SEEKING PROFESSIONAL EXCELLENCE IN WATER MANAGEMENT: CASE STUDY ON TRINCOMALEE WATER SUPPLY SCHEME

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Abstract - The Naval Dockyard Trincomalee is considered as the most strategic and important Naval Establishment of the Sri Lankan Navy. Naval Dockyard Trincomalee was established by the British, during the colonial era. Trincomalee naval water supply scheme was constructed in 1942 to accomplish the water requirement of naval Dockyard and Trincomalee town area. Although this system is more than 75 years old, it provides purified water requirement of Naval Dockyard and few other users within Trincomalee town, even today. The raw water source is Kalamatiyankulam reservoir, which has capacity of 47,029,300 Cubic meters. The water transmits to the Andamkulam purification plant only through the gravitational force and the energy increment by reducing the diameter of pipe. Similarly, the purified water also distributes to Naval Dockyard and other surrounding areas. The entire process is free from pumping, though the pumping station has been designed in original drawings. At present, water demand of Naval Dockyard has increased due to the rapid expansion of military infrastructure with the community.

The objective of the study is to analysis the sustainability of the Trincomalee naval water supply scheme with emerging demand of water. This study concerns direct relationship of the current water demand with existing water supply in order to the factors such as flow rate, wastage, etc. Whilst, analysing the best feasible solution for improvement of existing scheme will be determined based on the quantitative data such as rainfall, population, and flow rate. Furthermore, possibility of contributing to the national water distribution network through state agencies will also be analysed as the conclusion of this study. Finally, the paper presents to a substitution plan for water transmission and distribution considering the future demands of Naval Dockyard and Trincomalee town area. This study focuses on how best to collaborate professionalism to the social demand with view of balancing and sustaining the water resources.

Keywords - water resource management, sustainability, substitution plan

I. INTRODUCTION

Sri Lanka Naval Dockyard was established in Trincomalee by the British in the colonial era and it is surrounded by the Port of Trincomalee which is one of the largest natural harbour in the world. Naval Dockyard Trincomalee could be considered as the most strategic and important Naval Establishments of Sri Lanka Navy (SLN). SLN, being a professional body and first line of the defence of Sri Lanka, required to play a major role to safeguard the territorial water.

The existing Naval water supply scheme has been constructed in 1942 during colonial area and the system is more than 75 years old as to date and provides purified water for approximately 15,000 population consist of people inside dockyard and outsiders in Trincomalee area. This water supply system is the only reliable source of water available for the Naval Dockyard to meet the water demand.

This system consists with three main components. Main intake of Kalamatiyakulam reservoir, Andankulam purification plant and SLN Dockyard sump.

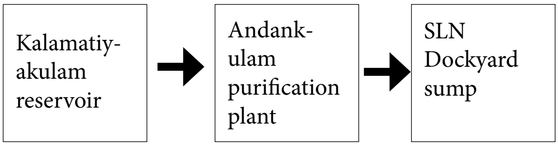

Figure 1: Main Components

The Kalamatiyankulam tank also known as NavalHeadwork's reservoir, had been built by the British in 1942 and situated in Thambalagamuwa area in the Trincomalee district. The path commences to the right of the Palampataru junction, which is located 22 kilometres away from Trincomalee town on the Trincomalee -Kandy road. This reservoir with a capacity of 47,029,300 m3 of water, standing 162 feet above the mean sea level, with 2,840 foot long bund.

The total catchment area is 25Sq.miles. Further 25'6" is the maximum water level of this tank .The main diversion point which is located in the Puliuththukulam (Near to the Thambalagamuwa border) from that point control the water flow into two directions ,One flow towards the Morawewa reservation and the other flow towards the Kalamatiyankulam tank. The way of water flow to the Kalamatiyankulam tank is shown below.

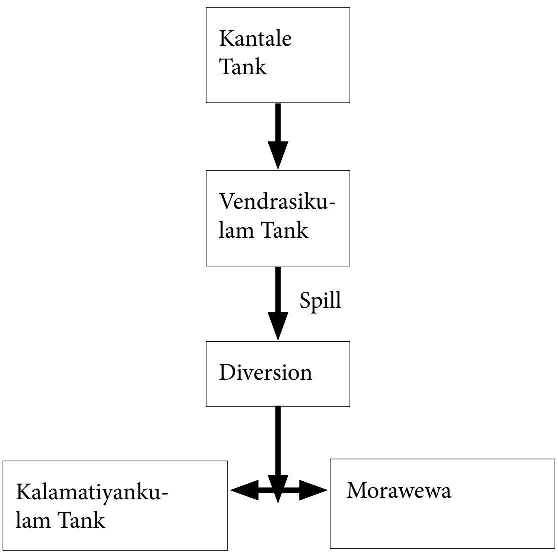

Figure 2: Main diversion path

The water main starts from tank form intake well. Main intake well consists with three draw off and variation of these draw as follows,

At Spill level (155 MSL)	-	3,800	Ac	ft
At Top draw off (148.75 MSL)	-	2,200	Ac	ft
At Middle draw off (138.75 MSL)	-	600	Ac	ft
At Bottom draw off (131.75)	-	91	Ac	ft

This water supply system conveys water through the combination of gravitational force and the energy increment by reducing the diameter of pipe. Kalumatiyankulam tank to Andankulam treatment plant, covering approximate 17 Km flow through slope of 06 inches to 1Km which conveys water through gravity without any pumping. Approximately 4500m3of raw water per day received to water treatment plant at Andankulam. Then, the raw water purified under conventional water treatment process (Aeration, coagulation, flocculation, sedimentation, filtration and disinfection.)

Currently, $4000m^3$of treated water daily distribution to SLN Dockyard and Trincomalee town .Naval water supply system provides treated water for important government institutes such as General Hospital , 22 Brigade SLA Camp, Court complex, police stations , Sri Lanka ports Authority , Government school and approximately 250 domestic dwellers. At present, water demand per day at Naval Dockyard is existing demand of water cannot be met from National Water supply & Drainage Board at Trincomalee.

However, the present water volume received to Andankulam purification plant is not sufficient to cater the present water demand in drought season due to restriction in the opening of sluice valves to prevent a burst of water line due to ageing of water main.

It has been revealed that most parts of the water main are in deteriorated condition, resulting frequent repairs to the water main. The systems adopted and practiced to repair the water main are conventional, complicated and not accommodative with available tools/spares and takes much time and wasted of man power unnecessarily with this repair work. Moreover then a water main is damaged/ leaked that will cut off water supply to Naval Dockyard and Trincomalee town area for 03 to 04 days until completion of the repair. Further, fittings and accessories requirement for repair maintenance are limited and not freely available in the market. The water main is mainly constructed with cast Iron pipe (CI), Hume pipes and Galvanized Iron pipes (GI) and tends to deteriorate with age and aggressive subsoil condition exists. Frequent breakages in raw/ water cuts to facilitate repairs.

II. LITERATURE REVIEW

As per the formulating Guidelines for Reservoir Sustainability (Kent C., Sean K., Randle T., 2015), it shows that reclamation has to be done for the reservoirs and channel system where the lifetime is exceeding 60 years. It also highlights that reclamation is essential for the reservoirs more than 80 years old. In this case, both the reservoir and channel system are over 80 years. Even though still the system works considerably good manner, without proper attention to the infrastructures of the system, the effectiveness of water management will be negatively affected by this fact.

In Local Water Management of Small Reservoirs: Lessons from Two Case Studies in Burkina Faso (Sally, H.; Lévite, H. and Cour, J., 2011) has shown that not only maintenance, but land use patterns in the catchment area will be crucial factors in effective and sustainable management water. In case of Kalamatiyankulam reservoir, the land use of catchment area is nominated as a sanctuary. Therefore it can be expected almost consisting amount of inflow of water for coming years where which is sufficient for supply the demand for Trincomalee Naval base and for civil organizations too. Still, through proper repairs in the channel system which the water being transported to Trincomalee this massive amount of water can be used with minimum wastage.

The Sustainability of Water Supply Schemes (Abebe, 2008) shows that not sufficient repairs have led the reservoirs to chaos and therefore it has become an element for poor sustainability and service delivery in water management. In this case also, it is a clear fact that wastage of water due to leakages in channel system is far greater than wastage of water due to improper usage. When it comes to level of service, practices adopting in water management cannot influence this factor considerable where the only solution lies on the other option.

In Design of Sustainable Water Distribution Systems In Developing Countries (Kalanithy Vairavamoorthy, Ebenezer Akinpelu, Zhuhai Lin, Mohammed Ali) developed international guidelines for the design of urban water distribution system in developing countries which help to sustain adequate and safe supplies. This was a new approach to the design of distribution system in developing countries. Conventional approach to network analysis was described and discussed with respect to their suitability for simulating conditions of water shortage. Alternative approach design had been developed by utilizing formal optimization techniques to ensure the maximum uniformity in supply. There were required modification model such conditions. Modified network analysis simulation tool had been developed by identifying required modification. This simulation tool had been verified by field survey data.

In the case study Sustainability of Community Water Supply Systems Managed by Water User Committee (Kalyani, 2014) which was totally based on assessments carried out in the field, observations notes, household survey and discussion with members of water user committee, it was discovered that all the water supply systems are smoothly operating and providing quality drinking water without financial, technical or institution problems with in water supply system and the community.

III. METHODOLOGY

- Study relevant documents to find out the catchment areas of Kalamatiyankulam reservoir.
- Analyse rainfall data of eight consecutive years.
- Calculate the runoff coefficient using Khosla's formula.
- Develop the mass curve using the obtained results and find out the possible demand.
- Find out the residential and non-residential demand in Naval Dockyard.
- Suggestions for water transmission and distribution considering the future demand in Naval Dockyard and Civic organizations in Trincomalee area.

IV. RESULTS AND DISCUSSION

Khosla's formula method (Subramanya)

$R_m = P_m - L_m$

Month	T ⁰C	Rainfall (P_m)(cm)	Monthly Losses (L_m)	Monthly Runoff (R_m)
Jan	26.5	21.826	12.72	9.11
Feb	27	16.376	12.96	3.42
Mar	28	7.64	7.64	0
Apr	29.5	3.997	4	0
May	30.5	9.798	9.8	0
Jun	30.5	0.144	0.14	0
Jul	30.5	5.379	5.38	0
Aug	30	10.483	10.48	0
Sep	30	9.416	9.42	0
Oct	28.5	30.026	13.68	16.35
Nov	27	39.457	12.96	26.5
Dec	26.5	48.279	12.72	35.56
	202.821		90.94	

$$\frac{\text{Annual Runoff}}{\text{(Annual Rainfall}} = \frac{90.94}{202.821} = 0.448 \approx 0.45$$

Table 2: Calculation of mass curve

Month	Rainfall (P_m) (mm)	Runoff Rainfall Ratio	Catchment area (Mm^3)	Monthly Runoff inflow Volume	Monthly Evaporation (Mm^3)	Monthly Flow Volume (Mm^3)	Accumulated Volume (Mm^3)
Jan	218.26	0.45	67.99	6.68	0.37	6.31	6.31
Feb	163.76	0.45	67.99	5.01	0.37	4.64	10.948
Mar	76.4	0.45	67.99	2.34	0.37	1.97	12.915
Apr	39.97	0.45	67.99	1.22	0.37	0.85	13.768
May	97.98	0.45	67.99	3.00	0.37	2.63	16.395
Jun	01.44	0.45	67.99	0.04	0.37	0	16.4
Jul	53.79	0.45	67.99	1.65	0.37	1.28	17.675
Aug	104.83	0.45	67.99	3.21	0.37	2.84	20.512
Sep	94.16	0.45	67.99	2.88	0.37	2.51	23.023
Oct	300.26	0.45	67.99	9.19	0.37	8.82	31.839
Nov	394.57	0.45	67.99	12.07	0.37	11.7	43.541
Dec	482.79	0.45	67.99	14.77	0.37	14.4	57.942

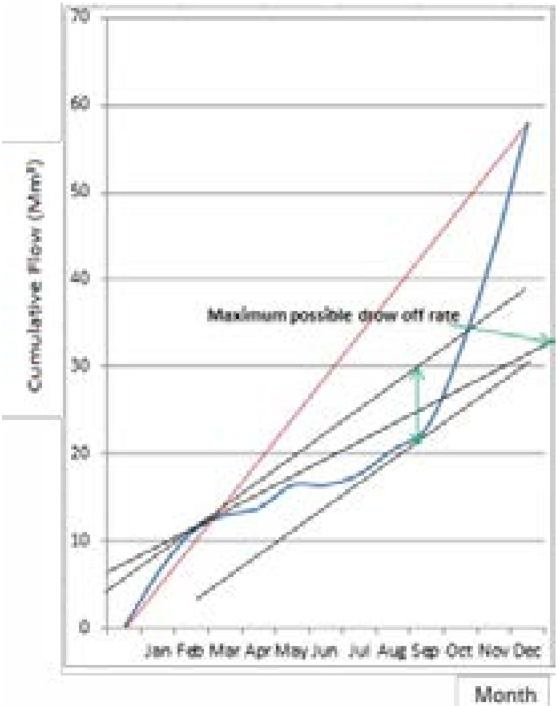

Figure 3: Mass curve

Uniform maximum draw off throughout the year with no spill over the spillway $= \frac{(57.612)}{365}$

$= 0.158\ Mm^3/day$

Existing Reservoir capacity = 3800 Acre feet

$= 4.687224\times10^6$

= 4.69 Mm3

After September reservoir begins to spill,

Hence maximum possible draw off rate

$\frac{36.2 - 7.58}{365} = 0.078$ Mm3/day

Consider 75% maximum possible draw off rate

= 0.0588Mm3/day

Current daily demand = 5000 m3/day

= 0.005 Mm3/ day

Consider 25 % maximum possible draw off rate

= 0.0195 m3/ day

Current daily demand improve 3 times,

= 0.015 Mm3/ day

Current demand x 3 < 25% Maximum possible draw off

$0.015m^3/day<0.0195m^3/day$

As a result of the operational study carried out in the research, it was discovered that the possible demand is sufficient for more than three times of current demand. But due to expired life time of the raw water main which is more than 80 years old, it is observed that repairing of the system is not much economical and not reliable compare to the replacing line. When compared to gravitational force, it does not requires any other power source for distribution of raw water main from Kalamatiyankulam reservoir to Andamkulam purification plant, which is an added advantage for economic management of water distribution. Still it is highlighted to improve the water purification capacity of Andamkulam purification facility including more number of sedimentation tanks as well as rapid sand filters. If not the total amount of possible demand cannot be utilized unless otherwise. Replacing the purified water distribution line is also paramount important for reducing the wastage and for increased efficiency of the distribution system. Compared to renovation of the distribution system, it is much economical to replace the line as the existing distribution line is having a period of service of more than 80 years to date.

Even though renovation of Andamkulam water treatment plant and replacement of water distribution system implemented, still it won't affect as long as the water sump facilities may improve. In this case,the study could able to identify abundant water tanks (Fort Frederick – 2500m3, Chainabay - 450m3 and Clappenburg - 450m3etc.) which is related to the Trincomalee water supply scheme. Rehabilitation of abundant tanks a better solution for the water management compare to the evaluated possible outflow from the reservoir. Therefore for sustainable and water management system, which is sufficient for more than three times of the existing demand, renovation and replacement of existing facilities is a must and it can be considered a probably the greatest investment for the future supply of water demand in eastern region of Sri Lanka.

V. CONCLUSION

An operational case study is carried out for selecting possible demand of Kalamatiyankulam reservoir. This provision of water to meet the domestic water demand of Trincomalee area, as well as ships and craft of Trincomalee harbour also considered. A compact non-linear optimization formulation for the reservoir outflow is derived by using basic calculation assumption and mass curve analysis. The result of analysis emphasized that possible maximum water demand (0.078Mm3/day) able to reach more than three times compared to the current demand (0.005 Mm3/ day). Similarly increasing the quantity of water management become paramount important with seeking excellence of professionals. Replacing raw water and purified water distribution mains which able to operate under the gravity flow with saving significant amount of energy and cost. This study concludes how to collaborate professionalism to the social demand with view of balancing and sustaining the water resources.

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