issues of water security, climate change adaption, culture, recreation, etc.

A. From Reactive Management to Predictive Management

Through appropriate thematic planning, wetlands and their ecosystem services can beeffectively protected both within and beyond the urban areas.Urban planning should completely integrate the wider elements of spatial planning (such as water resource management, development of physical infrastructure, production & supply) while articulating restoration considerations for wetlands. Several practices across different regions and urban areas demonstrate innovative strategies and methods for integrated urban and wetland planning (refer Table VI).

TABLE VI.CASE STUDIES - INTEGRATED URBAN AND WETLAND PLANNING

Sl.No.	Place	Drivers	Description
1	Colombo, Sri Lanka	-Rapid unplanned urbanization -Climate change -Increased flood risk	Wetland Management Strategy (WMS) for City Wetland Management & has the following objectives: -Prevent degradation & loss of wetlands -Restore degraded wetlands -Engage local community & different stakeholders to balance water user conflicts -Improved legal & management approaches.
2	Sydney Olympic Park, Australia	-Water quality enhancement. -Contaminated land remediation. -Wetland restoration -Biodiversity protection. -Recreation, education & wellbeing of the communities.	-'Wetland City', an exceptional example of successful co-existence of nature protection & urban development. -Wetlands are within the mosaic of the precinct's urban sprawl & embedded within the development structure for the effective & efficient design& management of the wetlands.
3	Suncheon Bay, South	-Wetland degradation due to sand	-The Suncheon City Government formulated a policy & comprehensive land use plan

	Korea	extraction -High rate of pollution	identifying four zones: Core,Urban, Transition& Buffer. -Wetland restoration projects are implemented in core zone. -Urban zone supports large scale infrastructure development projects.
4	Changshu City, China	-Water quality improvements -Biodiversity protection -Environmental restoration & sustainable development of Shanghu Lake.	-Urban Master Plan of Changshu has enforced control measures & has explicitly demarcated areas for lakes, rivers, wetlands & drinking water sources as prohibited & restricted construction areas. -The Special plan of Changshu for Sponge city aims at restoring wetlands to make them part of flood control. -Wetland restoration has been integrated into management plans to promote sustainable tourism & recreation opportunities for locals.
5	Panama City, Panama	-Frequent floods -A new municipal administration -Engagement with international experts -Community mobilisation	-Wetlands International coordinated the 'Water Dialogue Program' to mobilize the community & stakeholders to formulate flood solutions. This aspect led to the incorporation of wetlands into development planning programs. -Various innovative planning & design approaches for flood risk interventions such as water plazas, green spaces with biodiversity for active recreational purposes, etc. were developed which in turn appreciated property value.

B. Recommendations for integrated urban and wetland planning

Wetland management plans need to be formulated developed and integrated into urban planning as well as water resource management tomitigate the potentially negative impacts of unplanned development on the wetland ecosystem.

Recommendations to ensure an integrated approach to urban wetland management can be classified into two broad categories: general recommendations and specific recommendationsfor planners, policy makers and developers (Refer Table VII).

TABLE VII.RECOMMENDATIONS FOR INTEGRATED URBAN AND WETLAND PLANNING

General recommendations	
1	**Inclusivity and participatory approach:** Instituting communication, education & public awareness programmes to engage with the communities, government sectors involved in spatial planning and the stakeholders is vital for wetland restoration.
2	**Incentive systems:** Payments for environmental services should be encouraged within & beyond urban environments to protect wetlands.
3	**Comprehensive approach:** Comprehensive approaches to evolve localised solutions for development that ensures green supply chains as well as energy neutral (low carbon) to mitigate the adverse impacts on the wetland environs.
4	**Biodiversity hotspots:** Maximising biodiversity through the understanding of the native wetland habitats, landforms, hydrology& soil types.
Specific recommendations for planners	
1	Embark on integrated planning by incorporating diverse elements of urban spatial planning (such as water resources, storm water management, waste water treatment, etc.) to promote urban wetlands as natural green infrastructure for conserving ecological environment.
2	Clear articulation of the values of the urban wetlands to facilitate informed decision making process.
3	Develop urban wetland specific management planning by mapping and demarcating all the wetland features.
4	Map, monitor and conduct baseline surveys to analyse the key ecological

	characteristics of urban wetlands.
5	Coordinate the planning approach with the related public and private agencies.
6	Frame appropriate participatory methods to involve and empower the local communities and stakeholders at all the stages of planning process.
7	Select certain urban wetlands as natural waste water treatment systems to mitigate urban pollution and sedimentation, particularly to improve the sanitation without significantly compromising their ability of providing other ecosystem services.
8	Formulate comprehensive plans to adapt proposed urban developments to the existing ecological,physical, socio-cultural and economic traits.
Specific recommendations for policy makers	
1	Develop holistic urban planning policy development by incorporating development frameworks and spatial planning to help protect urban wetland ecosystems and their corresponding services (protection against urban flooding, temperature regulation, supporting green infrastructure, etc.).
2	Address water management issues at various as well as appropriate scales via urban wetland specific management planning.
3	Formulate legislative and regulatory framework for proactive urban wetland protection.
4	Provide encouraging regulatory charters to promote partnership among private and public agencies within urban wetland planning and design.
5	Involve local communities and stakeholders to promote participatory approach in all the stages of planning

	and management processes.
6	Incentivise economic activities (livelihoods, recreation tourism,aquaculture, etc.) through subsidies and payments for ecosystem service.
Specific recommendations for developers	
1	Promote restoration and rehabilitation of degraded urban wetlands through the support from local government for possible funding (if appropriate).
2	Foster the various positive benefits(community wellbeing, water safety, flood mitigation, recreation, temperature regulation,etc.) resulting from the incorporation of wetlands within a development.
3	Promote urban wetlands as natural green infrastructure in urban development activities (water resource management, water treatment, storm water managements,etc.).
4	Promote active involvement of local communities in all the planning stages and management processes.

These recommendations need to be incorporated in the development of action plans intending to raise awareness towards the positive impacts of the urban wetlands.

V. WAY FORWARD

Unregulated and unplanned urban expansion is continuously generating adverse negative impacts varying in their scale and geographic scope. Some of these impacts could be short term and local, while other could be long term extending beyond the regional and national boundaries.

Across different urban areas, there are several case examples proving the fact that urban wetlands provide a range of positive ecosystem services that can improve water quality, replenish groundwater, reduce flood risk, support rich biodiversity, and promote socio-cultural as well as economic activities. However, despite of these potential benefits urban wetlands are not taken into consideration while planning urban development activities.

In the planning process and the development of comprehensive plans (short term and long term), urban planners should have the awareness regarding the hydrologic consequences of their planningdecisions. Environmental planning

must pay due consideration for water resources along with other vital resources such as physical, socio-economic and cultural.

Integrated urban planning can enable agglomeration and densification meanwhile reducing per capita use of resources.To facilitate enhanced ecological environmental character and the optimal ecosystem services, urban wetlands should be restored as elements of urban especially water management infrastructure.Ecosystems, particularly urban wetlands are strong foundations for sustaining cities towards smaller ecological footprints.

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