Protection of Urban Water Body Infrastructure – Policy Requirements

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Abstract. Water body is an important infrastructure of urban landscape. Water bodies like tanks and ponds are constructed to harvest rainwater for local use. Such water bodies serve many environmental functions including flood and soil erosion control and are useful for irrigation, drinking water supply and groundwater recharge. A large number of water bodies recently have been lost due to anthropogenic activities and the remaining water bodies are under stress due to risk of degradation. There are many phases to solve or control the problem; starting from stopping the abuse, to restoration to monitoring and maintenance. In this situation, the existing urban and peri-urban water bodies are to be preserved and rehabilitated. In this study, policy requirements for the protection (preservation and rehabilitation) of water bodies are analyzed with special reference to Thanjavur city. Thanjavur city has many water bodies and moat around the Big-Temple and the palace, and stands as an evidence for water management in ancient days. These water bodies are to be protected and used properly for sustainable growth of the city. This paper envisages the following three: (a) need for evaluation of hydraulic and hydrologic properties of the water bodies for conserving rainwater and controlling flood water in the existing urban water bodies; (b) need for evaluation of potential of socio-environmental services by the water bodies, and (c) need for developing a relative importance index for protection of water bodies to prioritize the remedial actions.

1. Introduction
Water body is an important feature of urban landscape. While urban lakes are present all over the world, temple tanks are special to Indian context. A large number of water bodies recently have been lost due to anthropogenic activities and the remaining water bodies are under stress due to risk of degradation. Throughout the world, many water bodies are suffering from pollution and encroachment problems from industrial, urban and agricultural development. There are many phases to solve or control the problem; starting from stopping the abuse, to restoration to monitoring and maintenance.

Water bodies like tanks and ponds are constructed to harvest rainwater for local use. Such water bodies serve many environmental functions including flood and soil erosion control and are useful for irrigation, drinking water supply and groundwater recharge. These water bodies were maintained by local communities earlier. The shifting of maintenance responsibility from local community to the government agencies led to the menace of encroachment and abuse. The encroachment in urban and peri-urban areas is more prominent. The urban population growth demands more land for housing and other infrastructure. The scarce and costly land resources stress the water bodies ultimately. Even the government bodies find the water bodies as an easy source for extra land
for development. In this situation, the existing urban and peri-urban water bodies are to be preserved and rehabilitated.

Thanjavur city (10°46N, 79°08E), shortlisted for 100 Smart City Mission, by Ministry of Urban Development, Government of India is one of the cities undergoing the process of losing the water bodies for urban growth. Thanjavur became a corporation in the beginning of 2014, has an area of about 37 sq km and has a population of around five lakh. Thanjavur city is one of the old cities in India. Thanjavur is famous for the more than 1000-year old Big-Temple (Lord Bhrahadeeswara Temple) made of stones. This city was the capital of the Chola dynasty for many years. Thanjavur city with many water bodies and moat around the Big-Temple and the palace stands as an evidence for water management in ancient days.

A moat (water body) around the temple and the palace area are still seen though they are not in proper shape for a considerable stretch. There are number of tanks around the temple and palace and these tanks were connected by pipes. The surplus of upper tank was made to flow to a lower tank through the pipes. The upper tank acted as settling tank and pure water from the top layer was sent to the lower tanks, which served as water source for the town dwellers. The moat received the surplus water and served as a water blockade. There are more than 20 water bodies including a handful of temple tanks in Thanjavur with a capacity of more than one million m³. Apart from these temple tanks and lakes, a moat of about 4.5 km length and 40 m width, which is hydraulically connected to Cauvery river, is present in the main town area. These water bodies are to be protected and used properly for sustainable growth of the city. Keeping the status of the water bodies in Thanjavur in mind which is a common scenario in many of towns in southern states of India, the policy requirements for protection of urban water bodies is envisaged. The objective of this work is to identify (a) need for evaluation of hydraulic and hydrologic properties of the water bodies for conserving rainwater and controlling flood water in the existing urban water bodies; (b) need for evaluation of potential of socio-environmental services by the water bodies, and (c) need for developing a relative importance index for protection of water bodies to prioritize the remedial actions.

Very limited works have been reported in this field both in India and outside. In the Indian context, this is important as water scarcity and flooding both affect the cities and many tanks are encroached or being encroached and disappearing fast due to urbanization. In many developed countries, water quantity availability is not a major issue while the quality of water is a major issue. Hence, many international literatures are focusing on water quality issues.

2. Indian Scenario
Urban and peri-urban water bodies were studied by various researchers [9,13,17] in the recent years. Two tanks, one in Chennai city and another just out of Chennai city were studied [9] and the author tried to find the cause for the dry status of urban tanks. The author [9] reported that the human interventions like desilting and concrete flooring of tank beds as major reasons. Considering both quantity and quality aspects, the author [9] suggested methods to re-establish the hydrological role of tanks.

In Bangalore city, Varthur Lake which is fed by sewage, was studied for self-remediation through physical, chemical and biological analyses including BOD removal and nutrient loads [13]. It was identified that the lake behaves like an anaerobic-aerobic lagoon.

To monitor and prioritize conservation works of six water bodies in and around Chennai city, a Water Bodies Protection Index was developed [17]. To formulate the index five factors namely (1) quality of water, (2) bio-diversity, (3) encroachment of water body, (4) involvement of local community in the management and preservation of water body, and (5) role of government agencies in
protecting water body were used by the authors and they conducted a Delphi study to assign wightages to the above factors.

It is difficult to understand a long list of numerical values of various water quality and other parameters. An integrated single index value makes information more easily and quickly understandable. Such an index can facilitate comparison among various water bodies. Therefore, a single index value is better for transmitting information to general audiences or policy makers. In India, few researchers worked on developing a single index for assessing water quality. A water quality index was formulated and used [1], which considers the following six water quality parameters: dissolved oxygen, BOD, total coliform, turbidity, TDS and pH. The researchers [21] developed a water quality index to quantify overall water quality for human consumption and applied that for their study area in Tamil Nadu. They used the following twelve parameters: total dissolved solids, HCO₃, Cl, SO₄, PO₄, NO₃, F, Ca, Mg, Na, K, and Si.

3. International status
Developing a Water Poverty Index by linking water availability and socioeconomic variables was discussed to assist the policy makers on equitable water allocation [18]. The researcher [18] discussed the issues on acceptability and relevance, and the problem of scale of index and different approaches in forming a meaningful index in assessing the links between water and poverty. This work was followed latter by many researchers [4,14,19]. Further, many researchers proposed use of different water quality indices to get a single numerical expression for the overall quality of a water [1,2,12,15,21].

A single indicator called Watershed Sustainability Index for aggregating hydrologic, environmental, life and policy parameters was developed [3] and applied to a basin in Brazil. Ten ponds in Vienna, Austria were studied to get information on the seasonal variations in the environment [16]. Multivariate statistical analysis proved that ponds were affected by salinity and by algal biomass and the authors identified eutrophication and inflow quality as the cause. A model to relate environmental conditions and occurrence of algal species was developed which shows variation in states from season to season.

Maintaining or restoring towards a natural water balance not only keeps-up the environment, it also improves the living standards of urban area [8]. The effect of urban expansion on surface water bodies in Wuhan, China was studied [6]. The researchers reported that the reduction, disappearance and pollution of surface water bodies results in undervaluation of water bodies and increases the threat for further damages and recommended an integrated and proactive land-use planning and management system. Integrated use of social, economical and environmental parameters for sustainable water resources management of West Java, Indonesia was attempted [10] and [11]. They developed a conceptual framework for developing a Water Sustainability Index and applied Delphi technique to finalize the components/indicators of the index.

Self-purification potential that reflects the capacity of an ecosystem to assimilate all inputs was discussed in a research [20]. The potential for self-purification depends on the restoration and/or protection of the functioning of the ecosystem. Such quality objectives of the self-purification potential would allow the system to not to cross the limits of the ecological “resilience domain” which were set by the maximum allowable stress on environment so that the system can recover fast.

Policies on water quality management for an urban lake were proposed and evaluated [7] giving due consideration for the different interests of stakeholders. Alternative policies on water quality management were analysed and ranked using fuzzy Borda count and evidential reasoning methods and compared.
The literature review indicates that every city has its own unique hydrological system, human interference and problems. Thus, it can be understood that it is very difficult to provide a generalized method that is suitable for every situation. However, a more comprehensive work will provide guidelines or approaches to many other studies.

4. Base line data requirement
Knowing that the problems associated with water bodies are location specific, the policy requirements also location specific. However, before making the policies, certain baseline data may need to be collected to understand the problem. To make policies for the protection of urban water bodies certain baseline data are required which may cover the following.
- locations and size of the water bodies, encroachment of water bodies, sediment deposits necessity of deepening, inflow sources and arrangements, outflow arrangements, possibilities of improving the inflow into the water bodies
- utilization of water from water body for drinking, bathing, and washing of cloths, suitability of water quality, disposal of solid wastes, sewage, and open defecation in water bodies, eutrophication, contaminations and source control measures required, water quality variation with respect to seasons, groundwater recharge potential, potential of water bodies as flood control reservoirs, reduction of heat island problem by the water bodies, menace due to mosquito breeding in water bodies

5. Tentative steps required for protection of urban water bodies
Tentative steps required for the protection of urban water bodies comprises of three major parts viz. (a) estimating hydraulic and hydrologic properties of the water bodies, (b) estimating potential of environmental services by the water bodies and (c) ranking the water bodies for remedial actions. The first part involves field observations and analytical estimations. The second part involves analyses of quality of water samples and field observations. The third part involves survey through questionnaires and analytical study.

5.1 Estimating hydraulic and hydrological properties of the water bodies
The following components have to be envisaged under this part.
- Inventory of the water bodies: Identifying the locations and size of the water bodies
- Encroachment of water bodies: Identifying dumping of construction or urban solid wastes into the tank; dividing the water body into two by dumping soil and use the dividing bund for road transport – which will make one part of the water body dry as there is no inlet; implementing government plans in the water bodies.
- If a water body is not maintained, silting or sediment deposits may reduce capacity. Hence, identifying the necessity of deepening of a water bodies becomes essential.
- An urban water body may be disconnected from inflow sources. Hence, the inflow sources and inlet arrangements are to be identified. Further, arrangements for overflow are also to be identified. Few water bodies may fall in a chain, that is, they may have connections like surplus or release from one can reach the next downstream water body. Such arrangements are to be identified. In Thanjavur, it is claimed that few water tanks had links through underground pipe systems, which are to be explored, and possibilities of revamping is to be analyzed.
- Some of the water bodies are hydraulically connected to irrigation canals. Status of the connecting channels is to be explored.
- The recent water fillings due to rainfall and channel flow are to be studied. The possibilities of improving the inflow into the water bodies through connections will be studied. Using the land-use patterns, rainfall data and SCS curve number technique, potential of inflow will be estimated.

5.2 Estimating potential of environmental services by the water bodies
The following components have to be envisaged under this part.
• It is common that people use water directly from water bodies for their domestic water needs like drinking, bathing, and washing of cloths. The direct use of water from the water bodies will be studied. Suitability of water quality for such uses will be checked. Some of the water bodies are abused by disposing solid wastes, sewage, and open defecation. Urban water bodies may receive higher nutrient loads and hence eutrophication may cause problem. If contaminations are observed, the sources of contamination will be identified and source control measures will be suggested. The water quality variation in the water bodies with respect to seasons of a year will be analyzed.

• One of the important services of the water bodies is groundwater recharge. The potential of water bodies for recharging the groundwater will be studied. Variation of groundwater table in the neighboring wells with respect to water availability in the water body will be observed. The vertical hydraulic conductivity of the soil layer below the water body will be analyzed through groundwater flow modeling.

• If the bed of a water body is too porous, water will quickly flow down to the aquifer below and the water body will become dry soon. Mound in the water-table will not stay long and hence, the impact of recharge will not be realized much. If the bed of water body is of non-conductive in nature (clay layer), ground water recharge will not take place. It may be good to have a moderate vertical permeability to make the water available either as surface water or as groundwater. If the bed is too pervious or impervious, the bed should be modified with external materials. The thickness of material to be modified will be analyzed using groundwater modeling and suggestions will be reported.

• The potential of water bodies as flood control devices will be analysed using model study.

• Heat island problem of urban areas can be minimized by the water bodies. The effect of water bodies on the micro-climate (temperature variations) will be studied and reported.

• Water bodies may serve as breeding place of mosquitoes, habitat for frogs and insects. The menace due to these to the surrounding dwellings will also be studied.

5.3 Ranking the water bodies for remedial actions
Many of the urban and peri-urban water bodies are disappearing due to urbanization. Government agencies generally do not have sufficient resources to monitor, control and rehabilitate all the water bodies. In this situation, it is very important to prioritize and concentrate on few critical water bodies. The few water bodies to be selected for this purpose are to be identified based on many parameters. The money spent on the water bodies should return maximum tangible and intangible benefits. Hence, to prioritize the rehabilitation and to save precious fresh water resources, developing a comprehensive ranking index is of great necessity today. Indicators can help for ranking the water bodies and priorities can be assigned in a scientific logical manner. A comprehensive method for ranking the water bodies based on (a) hydraulic and hydrologic properties of the water bodies, (b) potential of environmental services by the water bodies, and (c) survey from experts and locals is to be evaluated.

6. Conclusion
Policy for the protection (preservation and rehabilitation) of water bodies is gaining more and more importance as the water bodies are being lost due to anthropogenic effects. Since the funding available for preservation and rehabilitation are limited, prioritization is also very important. Hence, in this paper, the points to be considered in the policy making, through three major divisions viz. (a) evaluation of hydraulic and hydrologic properties; (b) evaluation of potential of socio-environmental services by the water bodies, and (c) developing a relative importance index for prioritizing or ranking the water bodies are discussed in detail.

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