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# River for Jaffna-Cultivating Productive Water from Salt Water Lagoons in Northern Sri Lanka-What the Water Balance of Elephant Pass Lagoon Demonstrates?

**Kuganesan, S[1] and Sivakumar, S.S.,[2]**

**Abstract**—*The proposal of converting Jaffna salt water lagoons in northern Sri Lanka to fresh water lakes is revived again in the recent days due to the increasing demand and dearth of fresh water in this region. Jaffna lagoon consists of two internal lagoons in the Jaffna peninsula and the external lagoon, Elephant pass. Four intermittent rivers with the total catchment area of 940km$^2$ drain to the Elephant pass lagoon. This study focused on water balance of the proposed Elephant Pass fresh water Lake and hence available productive water for usage. Microsoft Excel based simplified reservoir simulation model was developed to study the water balance of the lagoon. Minimum operating level was set at 0.0 m MSL with the proposed spill crest level of 1.2 m MSL. The results of the monthly simulation of lake showed that even after high evaporation loss, nearly 2 MCM/month was available for release throughout the year. With upstream spill, nearly 4 MCM/month was available and excess of 6 MCM/month could be drawn from December to April. This study can be basis for future detail hydrological model study and planning of Elephant Pass lagoon for best use of water with minimum negative environmental impact*.

**Index Terms**— *salt water lagoons, Elephant Pass fresh water Lake, productive water, environmental impact, Elephant Pass lagoon, reservoir simulation*.

## 1 Introduction

IT has been proposed since as back as 1879 to convert the Jaffna salt water lagoons in northern Sri Lanka to fresh water lakes in order to improve the water resources in the Jaffna peninsula. Due to the nature of the Jaffna peninsula, Ground water is the only available source of water supply in this region. This scarce source has been increasingly contaminated in various ways. Salt water intrusion accounts for the major contamination in the coastal limestone aquifer of the Jaffna peninsula. The increasing deteriorated quality of ground water emphasizes the need for preservation and thinking of possible alternative sources of supply.

The extremely permeable high yielding limestone aquifer has been used extensively for all of the water needs of the Jaffna peninsula. In addition to the domestic use, ground water is pumped increasingly for agricultural and industrial activities. As Jaffna peninsula is surrounded by sea on all four sides and no place in it is more than 16 km from the sea, it is susceptible to sea water intrusion from all directions. Increasing extraction from the shallow aquifer has resulted in substantial fresh water level decline and subsequent encroachment of seawater into the aquifer.

- [1]Energy division, Norconsult AS, Postbox 626, 1303 Sandvika, Norway; PH (0047) 45401454; Email: engkuganesan@yahoo.com
- [2]Head of Department and Senior Lecturer, Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Kilinochchi, Sri Lanka,PH (+94) 772508730; email: sssivakumar@jfn.ac.lk

The recharge to the fresh ground water aquifer is entirely from percolation of rainfall in the local catchment, only a limited quantity is available. The rainy season recharges the ground water aquifer annually. The total annual average rainfall in this area is 1300 mm and 70% of it falls within three months from October to December. Most of the water drains to the sea through the intermittent rivers and through lagoons. It has been shown that the salinity of water in underground reservoirs increased when the recharge from the rainfall was reduced. Hence, steps should be taken to increase the recharge to the underground resources by conserving more of the rainwater (Navaratnarajah, 1994). Recharging the ground water reservoir and protecting it from salt-water intrusion are great importance to the existence of Jaffna Peninsula.

The Jaffna lagoon is a shallow coastal water body in the Jaffna peninsula, northern part of Sri Lanka. It is located between 79° 54'E and 80° 20' E longitudes and 09° 30' N and 09° 50' N latitudes. As shown in the Figure 1, Jaffna lagoon consists of two internal lagoons in the Jaffna peninsula, Vadamarachchi (Thondamannaru) and Upparu and the external lagoon, Elephant pass, which separates the peninsula from the main land of Sri Lanka. Vadamarachchi and Upparu lagoons comprise an area of 77.6 km$^2$ and 25.9 km$^2$. Catchment area of 298 km$^2$ and 220 km$^2$ drains respectively to these internal lagoons. The external lagoon with 78km$^2$ area get discharge from 940km$^2$ regulated catchment. All of three lagoons have exits to the sea and the fresh rain water inflow to these lagoons drains finally to the sea.

The hypothesis of converting saltwater lagoon into fresh water

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lake is to isolate the lagoons from the sea by constructing barrages and flush out the salinity of the lagoons repeatedly over a period of years with fresh water run-off. By this process of reducing the salinity of the brackish water in the lagoons, it is anticipated that the uncultivable lands fringing the lagoons would become suitable for cultivation and the brackishness of water in many of the wells in the peninsula would be reduced gradually. It is also envisaged that lagoons as surface water storage increase the detention of rainwater for percolation and increased recharge of groundwater aquifer.

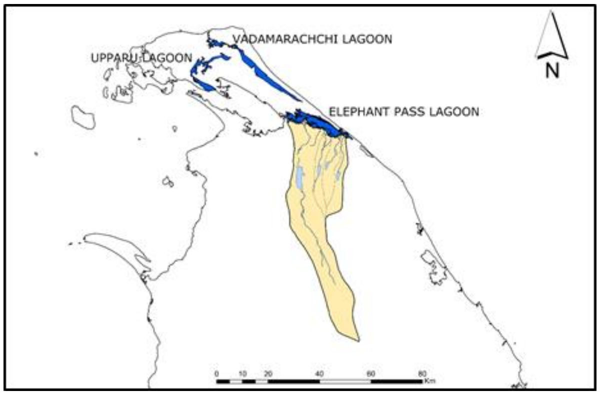


Figure 1: Overview of Jaffna lagoon

In 1950's Thondamannaru barrage in the sea mouth of Vadamarachchi lagoon and the Ariyalai barrage in the Upparu lagoon were constructed by the Irrigation Department. When the works to convert Jaffna peninsula internal lagoons into fresh water lakes was nearing completion, it was recognized that a plentiful supply of rain would be required over the years to leach out the salt encrusted lagoon bed. The leaching action of the two internal salt water lagoons would be naturally slow process on account of the limited catchment area draining into these lagoons. Attention was therefore directed towards converting the Elephant Pass lagoon into a fresh water lake and discharging the excess water into Jaffna lagoon to expedite the process of leaching (Shanmugarajah, 1993).

Elephant Pass lagoon is fed by the larger catchment in the main land and receives much more supply of water. The construction of Elephant Pass lagoon scheme commenced in the year 1962 with the construction of a bund cum spill across the east at Chundikulam and another bund in the west at A9 highway to seal the entry of sea water into the lagoon. Approximately 3.5 km out of 4.0 km long Mulliyan channel linking Vadamarachchi lagoon with Elephant Pass lagoon was also completed incorporating the above mentioned proposal of transferring the water to the Vadamarachchi lagoon. Unfortunately, a few years after construction, the Eastern closure bund was breached and then the lagoon has been encroached again by the sea water and made the water in the lagoon becoming brackish. After a long lapse of time, feasibility study was carried out with fresh field investigations in 1976 by Irrigation Department. (Shanmugarajah, 1993). However, due to the prolonged conflict in this region, the Elephant Pass lagoon scheme has been abandoned last 30 years without further detail study and implementation.

Elephant Pass lagoon proposal is revived again in the recent days due to the increasing deteriorated quality of ground water in Jaffna peninsula. The current expectation is the possible water supply to part of the Jaffna peninsula from Elephant pass lagoon as a fresh water lake and tourism with recreational activities in the lake and estuary in addition to the other envisaged benefits. The lake Ijssel in Nederland is expressed as the successful example project in the context of lagoon as a multipurpose fresh water lake. The lake Ijssel with the reservoir area of 1100km$^2$ at the elevation of - 0.2 m MSL and average depth of 5 to 6m was made by converting the inland sea (lagoon) into fresh water lake in 1932 by constructing a 32km long dam across the sea mouth (Wikipedia). Presently, The lake Ijssel functions as a major fresh water reserve, serving as a source for agriculture and drinking water. It also offers a number of opportunities for recreational activities. The lake Ijssel is fed by huge amount of water from the perennial river Rhine.

The estimation of total average annual inflow (net yield) to the Elephant Pass lagoon was reported as 112 MCM (91000 Ac.ft.) in the earlier study (Shanmugarajah, 1993). At glance, it is a plentiful amount of water flows to the lagoon and fall into the sea without usage. However, the intermittent rivers do not feed the lagoon throughout the year. There are the questions that how much water can be cultivated, will be any water available during the dry months in the lagoon for various purposes? The present water balance study tried to answer these questions. The study of the water balance structure of lakes, river basins and ground-water basins forms a basis for the hydrological substantiation of projects for the rational use, control and redistribution of water resources in time and space (e.g. inter-basin transfers, streamflow control, etc.). Knowledge of the water balance assists the prediction of the consequences of artificial changes in the regime of streams, lakes, and ground-water basins (Sokolov & Chapman, 1974). The main objective of the present study was to compute the average monthly values of water balance components and hence available productive water after various losses by using Excel based simplified reservoir simulation model.

## 2 Catchment Description

The As shown in the Figure 2, four intermittent rivers, such as Kanakarayan aru, Nethali aru, Piramanthal aru and Theruvil aru drain into the Elephant Pass lagoon. Medium and minor reservoirs in the river basins detain the rain water for irrigation demand. Kanakarayan aru river basin is the main and major one feeding Elephant Pass lagoon. It comprises about 75% of the entire catchment area.

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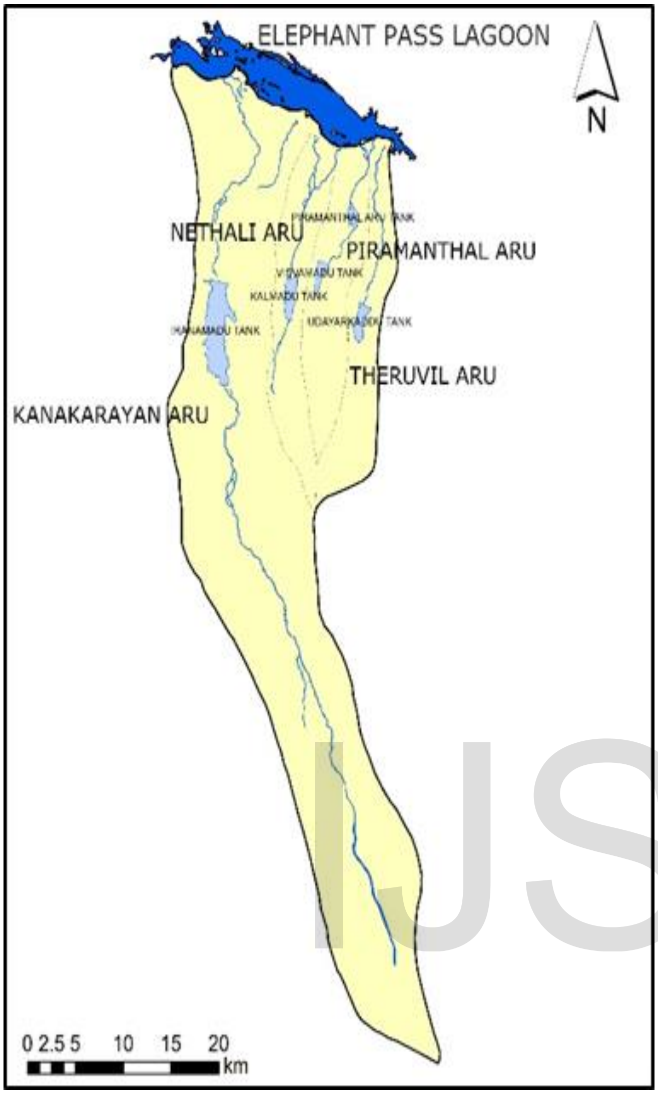


Figure 2: Catchment of Elephant Pass lagoon.

### *2.1 Climate of catchment*

Due to the location of Sri Lanka, close to the equator, the climate of the island could be characterized as tropical. Monsoonal and convectional rain account for a major share of the annual rainfall of Sri Lanka. (Metrological Department of Sri Lanka, 2012). Catchment of the Elephant Pass lagoon is in the hydrological dry zone of Sri Lanka. The catchment gets rainfall mainly from Northeast monsoon. In addition, depression in the Bay of Bengal and hence cyclones bring strong winds with intense rain, sometimes it leads to floods also.

Figure 3 shows the monthly average precipitation and temperature variation recorded during the period 1961 – 1990 in Jaffna. The average annual rainfall is around 1300 mm/year and daily maximum and minimum temperatures are 32.7 and 23.5 respectively. It can be seen in the Figure 3 that peak rainfall occurs during the months of October to December and rest of the months get a little scattered rainfall.

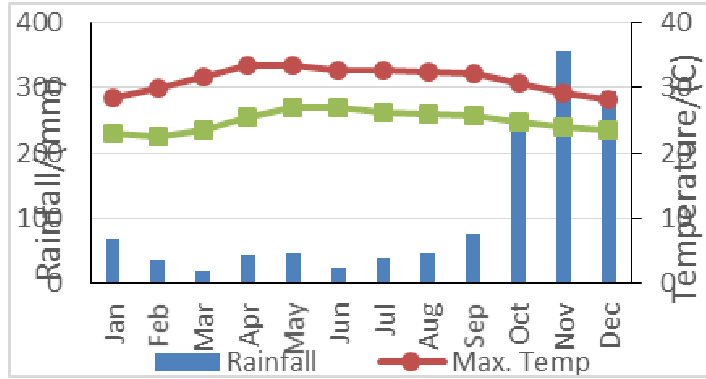


Figure 3: Variation of monthly average rainfall and temperature recorded in the Jaffna weather station (Source - World Meteorological Organization (WMO)).

### *2.2 Bathymetry of Elephant Pass lagoon*

Figure 4 shows the variation of area and storage with elevation of the Elephant Pass lagoon bed. It was plotted by using the data from survey conducted in 1976. It can be seen that bed of the shallow lagoon elevation varies from -1.0 m MSL to +2.5 m MSL.

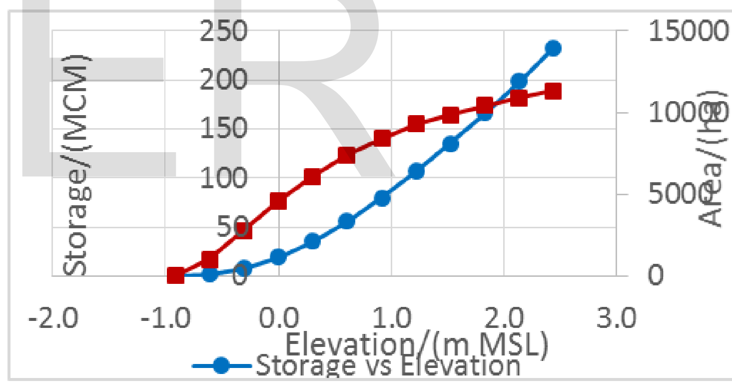


Figure 4: Area, Elevation-Storage curve for the Elephant Pass lagoon (Source - (Shanmugarajah, 1993))

## 3 WATER BALANCE COMPUTATION

Basically The water balance equation for any water body indicates the relative values of inflow, outflow and change in water storage for the volume considered. The simplified water balance equation for the reservoir (lagoon) can be written as follows:

$$S_{t+1} = S_t + I_t - O_t$$

Where
$S_{t+1}$ - Storage at the end of time step
$S_t$ - Storage at the beginning of time step
$I_t$ - Inflow to the reservoir during time step
$O_t$ - Outflow from the reservoir during time step

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Microsoft Excel based simplified reservoir simulation model was developed to study the water balance of the lagoon. The reservoir simulation model comprises Inflow module and Simulation module.

### 3.1 Inflow Module

Stream flow records are not available for the study. The monthly inflow to the lagoon was computed first in the inflow module and then used as input data to the simulation module. The local knowledge of the river basin was the basis for inflow computation. Reservoirs in the upstream catchment detain the annual runoff from the intermittent rivers and the stored water is released for irrigation demand for the two cultivation seasons. Spilling from the reservoirs may occur in the subsequent months of rainy season. Based on the above information, inflow to the lagoon was taken as downstream component and upstream component in order to simplify the inflow computation. Downstream of the reservoirs in the four river basins considered as local catchment to the Elephant Pass lagoon and runoff yield from the local catchment and the lagoon area was the downstream component. The contribution from the upstream reservoirs was defined as upstream component.

### *3.2 Downstream Component*

The monthly runoff yield from the catchment was computed with 75% probability monthly rainfall and the seasonal specific yield of the catchment for that month by following the guidelines provided in the “Design of Irrigation Headworks for Small Catchments” by Ponrajah (1982). The 75% probability monthly rainfall is the 75% relative frequency of occurrence of that rainfall in that month and it is always less than the mean values. When an Operation study is to be performed for a single year, it is recommend to use the 75% probability monthly rainfall rather than long term monthly rainfall in order to obtain more acceptable sizes of reservoirs and areas of development to meet prevailing economic and social factors (Ponrajah, 1982). For this study, the 75% probability monthly rainfall was derived from the observed rainfall records available from 1939 to 2014 at Iranamadu meteorological station in the catchment. The derived 75% percentage probability monthly rainfall is tabulated in Table 1.

| Month | 75% probability rainfall /(mm) |
|---|---|
| Jan | 35 |
| Feb | 15 |
| Mar | 10 |
| Apr | 40 |
| May | 25 |
| June | 0 |
| July | 0 |
| Aug. | 15 |
| Sep | 35 |
| Oct. | 140 |
| Nov | 220 |
| Dec | 150 |

Seasonal specific yield for the local catchment was obtained from iso-yield maps of Sri Lanka plotted for the two seasons, Maha (From October to March) and Yala (From April to September). Specific yield of the catchment for the Maha season is 190.4 x $10^3$ $m^3/km^2$ and for Yala season is 23.8 x $10^3$ $m^3/km^2$. By using the above constant seasonal specific yield values, monthly runoff was computed.

Lagoon consists of considerably large surface area (78$km^2$) and yield from the lagoon was the direct rainfall on the lagoon (reservoir) area. When computing the precipitation that falls on the surface of lakes and reservoirs, it is necessary to take into account the fact that, due to the attenuation of ascending air currents above the water surface, which aids in the formation of convective local precipitation, the amount of precipitation falling on the water surfaces is less than on the land. It may be 15-25% less than the precipitation recorded from a gauging station on the land. (Sokolov & Chapman, 1974). Monthly yield from the lagoon was taken as 80% of the 75% probability monthly rainfall volume within the lagoon area in this study.

### *3.3 Upstream Component*

Upstream component was the drainage from the irrigation release in the upstream catchment and spill volume from the upstream reservoirs. Catchment of Iranamadu tank accounts for 75% of the upstream catchment. Irrigation demand and spilling data from Water Balance study of the Iranamadu tank (Ranwala, 2014) was used in this study. The total monthly average of irrigation demand of the upstream reservoirs was derived and the drainage volume was computed as 20% of the irrigation demand in the upstream catchment. Based on the observations, spilling from the reservoirs in the upper catchment occurs probably during the months of November, December and January. Mean simulated spill from year 1945 to 2012 for Iranamadu tank with year 2035 operation scenario is 65 MCM. However 40% relative frequency of occurrence of spill in a year derived from the data is 45 MCM. The total 40% probability spill volume from upstream reservoirs was taken as 60 MCM/year and it was used as input to the simulation.

### 3.4 Simulation Module

Operation simulation is a process often employed in hydrotechnical developments, e.g. for hydropower plants, water supply works, irrigation projects and flood control projects. The purpose of operation simulation is to estimate the production and economic benefit of the system under varying hydrological conditions (Killingtveit & Sælthun, 1995). Components of the water balance equation (inflow, outflow and storage) were incorporated in the simulation module by logical procedures with the help of Excel functionality. The monthly inflow computed in the Inflow Module was linked to the Simulation module as input data. Water surface area and Water level in the lagoon was given as function of reservoir storage by using the Area, Elevation-Storage curve for the Elephant Pass lagoon shown in Figure 4. Outflow from the lagoon includes evapora-

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tion loss, percolation, demand and spillage. The outflow components as described in this section were computed in the simulation module.

### 3.5 Evaporation loss

Evaporation in the study area is considerably high and significant in this study. Evaporation loss was estimated by using Pan Evaporation data. Monthly evaporation values measured by Pan Evaporation at Iranamadu meteorological station and adjusted with the Pan Coefficient of 0.8 were used in this study and tabulated in Table 2. Evaporation loss from the reservoir (lagoon) was computed as a function of water surface area.

| Month | Pan evaporation /(mm/month) |
|---|---|
| Jan | 76.2 |
| Feb | 82.9 |
| Mar | 110.6 |
| Apr | 102.7 |
| May | 117 |
| Jun | 127.4 |
| Jul | 126.8 |
| Aug | 123.4 |
| Sep | 122.5 |
| Oct | 97.5 |
| Nov | 69.2 |
| Des | 67.4 |

Table 2: Monthly Evaporation values at Iranamadu meteorological station.

### 3.6 Seepage loss

In the operation studies of irrigation reservoirs, monthly seepage loss is taken as 0.5% of the volume of water stored in the reservoir (Ponrajah, 1982). Percolation was suspected to be high in the lagoon area and reservoir simulation was done with 2% seepage loss.

### 3.7 Demand

Demand is not limited to any particular purpose in this study. It can be either diversion to the internal lagoons or water supply from the lake or lift irrigation. In this study the minimum operating level was set at 0.0 m MSL for release. Simulation was done with constant release throughout the year and then simulated with higher release when the water level was above 0.7 m MSL.

### 3.8 Spillage

Spill cum causeway with crest level at 1.2m MSL was proposed by the irrigation department feasibility studies in 1976 (Shanmugarajah, 1993). Simulation was done with spill crest level of 1.2 m MSL in this study. Spill volume was computed as rest volume at end of each time step when the storage at the end of month exceeds the reservoir capacity (106.5 MCM).

### 3.9 Operation Simulation

Operation simulation for the lagoon was run with monthly time step for two cases.
Case - 1: Without upstream spill
Case - 2: With upstream spill (40% probability spilling event)

## 4 Results and Discussion

Reservoir simulation without spill from upstream reservoirs (Case-1) showed that nearly constant release of 2 MCM/month was available throughout the year. Figure 5 shows the monthly quantity of water balance components from the reservoir operation simulation. The water level reached maximum of 0.80 m MSL in January with 70 MCM storage and it lowered to the minimum operating level with 18 MCM dead storage at the end of September. It can be seen that there was considerably high evaporation loss entire year.

The Figure 5 shows the water balance components from reservoir simulation with spill from upstream reservoirs (Case-2). It showed that 10 MCM/month was available from December to April and 4 MCM/month, rest of the months. Spill occurred in January and it lowered to the minimum operating level at the end of September.

As shown in the Table 3, 70% of the total inflow evaporates in Case-1 and 48% evaporates in Case-2 from the reservoir and it is an unproductive loss. Evaporation loss is very high, obviously due to the large water surface area of the shallow lagoon. Surface area of Elephant Pass lagoon (9300 ha) with the capacity of 106.5 MCM at proposed spill crest level (+1.20 m MSL) is nearly 7 times larger than the surface area of Iranamadu reservoir (1300 ha) with the capacity of 131 MCM. Pan Evaporation data measured by a class-A pan on the reservoir's bank usually overestimated the reservoir evaporation. The reason for this difference is presumably the significantly different thermal condition of the pan water as compared to reservoir water (Tanny, et al., 2008). Thermal condition of coastal waterbody (lagoon) is totally different from the Iranamadu inland meteorological station.

Releasing more water in the rainy months and minimum release during the dry months reduced the evaporation loss and increased the annual release. It is due to reduced reservoir water surface area during the dry months. It implies the need for reservoir optimisation and developing reservoir operation strategy in order to increase the productivity.

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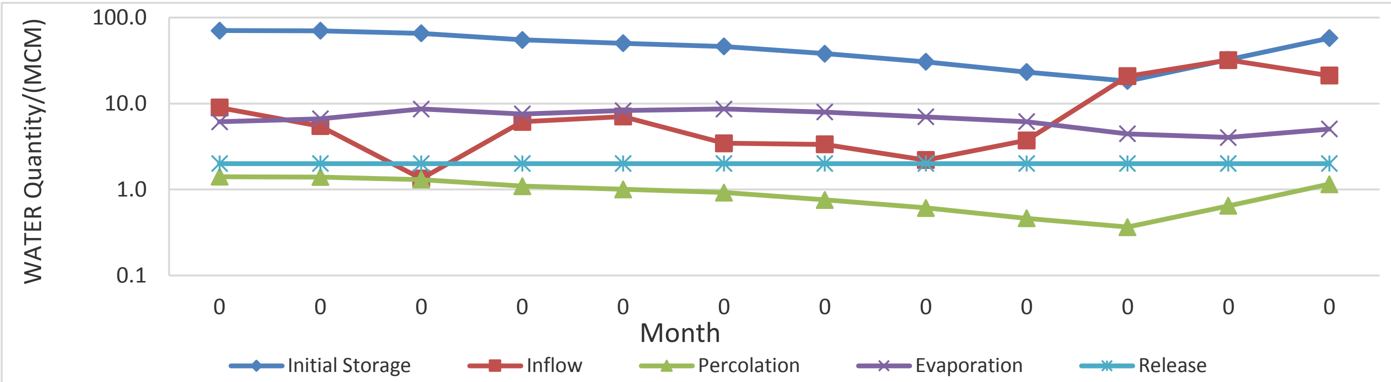


Figure 5: Simulated monthly water balance components for Case - 1.

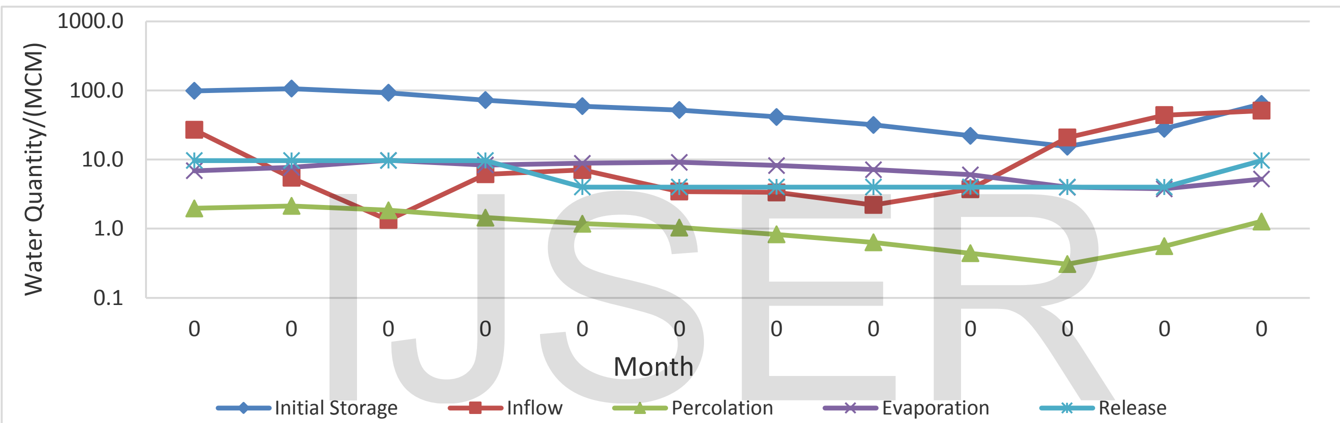


Figure 6: Simulated monthly water balance components for Case - 2.

Table 3: Simulated annual water balance components.

| | **Total annual Inflow/ (MCM)** | **Evaporation loss** | | **Percolation** | | **Release** | | **Total Spill/ (MCM)** |
|---|---|---|---|---|---|---|---|---|
| | | /(MCM) | /(% of total inflow) | /(MCM) | /(% of total inflow) | /(MCM) | /(% of total inflow) | |
| Case-1: Without upstream spill | 116 | 80 | 70 | 11 | 10 | 24 | 21 | 0 |
| Case-2: With upstream Spill | 176 | 85 | 48 | 14 | 8 | 77 | 44 | 0.5 |

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## 5 Conclusions and Recommendations

The results of the monthly simulation of lake showed that nearly 2 MCM/month was available for release throughout the year. When there was spill from upstream reservoirs, 4 MCM/month was available and in addition excess of 6 MCM/month could be drawn from December to April. It should be noted that, probability of such spilling event in a year is only 40%. Flushing out of lagoon bed in order to reduce the salinity can be carried out during these months with plentiful water when spill occurs from upstream reservoirs. It is significant from the present study that substantial amount of water is available for utilisation even after high evaporation loss. Future studies should focus on reservoir optimisation in order to make the project economically viable and environmentally sustainable.

The use of long time steps, e.g. a month, may lead to systematic under estimation of flood loss in the system and over estimation of water available for use/demand in the system. Figures up to 15-20% have been reported. This error can be reduced or eliminated by using a one day time step (Killingtveit & Saelthun, 1995). Detail hydrological modelling of entire catchment of Elephant Pass lagoon and reservoir simulation with daily time series of input data should be done in the future. In this occasion, it is recommended to reestablish the river gauging station in the Kanakarayan river basin and record the daily flow measurements. It is essential for hydrological model calibration and validation in the future studies.

Storage Area Elevation curve is derived from the land survey in 1976. Bathymetric survey should be done to get the present contours of the terrain. Measuring the storage capacity of lagoon by conventional means is labor-intensive, costly, and time-consuming. The advances in remote sensing can be used to estimate the present reservoir area-elevation-storage of Elephant Pass lagoon.

There are uncertainties in percolation and evaporation computation. Seepage loss was assumed in this study as 2% of the initial reservoir volume at each time step. Field measurements are required to verify the assumption. Evaporation loss was computed by Pan Evaporation data. Direct field measurements and model studies are important in order to verify the actual evaporation. Upparu and Vadamarachchi lagoons are already functioning. They can be the test lagoons and observations and study results from these lagoons can be used in future studies of Elephant Pass lagoon.

## References

[1] *Elizabeth, M. (1994). Hydrology in Practice (3rd ed.). Stanley Thomas Ltd.*

[2] *Janen, S. S., & Sivakumar, S. S. (2014). Ground Water Quality Improvement of Jaffna Peninsula of SriLanka by Regulating Water flow in the lagoon Mouths. International Journal of Scientific & Engineering Research, Vol. 5, 973-978.*

[3] *Killingtveit, A., & Saelthun, N. R. (1995). Hydrology, Hydropower Development Vol.7. Norwegian Institute of Technology, Division of Hydraulic Engineering.*

[4] *Metrological Department of SriLanka. (2012). Climate in SriLanka. Retrieved from Metrological Department: www.meteo.gov.lk*

[5] *Navaratnarajah, V. (1994). Water Problems in the Jaffna Peninsula. Affordable Water Supply and Sanitation, Proceedings of the 20th WEDC Conference. Colombo, SriLanka: WEDC Loughborough, UK.*

[6] *Ponrajah, A. J. (1982). Design of irrigation Headworks for small catchments. Irrigation Department, Colombo, Sri Lanka.*

[7] *Ranwala, D. A. (2014). Water Balance Study Report, Jaffna and Kilinochchi water supply and Sanitation Project: Irranamadu Component. Colombo: Ministry of Provincial councils & Local government, SriLanka.*

[8] *Shanmugarajah, K. (1993). Water Resources Development Jaffna Peninsula. Fast Books, A division of Wild & Woolley Pty. Ltd Glebe.*

[9] *Sivakumar, S. S. (2002). Water Resources and Agriculture Development Strategy North East Province 2002/2012. Irrigation Department.*

[10] *Sivakumar, S. S. (2013). Reclamation of Land and Improve Water Productivity of Jaffna Peninsula of Northern SriLanka by improving the water quality of the lagoons. Irrigation Department.*

[11] *Sokolov, A., & Chapman, T. (1974). Methods for water balance computations, An International guide for research and practice. The UNESCO Press, Paris.*

[12] *Tanny, J., Cohen, S., Assouline, S., Lange, F., Grava, A., & Berger, D. (2008). Evaporation from a small water reservoir, direct measurements and estimates. Journal of Hydrology, 351, 218-229.*

[13] *Wikipedia. (2015). IJsselmeer. Retrieved from Wikipedia, the free encyclopedia: https://en.wikipedia.org/wiki/IJsselmeer*

[14] *World Meteorological Organization (WMO). (2015). Climatological Information, Jaffna, Sri Lanka. Retrieved from World Weather Information Service: http://worldweather.wmo.int/*