Suppressing Capillary Salination and Reclaiming Land and Water Resources

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Abstract

An innovative concept to harvest water from the downstream catchment areas of Kanagarayan Aru from Iranaimadu Tank (IT) up to Murasu Moddai causeway is discussed in the paper. Beside the storm runoff from the downstream catchments, the overflowing excess irrigation water from Killinochi Irrigation Areas (KIA)will be also harvested at the causeway. This water is currently unused and discharged into Elephant Pass Lagoon (EPL). The runoff collected at Murasu Moddai causeway can be used for irrigation by lifting it and discharging into the high-level irrigation canal to replace the water drawn from IT to irrigate the gazetted downstream KIAs.

By doing so, it is possible to keep in storage the equivalent amount of water in the IT which can be made available to Jaffna Water Supply (JWS) project as proposed by ADB. ADB could not procure the anticipated water, even after upgrading the dam to store more water in the IT, due to KIA farmers concern that they will be deprived of irrigation water if water is abstracted from IT for the water supply project. This situation will not arise in the concept proposed in the paper because the KIA's farmers entitlement to use the entire runoff from the upstream catchment areas of IT will not be compromised with as the project discussed in the paper uses only the unused runoff collected from the downstream catchment areas and retained in the IT via the innovative approach discussed in the paper.

In addition to the above benefit, the project will also enable to supply the critically needed water in the major water storage lagoons known as Vadamaradchi East Lagoons in Jaffna peninsula to suppress the capillary induced salinity intrusion in the lagoons which occurs during the dry months of July, August, and September. This will tremendously help to enhance the freshwater availability to farmers in the adjoining areas of the lagoons as discussed in detail in the paper.

A comprehensive hydraulic and hydrology modelling done to the project area revealed that the above option is technically feasible.

Keywords: Capillary, Salination, Water swap, Desalination, Airspace, Carryover, Reclamation

1. Introduction

An innovative engineering option to harvest water from the downstream catchment areas of Kanagarayan Aru from Iranaimadu Tank (IT) up to Murasu Moddai causeway is discussed in the paper. Beside the storm runoff from the downstream catchments, the overflowing excess irrigation water from Killinochi Irrigation Areas (KIA)will be also harvested at the causeway. This water is currently unused and discharged into Elephant Pass Lagoon (EPL) . Detail location of IT, EPL and other features are shown in Figure 1.

The water thus harvested at Murasu Moddai causeway will be used to augment the largest storm water storage lagoon, known as Vadamaradchi East Lagoon (VEL) in Jaffna peninsula, which is currently saline and thus the water is unusable for agriculture or drinking purpose. There are several spins off benefits that can be accrued from this project as explained in the paper.

The main focus of this paper is to explain how to harvest the unused surface runoff from the downstream catchments of Iranamadu Tank (IT) and how it can be used to supress the salinity intrusion and convert the saline infested water in the lagoon. The project will also ensure the badly needed water from IT for Jaffna Water Supply project which ADB could not implement till date due to non-availability of water from IT because of the concerns raised by the farmers of Killinochi Irrigation Areas(KIA) The paper explain how the concerns of the farmers of KIAs can be overcome without compromising on their legitimate right to use the runoff stored in the IT from the upstream catchments of Kanagarayan Aru.

The paper discusses the engineering aspects of the salinity intrusion in the lagoon which occurs

perpetually in the dry months of July, Aug, and Sept. The paper explains the capillary action phenomenon that occurs every year in the dry months of July, Aug, and Sept when the water level in the lagoon drops to the lagoon's bed level and subsequently the bed becomes dry. As a consequence, up flow of saline groundwater to the lagoon occurs and as and when the saline ground water reaches the dry bed, it gets evaporated, leaving the salt deposit behind in the bed. This phenomenon is called "Capillary Action." (Similar to tiny body's capillaries, which draw sweat away from the skin, onto the fabric, and allow it to evaporate on the surface of the material rather than on the skin)

The project will make available the critically needed fresh water required in the lagoon in the dry months of July, Aug, and Sept to supress the up flow of saline ground water into the lagoon and prevents the salt deposition in the lagoon's bed. It is estimated that within 3years with accelerated water quality improvement, the lagoon will be converted into a freshwater lagoon and be capable of providing sufficient water for drinking and irrigation purposes to the people in the peninsula

The proposed conversion of salty lagoon water into a freshwater lagoon will enable the farmers to rehabilitate and recover a substantial area of agricultural lands adjoining the lagoon. They are currently uncultivable due to saltwater contamination by the spilled salty water from the lagoon during the wet months. Conversion of saline water into fresh water in the lagoon the lagoon will also help to harness the unique underground aquifer and surface water resources available to Jaffna peninsula. This will entail rehabilitation of numerous small Tanks to retain a substantial amount of monsoon storm water flows from the annual rainfall of about 1350mm in the peninsula.

2 Jaffna Water Resource

Jaffna Peninsula is mostly a flat terrain with a fragile limestone aquifer based unique hydrogeological formation. The aquifer has been providing water for drinking and agriculture purposes to the people for centuries. The annual replenishing of groundwater in the peninsula is entirely from rainfall percolation. Fortunately, the peninsula has a good monsoon rainfall which occurs from Oct to Jan.

The average precipitation during this period is about 1350mm. All the shallow groundwater found within the limestone cavities is from the infiltration of rainfall, and this shallow groundwater forms mounds or lenses floating over the saline water permeable soil. The peninsula has an old irrigation system consisting of two thousand man made small Tanks. The water retained in these tanks during the monsoon months greatly help to replenish the ground water aquifer.

There are three non-perennial rivers, namely Thondaman Aru also known as Vadamaradchi lagoon, Uppu Aru and Valukai Aru in Jaffna peninsula which have water only during monsoon months. They can be better used to recharge ground water and arrest salinity intrusion in the aquifer during non-monsoon months if adequate surface water can be brought into Jaffna Peninsula.

There is always a delicate balance between seawater lens and the fresh water in the aquifer. Thus, good replenishing of the ground water takes place by capturing more rainwater during monsoon months in the numerous ponds and tanks within the peninsula. The ponds and tanks require regular desilting to maximise the benefits. They have been neglected over the past few decades.

3. KIAs farmers concerns and Jaffna Water Supply

Under the ADB funded Jaffna Water Supply Project, the IT bund was strengthened and raised by 0.6 m to increase the storage from 132 MCM to 148 MCM. This included an allocation of 18 MCM of water for Jaffna Water Supply (JWS). However, the Killinochi farmers have expressed concerns to the use of the water for JWS despite excessive spilled water wasted to sea with downstream flood damages.

Any options to secure the 6 MCM water is mindful of the concerns expressed by the farmers of Killinochi Irrigation Areas (KIA) that the stored water in the IT is meant only for irrigating the gazetted KIAs during Maha and Yala cultivation period with a maximum cropping intensity of 1.4 (Irrigation department planning requirement). Thus, abstracting any water from the existing storage of IT for other use such as to prevent the salinity intrusion in the VEL is not a

feasible option unless an alternative way of retaining the required quantity of water in IT without compromising supply to KIA farmers.

4. Vadamarachi East Lagoon (VEL)

The Vadamarachi East Lagoon (VEL) is one of the largest lagoons in the peninsula with a catchment area of about 138 Sqkm, which is about 13% of the total area of Jaffna peninsula. The lagoon has a water surface area of about 34 Sqkm, when it is full. At 1.3 m aMSL the lagoon storage capacity is 18.9 MCM. This is adequate to rejuvenate adjoining ground water aquifers and agricultural lands. It can also provide water for drinking and farming purposes, if the salinity is eradicated.

Description	Quantity
Catchment Area (sq.km)	138
Lagoon surface area at FSL	34
Storage Volume at FSL (MCM)	18.9
Catchment Area/Volume ratio	9.1
Annual rainfall (mm/day)	3.56
Annual Simulated inflow (MCM)	67.8
Direct rainfall in Lagoon (MCM)	29.9
Evaporation (MCM)	20.2
Spill (MCM)	33.1
Draw & Groundwater losses	42.4

Table 1 – Simulated water balance in VEL

The rainfall runoff collected in the lagoon during the monsoon months becomes saline due to perpetual salt deposition in the lagoon beds due to seawater intrusion by a phenomenon, called "capillary action" as shown in Figure 1. It takes place during the dry months of July, Aug, and Sept when the lagoon's bed is dry and void of freshwater head to suppress the capillary flow. Significant trend in water quality improvement after refurbishment of gates to the Thondamanaru Barrage has achieved.

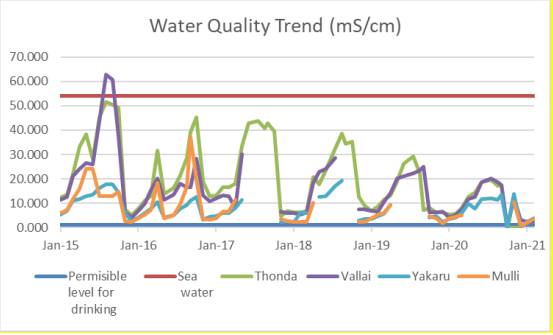


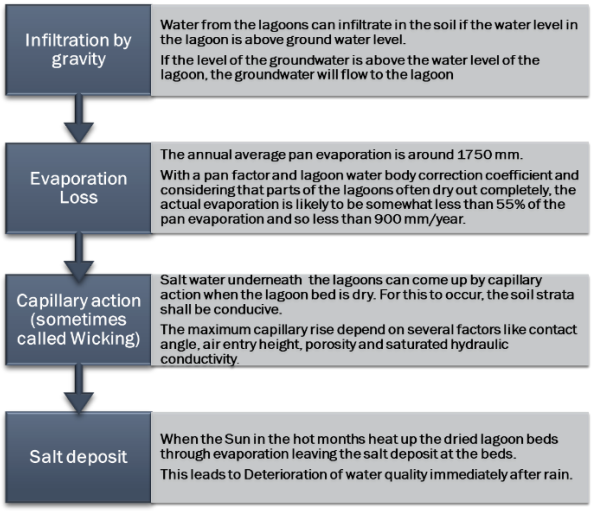
Figure 2 Water Quality trend

The proposed option will ensure adequate fresh water to the lagoon to fill up the bed's dry weather channel to a depth of at least 300 mm in July, Aug, and Sept. This will keep the bed wet and in a submerged condition to suppress the capillary flow by interconnecting the sinks in the VEL bed for a length of 20 Km as shown in figure 4 (ref page 8)

5. Capillary Salination in lagoon

How salt deposition occurs

A flow chart on salt deposit process ism outlined below:



Capillary action is a process by which a fluid can flow upwards against gravity through the narrow voids in the soil strata. The process is very similar to the way the oil moved upwards by a wick in an oil lamp. As long as the oil lamp continues to burn, the oil will continuously rise to the top of the wick and burn itself.
Similarly, during the dry months of July , Aug and Sep , the seawater lens rises by capillary action and evaporates, leaving the salt deposits in the lagoon bed as shown in Figure 3. This very prevalent at the sinks. Over a period more salt deposits and makes the incoming storm water to the lagoon to become saline.

Previous attempts to control salinity

In the past Engineers have made several attempts to prevent salinity intrusion, improve water quality and provide fresh water. Their efforts included blocking off salt-water lagoons from the sea and bring trans basin water from the mainland to peninsula. These efforts date back to the 17th century. A famous plan known

as 'A River for Jaffna' prepared by Eng. Arumugam in 1954, then acting Director of the Northern Irrigation Department.
The project 'River for Jaffna' is currently under consideration by the Government of Sri Lanka to transfer water from Killinochi district to the lagoons of in the Jaffna peninsula. This will improve the water resources situation in VEL and suppress the salinity in the ground water.

Connecting sinks and preventing salt deposition

Fortunately, the salt deposition occurs only in the limited low-lying dry weather flow channel of the lagoon. Thus, by keeping the bed of the channel submerged during the dry period of July to Sept will prevent the capillary action. This process will enable the lagoon to become saline free over a period of about 3 years of flushing of the inherent salt deposit. Thus, after three years, the lagoon's water quality will improve and be capable of providing potable quality water for drinking and farming purposes.
Thus, improving the quality of water in VEL, will in turn cascade and improve the water quality in Vadamarachi North and Upparu lagoons over a couple of years.

Water required to suppress salinity

It is estimated that 6 MCM of fresh water is required in July August and Sept to supress the capillary action in the three compartments of VEL. 6MCM is adequate to compensate the evaporation. Further this resource amount has been optimised splitting VEL into three compartments as marked in Figure 4.

6. Securing 6MCM of fresh water.

Hydrology and Environmental flows

The modelling study established that about 70 MCM of storm runoff from downstream of IT catchment of 200sqKm of Kanagarayan Aru is available at EPL in an average year. The 70 MCM confirmed in a separate hydrological modelling conducted by Mahaweli Authority (ref 8) .However, CAPP limit to harvest is set at 35MCM so that the reduction in the total flow of fresh water to Elephant pass lagoon limited to only 17.5% of the total 200 MCM arriving to EPL. This allows for the needs of the prawn cultivation, bird sanctuary and environmental requirements at Chundikulam. Thus, infrastructure needs to be built to harvest a total of about 35MCM storm runoff to EPL. Resource requirement is allocated for multipurpose as follows:

- 6 MCM to suppress capillary salination in VEL. This will generate 18 MCM water resource in VEL with a net gain of 12 MCM. This will realise 2400 Ha of land for OFC crop or fruits/vegetable development.
- 9 MCM for JWS
- 16 MCM to irrigate 3200 Ha of ungazetted agriculture/horticulture land for OFC or fruit/vegetables crops
- 2 MCM for blended water (brackish and saline) for Aquaculture around EPL and Jaffna lagoon.
- 1 MCM for livestock farming.
- 1 MCM for industrial use.

EPL Wetland

The main purpose of this wetland is to supply the vital 6MCM of water that required in VEL in the dry months of July, Aug, and Sept. Surplus harvested wetland water more than 6 MCM will be stored at Yakkachi via pumped storage. This can be used for other beneficial agriculture/ aquaculture uses. Note that there will be no stored fresh water in the Peninsula during the dry months as the small Tanks will be dry in the period. Thus, water must be brought in from a storage reservoir from IT which is about 31 km south or Yakkachi pumped storage which is 4 km SW of VEL. The required amount of water can be obtained from IT. However, it is emphasised that this water will not be part of the KIA farmers allocation.

Water Swap

Concept of re-using irrigation water (operational mismatch and farm loss) from Iranamadu Tank (IT) and d/s catchment run-off during the northeast monsoon by capturing at Murasu Moddai causeway and pumping to irrigate areas that would otherwise have to be supplied directly from IT. This water would otherwise flow along Kanagarayan Aru to Elephant Pass Lagoon and wasted to sea. The water saved and stored in IT (without building any expensive storages), will then release as Jaffna Water Supply (JWS) needs during eight

months other the rainy season. Any water saved through pumping d/s of Iranamadu and Kangambihai tank that presently not utilized by KIA farmers will be able to use through a balancing tank at Uriyan to irrigate nearby rainfed area, thus increasing district productivity.

Frequent IT Spills and d/s flooding

Recent hydrological study on Iranmadu tank (IT) annual spill volume probability exceedance indicates that a spill frequency of 1 in 2 years with recent observed d/s flooding. However, availability of sufficient hydraulic head in IT for transmission of water all the way to VEL through a gravity pipeline is vital to cross the low-lying Elephant pass lagoon. Hence, there was a need to develop an ingenious way to replenish the water that will be abstracted from IT and conveyed via gravity pipeline to VEL without compromising on the irrigation requirements of the KIA farmers. Any spill water that not used directly for JWS requirement will be stored at Yakachi tank. Thereby saving energy in pumping from wetland.

Conveyance of saved water and spill water

To convey this saved water, spill water, air space management water for flood mitigation and advanced release for JWS from IT with higher hydraulic head a pipeline is essential. Advance release to JWS must adopt as a commonly used "Water allocation Carry Over Accounting System" that will not affect the KIA farmers water allocation. Furthermore, this conveyance system will also use for other beneficial development purposes such as horticulture, aquaculture, industries, suppressing capillary salination, stock supply and efficient green energy,

7. Integrated Approach

It is particularly important that an integrated approach to be adopted for the best benefit of the community in the Jaffna and Killinochi districts considering:

- Environmental flows
- Wetland Harvest
- Water Swap
- Frequent Spill water & d/s flooding
- Cascaded VEL Capillary salinity suppression
- Creation of usable water resources in VEL
- Jaffna Water Supply and Desalination
- Land Reclamation
- Security of nearby tank irrigation supply
- Killinochi and Jaffna district productivity

Considering the enormous benefits, this integrated approach with water saving and using this water for Jaffna supply at a higher head in IT is a worthwhile to compare against desalination option. The primary benefit of the proposed project is to rejuvenate ground water aquifers and surface water resources in Jaffna Peninsula and provide water for Jaffna water supply scheme. There are other spinoff benefits that the suggested option can offer with total CAPP on 35 MCM harvestable resources.

8. Conclusion and Recommendation

Decent quality water is acutely scarce and is essential for all life on this planet. With climate change this situation will further aggravated. Water is being extensively traded in international markets due to scarcity and demand.

Therefore, it is very essential that this valuable resource is shared in a fair and equitable manner. Furthermore, the sharing should be done in an integrated manner encompassing drinking / agriculture /aquaculture /stock and industry. This is a far superior alternative to expensive de-salination plants which also have high operating costs that the community can ill afford.

Hence it recommended that this proposal to considered for adoption.

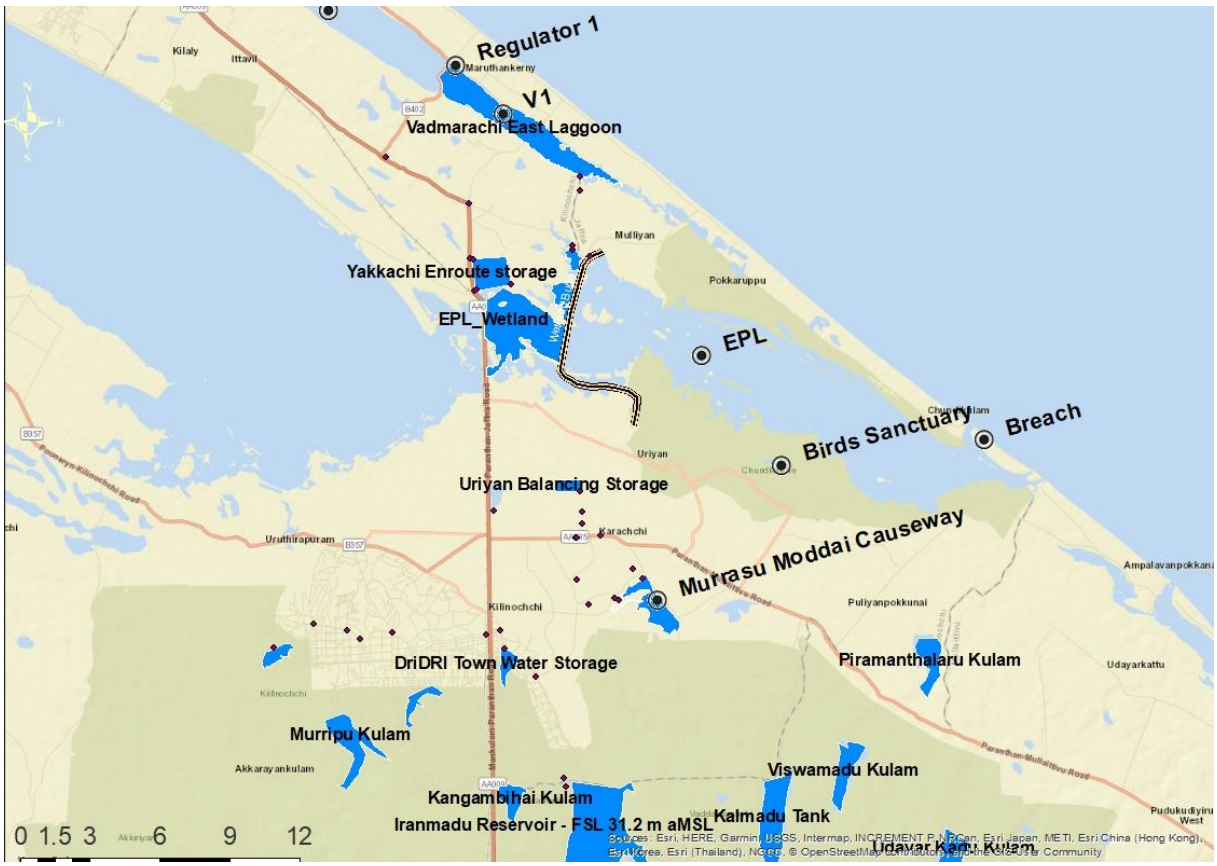


Figure 1 - Location Map

Figure 3 – Salinity affected VEL in September 2018

Figure 4 – Maintain water in connected sinks to suppress capillary salinisation

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