International Journal of Engineering Research
Volume No.7, Issue Special 1, pp : 54-59
ISSN:2319-6890 (online),2347-5013(print)
11-12 Jan. 2018

Water Sensitive Development – An Approach to Smart Cities

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Abstract: Water is an important natural resource which is becoming scarcer day by day. Conservation of water and exploring alternative sources is therefore important in the given context. The present paper addresses the issue of water sensitive development on a regional scale and tries to suggest skeletal guidelines for an action plan to be implemented as a part of conceptualization, formulation and implementation of Smart cities.

Keywords:

Water Sensitive development, Integrated Design, Flood Management, Contemporary towns, Regional Planning, Policy guidelines

1.0 Introduction

India has been facing acute water shortage over the past years with more than a quarter of its population severely deprived of water. The situation in rural India is bad with farmers committing suicide, armed guard deployed to protect water and trains carrying millions of gallons of water to quench the thirsty areas. In Urban areas the situation is no better, with most of the metropolis in India reeling under water crisis. Since two third of India's cultivable land is dependent on rain –fed irrigation food security is an important issue linked to water crisis as stated by Mr. K. D. Sharma in Current Science No. 11 that rain-fed agriculture irrigating 65% of India's land will play a major role in India's food security and sustainable economic growth, and there are large opportunities for gains from adaptation and new investments in water management under the proposed National Food Security Act.

With subsidized electricity farmers draw up groundwater recording an annual fall of water table at the rate of 0.3 m to 4 m, as mentioned in the newspaper the economist May 25th 2016. Water starved regions often grow water hungry crops like paddy cotton and sugarcane.

Water related violence have spread from Urban slums to sophisticated neighborhoods of Bangalore following the Cauvery water dispute. Following these footsteps it is not unlikely that water woes would have unprecedented consequences.

The National Water Policy 2012 identifies that conservation, distribution and minimizing wastage through proper development and resource management is the key to address this problem. The five identified goals of the Mission as enunciated by *Ministry of Water Resources, River development and Ganga Rejuvenation*, are Comprehensive water data base, water conservation, augmentation and preservation, attention to vulnerable areas, increasing water use efficiency and integrated water management.

2.0 Water Sensitive Development

India tops the list of countries with the greatest number of people being deprived of safe drinking water (The State of World's Water 2017), despite having a high average annual rainfall. Rainfall, being the primary source of fresh water, the concept behind conserving water is to harvest it.

India, despite its different geographical locations, wide climatic diversity and varied cultural perspectives, has been traditionally conserving rain water in almost all parts of the country. These are century old practices many of which have been forgotten in recent times. The methodology of conservation in different parts of the country is different depending on local need and availability but the ultimate intent is conservation of rain water and storing it for use during drier months. A few practices that are commonly adopted in different parts of the country are *Kul* or channels carrying molten glacier water in Himachal Pradesh, *Naula* or surface water harvesting method typical to the hill areas of Uttaranchal, *Khatris, Zobo* or conservation of impounding run off in Nagaland and *Eris* in Tamil Nadu which have played important role in maintaining ecological balance as flood control systems, preventing soil erosion and wastage as run-off, during periods of heavy rainfall while recharging groundwater.

In the Urban context also water sensitive development was witnessed, starting from Harappan Civilization that focused on the Great Bath House and the drainage channels. The city of Dholavira located in Khadir island of the Rann of Kutch, seen today as a fortified quadrangular city set in harsh and arid land, was once a thriving metropolis with water conservation techniques from rain water harvesting consisting of large rock cut reservoirs, rock cut wells and huge stone drains. One of the most ornate structure in Gujarat the Rani ki Bav, at Bundi iis a magnificent example of ornate stonework around a stepwell for water harvesting. The Jahaj Mahal at Mandu, built by anonymous architect of Ghiasuddin Khalji, the Delhi emperor incorporated several principles of solar passive architecture and water sensitive planning such as, placement of fenestration, use of rainwater, integration of landscape, design of opening and jaalis, with a mix of playfulness and elegance, where wind and water were woven through the built fabric (Grover Satish , Architecture during the Mughals)

3.0 Methodology

The present paper aims to explore the development of contemporary towns where principles of water sensitive development have been implemented and tries to understand whether these methods can be applied to the modern town planning. It also looks at a few successful examples of

ISSN:2319-6890 (online),2347-5013(print)
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planning of new towns and aims to derive a framework for water sensitive development in future.

4.0. Water Sensitive Development in Contemporary towns

There are economic, environmental and social benefits of water sensitive development.

Water sensitive development results in capital cost saving**,** construction cost saving, development cost saving, maintenance cost saving, improved resource utilization and improved market value.

Environmental Benefits include maintenance of hydro-geological balance, sensitive area protection, waterways restoration impact reduction, enhancement of natural habitat and ground water recharge.

The social benefits may include inclusive design and decision making by various communities, visually appealing urban residential landscapes, opportunities to link communities through open spaces and ameliorating urban heat island effect

Most of the ancient Indian cities grew around riverbank and many developed as harbors, nourishing trade and commerce along the coastline. Varanasi, one of the oldest cities along the Ganges is still thriving as a Living heritage. In order to ensure that a source of water was perennial, its catchment was protected. The river systems in ancient India were celebrated and respected. Although the medieval era witnessed political turbulences but organic growth and development occurred barring a few examples.

In the recent times Industries and employment opportunities dictated the growth and development of new towns. Polis slowly became metropolis and megalopolis and the crunch on natural resources was felt. To add to this, havoc was created by pollution, reclamation and neglect of existing water channels and clogging caused by unprecedented dumping of plastic and other solid waste. Moreover huge amount of urban paved surface and storm water drains stopped the rain water from percolating and drained them directly to the sea that resulted in acute shortage of fresh water and caused floods during torrential rain.

While locating a city and delineating its growth poles it is imperative that the regional perspectives are considered. The development should be such that the natural drainage channels and catchment area is preserved and the local flora and fauna should co-exist with it. Also replenishment of natural resources or sustainable development should be the focus. Every city or urban fringe should be surrounded by a buffer zone for regenerating its natural resources like catchment area for rain water harvesting holding ponds, thick vegetative cover etc. The catchment area would be based on natural contour that forms a watershed with a network of check dams, drainage channels and reservoirs that suffices the water requirement of the future projected population.

The following approach may be adopted for water sensitive urban development on a regional scale as enunciated by water sensitive urban design guidelines for Australia

A thorough knowledge of the existing land strata, soil typology, vegetation (water loving plants),geological maps and cross sections give important clues while planning. Integrated management of all water resources, coordinated planning and development, land use planning based on seasonal and annual water availability can be identified.

Water availability can guide the planning of services and infrastructure related to transport, health and community facilities and identify the appropriate land to develop industrial, commercial and residential sectors.

Replenishment of water in natural water reservoirs should be aimed such that it suffices the future needs of projected population in a particular region.

Treatment of used water before disposal is absolutely necessary involving clarification, reduction of BOD including carbon filtration and electro-dialysis reversal.

Recycling of water should be emphasized as much as possible before treatment to reduce the treatment load.

A network of small water harvesting structures to be planned on a regional scale, which would not be affected by urban development and sprawl.

Reclamation of existing water bodies and drainage channels should be avoided as much as possible.

4.1 Water sensitive approach to Urban Development-Guidelines for New Towns and Smart Cities

Water sensitive approach to urban development would aim at conservation of fresh water, optimum utilization of water through conservation and recycling, sensitive development encouraging percolation, and non depletion of water table, proper treatment and disposal of used water to reduce pollution and segregation of contaminated and non – contaminated water.

Zoning of urban areas and land use planning should be such that mixed-use neighborhoods and transit-oriented centres are encouraged within structure plans. This provides the basis for the design and development of areas in which population is expected to grow, such as transit corridors, new growth areas and revitalized centers in cities and towns so the future projected population and water needs are in tandem. A few other considerations may be

1. The residential zones could be planned such that they have intermittent green pockets connected by continuous green corridor and drainage channels for percolation, collection and storage of rain water.
2. In each individual plots and building units, rain water collection tanks along with required infrastructure should be installed and paved surfaces should be reduced as much as possible. Also the drainage layout should be done such that the fresh water collected from rains could be reused for landscape, washing and other activities.
3. In addition to this, complete and partial recycling should be encouraged and water saving gadgets and devices installed.

ISSN:2319-6890 (online),2347-5013(print)
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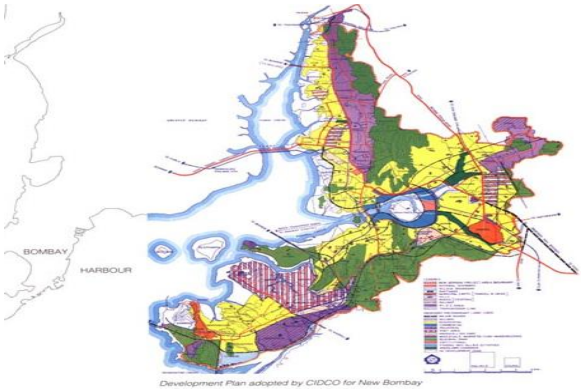
4. Monitoring of usage of water through water meters should be encouraged.

4.2. Water Sensitive development for the case of Navi Mumbai: Navi Mumbai is a new town where principles of Water sensitive urban design are witnessed in the overall planning as well as in the detailing of various nodes and sectors.



Navi Mumbai experiences average annual rainfall from 2500-3000 mm which may extend to 5000 mm considering the catchment areas of hill ranges .It has a peculiar setting, with creek on one side i.e. 150 km long coastline which houses vast stretches of mangroves, paddy fields, salt pans and fresh-water lakes; and hill ranges bounding it on the other side.

Figure 1: Map showing coastline and green buffers in Navi Mumbai (Source: CIDCO)

About 20% land is low lying and reclamation of these areas is not feasible economically and environmentally. Thus, combination of high rainfall in the rainy season along with the high tide in the creek makes the site vulnerable to flooding and efficient disposal of storm water is vital.

In the planning of Navi Mumbai, CIDCO (City and Industrial Development Corporation) has planned its land use considering the water shed area, minimizing the damage to the Natural drainage of the site.

From the point of view of water management, the infrastructure of the city was developed in a manner to have separate drainage lines for storm water and sewage drain.

In coastal areas there is inevitable incursion of salt water which contaminates the fresh water bodies leaving them unfit for any practical application. CIDCO has been proactively taking necessary steps to circumvent the impacts of ingress of sea water by constructing uniquely designed holding ponds with unidirectional flap gates along the coastal belt. The ponds store the water during high tides and release the water during low tides. 30 holding ponds were constructed encircled with trees. Also 16 detention ponds were designed which help regulate the flow of water runoff from the hills, which would have otherwise created a menace during high tides. These ponds are only functional in the four monsoon months and run dry rest of the year. The treated effluent from STPs is used for landscaping and maintenance of gardens. Unlike Navi Mumbai, Mumbai does not have these features, which makes it vulnerable during monsoon months

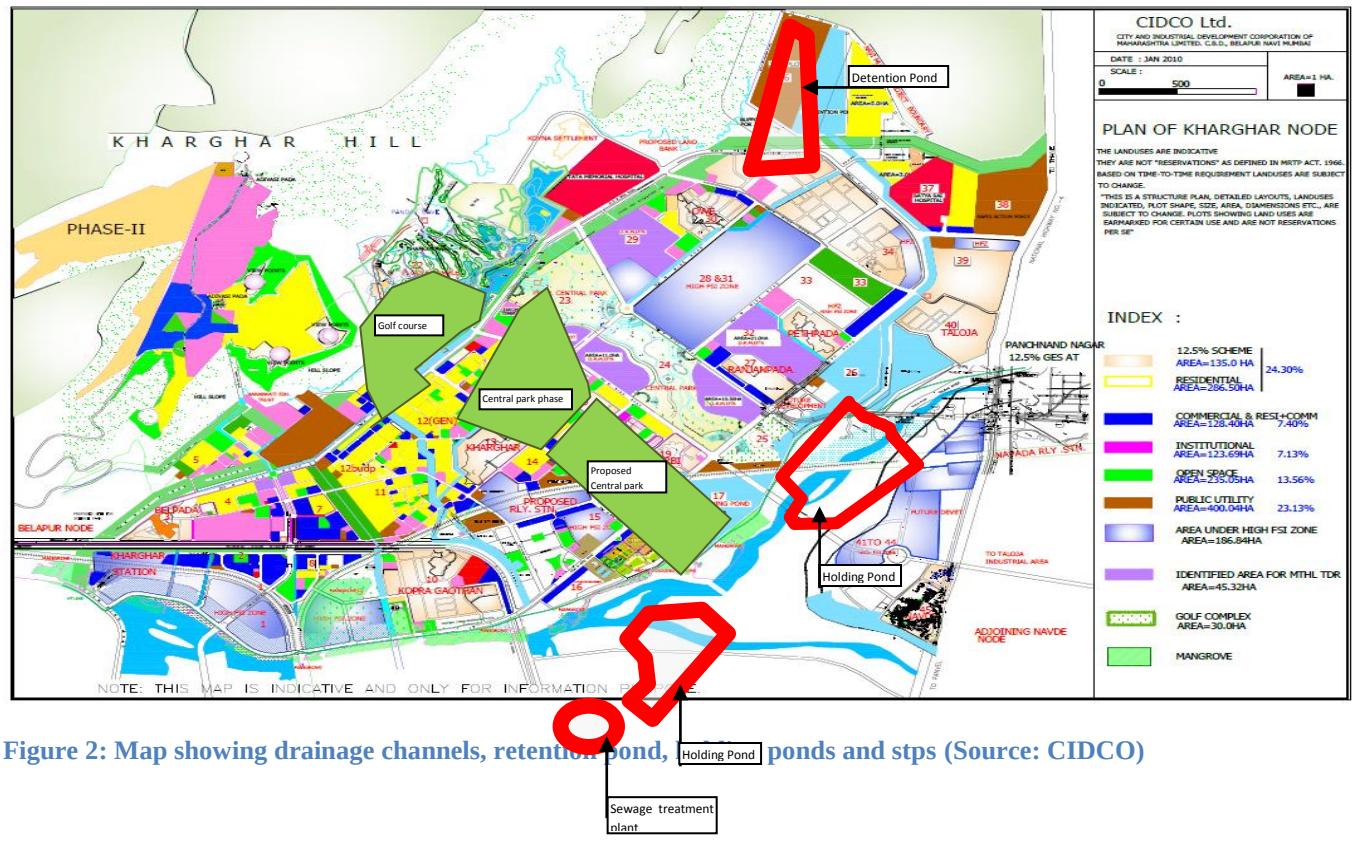


Figure 2: Map showing drainage channels, retention pond, Holding Pond ponds and stps (Source: CIDCO)

ISSN:2319-6890 (online),2347-5013(print)
11-12 Jan. 2018

5. Strategies for Planning of New Towns and Smart Cities

The planning of new towns should start with a regional approach with an integrated water management system extending from the regional catchment scale to the site specific built form including an alternative water source which could be surface water, ground water, recycled waste water, storm water and desalinated sea water focusing issues of local scale within the built fabric. It should be adopted right from the land-use planning stage focusing on conservation of bio-diversity and ecological integrity. Water should be prevented from adverse pollution and opportunities for safe re-use should be explored. Protection of public health and community values should be incorporated while decision making. A through cost benefit analysis should be done from the preliminary stage and indigenous cultural relationship to water should be recognized. (Creating more livable and water sensitive cities in South Australia 2011)

The subsequent sub-sections elaborates on principles that may be adopted at strategic level

Run-off quality Water sensitive design may be implemented to manage the urban run-off quality to mitigate environmental degradation by reducing the total suspended solids by 80%, phosphorus by 60%nitrogen by 45% and total gross pollutants by 90%.(Environment Protection Act 1986)

Run off Quantity The hydrological impact of built environment on watercourses and their eco-systems should be minimized. For waterway protection the rate of run-off discharged from the site should be managed so that it does not exceed the pre –urban development of 1 year average recurrence interval (ARI) peak flow.

Flood management For development and other relevant infrastructure, systems should be devised that will drain runoff to an existing publicly managed drainage system or to a drainage system such as a creek or water course.

Integrated design The approach to design should be integrated such that achievement of multiple outcome is possible so that habitat development along with amenities, efficient energy use and reduction of greenhouse emissions with engagement of stakeholders at appropriate stages of planning, designing, constructing and managing at regional and local level.

6.0 Assessment of existing situation

A methodology can be developed for assessment of existing situation to understand the present requirement as well as the requirements of new towns. This could be done by assessing the needs of the present population in terms of available water supply, scope of recycling, future needs, present as well as future deficits and exploring alternate water sources. After assessment strategies have to be devised and a regulatory framework for implementation has to be designed Assessment can further be done by listing down the parameters that lead to water sensitive development like monitoring water quality and quantity through water efficient appliances and fittings, rain water tanks along with storm water harvesting plan, recycling and treatment of water, bio retention practices and constructed wetlands etc.

The green colour shown in table 1 highlights ideal conditions, pink colour shows requirement of assisted conditions and red unsuitable conditions.

Analysis of gaps will tell us the appropriate ways and areas where intervention is needed.

Table showing areas where water sensitive measures can be taken
Source: Evaluating Options for water sensitive development: A National Guide, Australia (Refer Table 1)

7.0 Proposed Action Plan

The state of Maharashtra has already pledged to be the first state to evolve an integrated water plan including amalgamation of five major river basins for better co-ordination and distribution of water. The plans built on five parameters will include structural measures, operational measures, watershed management, demand management and equitable distribution as enunciated by Government regulations.

The Action plan may incorporate establishment of National level and State Level Frameworks to adopt water sensitive performance principles in Government and privately managed infrastructure projects and to ensure water sensitive development is supported in the land-use planning stage in terms of continuous network of green spacxes in bio retention ponds in urban areas. It also includes support of water sensitive development in the building approval process like having a site based rain water harvesting strategy and devising designs that encourage ground water percolation and to align the principles and policies of water Sensitive design with the Environment Protection Act 1986. In the National Skill Enhancement Programme, we can provide a dedicated curriculum and a team for capacity building and management of sustainable practices. Another suggestion is to provide continuous engagement of the National Policy through State nodal agencies, local Government and industry for appropriate implementation and to engage relevant research bodies for improved information and guidance. Considerations may be there to ensure alignment between Natural Resource Management (NRM) and Water sensitive design objectives to frame guiding and performance principles and performance targets and to promote water sensitive urban design in catchment based storm water management plans and Water sensitive design in new developments like arterial road, major Government infrastructure projects and redevelopment and renewal of existing State owned infrastructure. Suitable process of reporting, monitoring and evaluation may be established.

ISSN:2319-6890 (online),2347-5013(print)
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8.0 Discussions and Conclusion

While rural areas have huge potential for water sensitive development on a regional scale the development in urban areas is comparatively constrained and therefore needs to be streamlined from beginning. These issues should be immediately recognized by urban planners and incorporated in the development of new towns and smart cities. Thus there is a need for a National Framework on water Sensitive Development of New Towns. The framework may incorporate diversity of climate, topography and water availability but should focus on decentralized collection and storage and minimizing wastage. The land use planning and zoning of new town should focus on water sensitive development Watershed management techniques need to be adopted for harvesting, channelization and distribution of rain water following the natural contour and drainage pattern with least impact on the local flora and fauna .Management of water in Urban areas may incorporate site specific techniques like enhancing percolation, seasonal collection, recycling and metering. Also decentralized approach to water management and treatment and exploring alternative sources of water rather than complete dependence on municipal supply should be encouraged. The contemporary planning practice may incorporate traditional techniques like network of ponds, urban centers incorporating bawries (stepwell), planning along water channels etc, more emphasis on promenade development, retaining natural edges of water channels and integrating water bodies visually and ecologically to the city's development

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Measures	Water Quality					Water quantity			Objective			Amenity					Functionality		
									Water Supply		Waste water								
	Primary Treatment	Secondary treatment	Tertiary treatment	Achieve WQ-Os	Reduce Pollutant loads	• Disconnect Impervious Areas'	Provide Detention	Allow storm water harvesting	Can provide alternative water source	Reduce portable demand	Reduce waste water flows	Measure allows multiple uses	Form can be integrated in to land scape	Retain natural features and enhance or restore riparian corridor	Minimal public safety issues	Linkages (Pedestrian, Bicycle, vehicular) maintained or enhanced	Maintenance elements can be incorporated within measure	Maintenance plans can be provided	Allows integration with service corridor
	Portable water demand / waste water generation reduction techniques																		
Water Efficient Appliances																			
Water Efficient Fittings																			
Rain water tanks																			
Reticulated Recycled water																			
Gray water treatment reuse																			
Storm water harvesting / reuse																			
Changing landscape form																			

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Water use education program																			
	Storm water management techniques																		
Sediment basins																			
Bio-retention swales																			
Bio-retention basins																			
Sand filters																			
Swales																			
Buffer strips																			
Constructed wetland																			
Ponds and Lakes																			
Infiltration Systems																			
Porous pavements																			
Aquifer storage and recovery																			
Water quality education program																			
Practice/Measure idealy suited																			
Practice /measure may assist																			
Measure generally unsuitable																			
Not applicable																			

Table 1: Parameters for identification of gaps for water sensitive development