RESEARCH ARTICLE

Feasibility study on formation of fresh water reservoir and impounding the surface runoff for urban water survival in a coastal brackish water region of Kollam, India

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Abstract: The paper presents the feasibility study on the formation of fresh water reservoir and impounding the surface runoff in a typical brackish water lake of southern India, Ashtamudi Lake for urban water survival of coastal town, Kollam, India. The concept envisages of building a barrage at the outlet of Ashtamudi Lake at the mouth of the Arabian Sea to serve the purpose of preventing seawater intrusion into the lake, avoiding the contamination of the freshwater supply from sea water. To validate the concept, it is proposed to conduct a feasibility study which addresses the concerns about the availability of runoff from Kallada River. The paper also presents possible schemes for storing fresh water within Ashtamudi Lake by constructing dikes at appropriate locations. The length of dike and the volume of water that can be stored with proposed schemes are outlined in the paper.
Keywords: coastal reservoir, brackish water, dike, runoff

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Received: July 2, 2017; **Accepted:** August 10, 2017; **Published Online:** September 30, 2017
Citation: Sitharam T G, Kolathayar S, Samuel M P, *et al*., 2017, Feasibility study on formation of fresh water reservoir and impounding the surface runoff for urban water survival in a coastal brackish water region of Kollam, India. *Journal of Sustainable Urbanization, Planning and Progress*, vol.2(2): 34-37. http://doi.org/10.26789/JSUPP.2017.02.004

1 Introduction

As the available fresh water sources are very less throughout the world, there is a stress upon the available sources and in conservation structures. The focus of desalination and other techniques are increased, but for a developing country like India, it is very difficult for a huge investment in projects like desalination which demands high maintenance cost as well. The coastal cities are normally more urbanized. There is a rapid migration of people there because of the job opportunities. There would be rapid increase in population where the demand for water would increase exponentially. Presently the solution for this issue would be a Coastal Reservoir (fresh water reservoir) i.e. a reservoir near the sea. Coastal reservoir is a unique structure constructed at an estuary (point where a river meets a sea) to store the excess water at flood times. This coastal reservoir has its own advantages in case of land acquisition and forest clearance. They are already put to work in countries like Netherland, Singapore etc and proven to be beneficial also. This plan would be the only clear source of fresh water during drought times. The construction follows a unique concept which can cater the action of both saline and sea water. They are designed with gates so that the excess flood water more than the capacity of the reservoir can be discharged into the sea[1].

Table 1. Proposed storage schemes.

	Location of storage	Storage capacity (TMC)	Length of dike (m)
Scheme 1	Chittumalachira, part of Ashtamudi	0.3	775.25
Scheme 2	Ashtamudi partially	3.0	267.00
Scheme 3	Ashtamudi full	12.0	622.02

Kollam city is the fourth largest city in the state of Kerala, India, with a population of 389 thousand. The Kollam district accounts for 2.64 million population. As per Census 2011, the city has a gross population density of 6,090 persons per km^2, which is second highest in the state.

The Kallada River has its origin in Papanasam range South of Kulathupuzha in Kollam district itself at an altitude of 900 m above MSL. The river has a length of 121 km, and drains an area of 1,699 km^2 before confluencing with the Ashtamudi Lake. Even though the monsoon period of the basin is considered from June to November, the basin gets most of the rainfall during June to August. The Kallada Basin recieves good

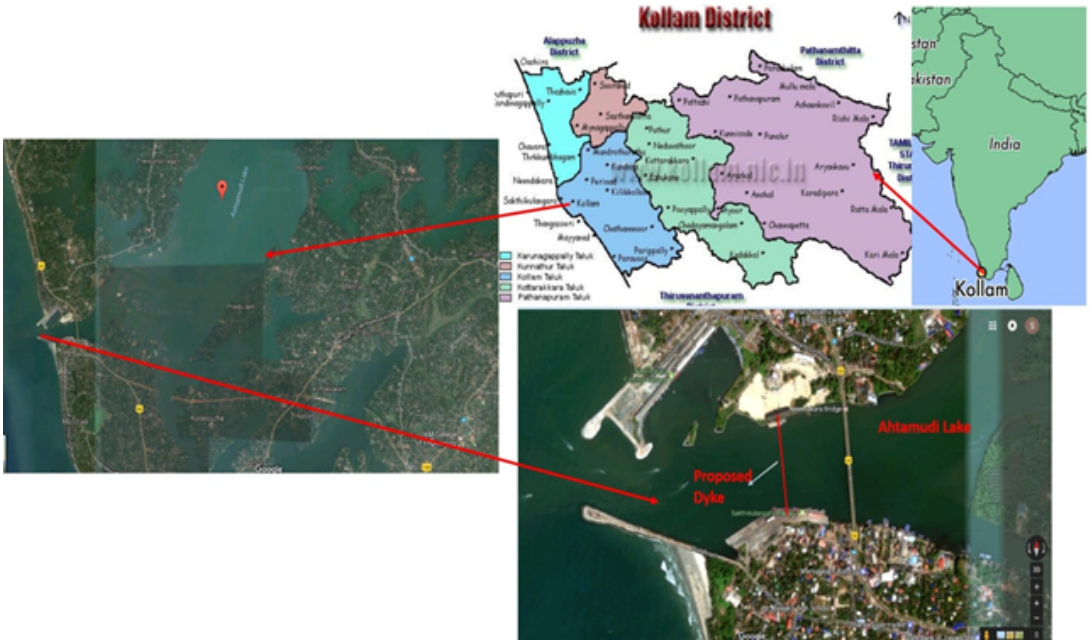

Figure 1. Location of study region along with proposed dyke.

rainfall with annual rainfall varying from 2,225 mm to 4,038 mm[2].

Ashtamudi Lake is the second largest lake, next to Vembanad Lake in the state of Kerala, India. Ashtamudi wetland is an estuary filled with brackish water and this lake has eight arms and all the arms converge into a single outlet at Neendakara, to enter the Arabian Sea. Ashtamudi is the deepest estuary in Kerala with a maximum depth of 6.4 m at the convergence zone.

2 Need of the Study

In-spite of high rainfall in the district, Kollam city and surrounding regions are facing water shortage in summer due to storage shortage. Kollam city has a total water demand of 60 MLD of water per day and the current availability is 28 million liters per day. The total current water requirement in Kollam city is 0.77 TMC ft. Kollam Municipal Corporation draws 16 MLD of water from Sasthamkotta Lake, which goes almost dry in summer months. Ashtamudi Lake is a much bigger lake (6,424 ha) which contains brackish water and hence unqualified for domestic use. This necessitates a feasibility study on the concept of formation of a fresh water reservoir to augment the water demands of Kollam city by converting Ashtamudi Lake to a fresh water lake (partially or fully). Besides this, the sea level rise, according to researchers, is of serious concern in the state of Kerala which has a 590 km-long coastline and large expands of backwaters and estuaries and low-lying areas such as filtration ponds. Some tiny islands in Ashtamudi Lake like Munroe Thuruthu Islands seem to be gradually sinking due to subsiding coasts, eroded shoreline, loss of wetlands, reduced sediment deposits and sea-level rise. Nearby areas are facing frequent and increased tidal flooding through the year. The role of proposed project in saving these islands and other low lying areas from tidal flooding and sea level rise will be investigated and presented. This paper proposes the concept of constructing a dike at the mouth of a popular brackish water lake of southern India, to check sea water intrusion into the lake and to save tiny islands in the lake from the after effects of sea level rise and climate change. Salt water intrusion is perceived in the shallow aquifer in the western part of Kollam district which is in connection with the back water. There is water scarcity along the eastern hilly areas and water logging issue is observed in rainy season along the western part of the district bordering the back water.

3 Gist of the Study

This study aims to conduct a comprehensive feasibility of the concept of conversion of brackish Ashtamudi Lake to a fresh water reservoir by building a barrage at the outlet of lake at the mouth of the Arabian Sea (Neendakara) and also suggest the remdial measures to clean up the lake from the sewage disposal. On one side, it will block freshwater flowing from Kallada River to the lake from being dispersed into the sea. On the other side, the barrage will prevent seawater from entering the lake, avoiding the contamination of the freshwater supply from saltwater. The project schemes comprise mainly two steps, first is the construction of the dike at the mouth of Ashtamudi Lake, and second is the process of natural replacement of salty water by rainwater and surface runoff to the lake. The dike must be designed to separate fresh water from the salty waters of the Arabian Sea. The quantity of flood water has to be estimated and the possibility to alleviate flooding during high tides in the ocean. Large steel/concrete gates are suggested, that can be raised or lowered depending on the need during low tide and

high tide. As the water level in the reservoir rises, the gates incline downwards, releasing water out to sea but preventing the entry of water from the sea into the reservoir. The dike has to be supported on pile foundation founded on the rock.

4 Kallada River Basin Details

Kallada river basin with geographical coordinates 9°10'0" N to 8°44'0" latitudes and 76°30'0" E to 77°20'0" longitude is one of the major river basins in Kerala with an area of 1,654 km^2. Kallada River originates from the Karimalaikadakkal ranges (1,524 m) of Western Ghats, flows towards the west and ultimately drains into the Ashtamudi Lake in Kollam District. Average annual rainfall of the basins is found to be 2,800 mm and average annual streamflow is found to be 3,374.86 mm^3. Important rainguage stations are Punalur, Quilon, Kottarakara, and Thenmala and discharge stations are Enath, Punalur and Thenmala [3].

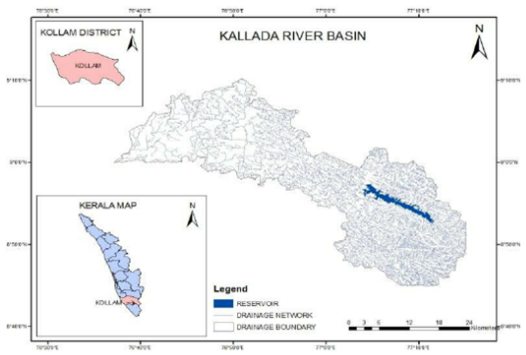

Figure 2. Stream network of drainage basin for Kallada River Basin.

For Characterization/classification and analysis of coastal sub-watersheds (Ashtamudi Basin) with Morphological, and Hydrological parameters, clustering algorithms can be useful for urban watersheds classification to form homogenous groups, particularly if many parameters are associated with watersheds. In the study, clustering analysis techniques including Kohonen Neural Networks (KNN), K-means Cluster Analysis (KCA), Principal Component Analysis (PCA) will be adopted and a genetic programming based Hybrid clustering algorithm will be proposed for characterization/classification of sub-watersheds in the study region of brackish Ashtamudi basin. High nitrogen and phosphorus concentrations in storm water runoff have the potential to impact ecosystem integrity and river ecology. Suspended solids and industrial wastes are discharged into Ashtamudi Lake from shores and river absorb various substances such as heavy metals and nutrients. In this context, a study has been contemplated in the proposed project to continuously monitor the quality of Ashtamudi Lake water through periodical sampling and conducting standard physico-chemical analysis and subsequently design a water filtration system in the proposed barrage complex.

5 Marina Barrage

The details of Marina Barrage are included herewith due to slight resemblance of the proposed project with the Marina Barrage in terms of construction and geography. The Marina Barrage acts as a barrier between fresh water in the Marina Bay and salt water of the South Chinese Sea. Nine large steel gates were installed at the site that can be raised or lowered. As the water level in the reservoir rises, the gates angle downwards, discharging water out to sea and stopping the passage of sea water into the reservoir. When the barrage was first instituted, the reservoir contained a mixture of freshwater and seawater. The reservoir water was turned completely freshwater through the natural process of replacement by rainwater, which began in April 2009. In 15 months the bay has become a freshwater reservoir with a stable water level [4].

6 Proposed Fresh Water Storage Strategy

Sasthamkotta Lake is rain fed and has no visible fresh water source or tributaries. The groundwater recharge to lake is greatly reduced these days. But it is not the best option to take Kallada water to Sasthamkotta. Because during rainy season it is already fed and there is no point in taking flood water to Sasthamkotta. In contrary, Ashtamudi is a brackish lake and even if one mudi (arm) is replaced with fresh water, it can augment the water demand of Kollam and adjacent regions throughout the year which is not possible from Sasthamkotta which has insufficient water in summer. Three schemes are proposed here as shown in Figure 4. Scheme 1 is planned in Chittumalachira which is already connected to Ashtamudi through a canal. If we can have a canal from Kallada to Chittumalachira, fresh water from Kallada can be drawn for Scheme 1. Scheme 2 envisages to convert one arm of the lake into complete freshwater reservoir. Scheme 3 aims at converting entire Ashtamudi Lake into a fresh water reservoir for which the dike has to be constructed at the outlet of Ashtamudi Lake into the sea at Neendakara. Details of proposed storage schemes with storage capacity and dike lengths are shown in Table 1. The annual yield of Kallada River is about 80 TMC ft and enough water is available every year to supply fresh water to proposed schemes in Ashtamudi Lake.

7 Conclusion and Recommendations

This study proposed the concept of constructing a dike at the mouth of Ashtamudi Lake, to check seawater intrusion into the lake and to save tiny islands in the lake from the after effects of sea level rise and climate change.

Conversion of brackish Ashtamudi Lake to a fresh water reservoir is feasible by building a barrage at the outlet of lake at the mouth of the Arabian Sea (Neendakara). On one side, it will block freshwater flowing from Kallada River to the lake from being dispersed into the sea. On the other side, the

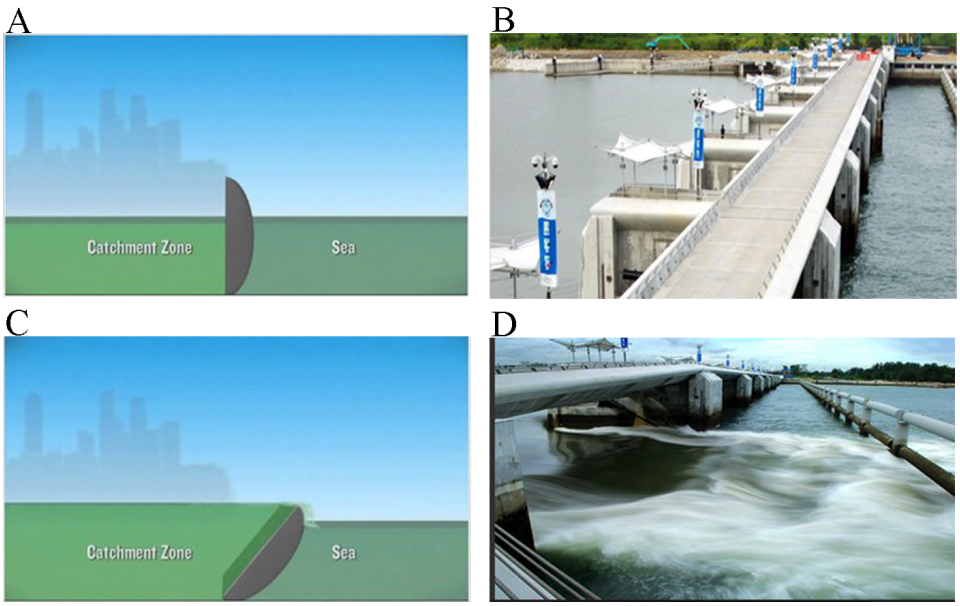

Figure 3. Marina Barrage mechanism. (A) Mechanism, showing vertical "closed" gates. (B) Marina Barrage, with "closed" gates. (C) Mechanism, showing diagonally tilted "open" gates. (D) Marina Barrage, with "open" gates.

Figure 4. Proposed schemes of fresh water storage strategy in Ashtamudi Lake.

barrage will prevent seawater from entering the lake, avoiding the contamination of the freshwater supply from saltwater. This paper presented three different possible schemes to meet the water demands of Kollam city, Kollam district and entire state of Kerala. The required lengths of dikes for these schemes are presented along with storage capacities. Scheme 1 can supply water to entire Kollam Muncipal Corporation. Scheme 2 can meet water demands of Kollam, Cochin and Thiruvananthapuram cities. Scheme 3 will suffice to supply water to entire state of Kerala. Coastal reservoirs use the sustainable storm flood waters which are reasonably cleaner. This will emerge as a sustainable strategy for water resource development in the coming years. The annual yield of Kallada River is 80 TMC ft and hence enough water is available every year to supply fresh water to proposed schemes in Ashtamudi Lake.

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