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Design of Reservoirs for Multiple Use of Water Aparekka Ara Reservoir in the Nilwala Catchment

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Abstract: In general, medium scale reservoirs, which have been constructed in Sri Lanka, aimed to fulfil only irrigation requirement. Although, many modern reservoirs that operate today serve two or more purposes. The most common purposes of these reservoirs are to generate hydroelectric power, water supply, provide flood control, enable irrigation, inland fishery and provide recreational opportunities. When a reservoir functions in such varied ways, it is called a multipurpose reservoir. The proposed Aparekka Ara Reservoir has planned as a multipurpose reservoir to fulfil the needs of the surrounding area. It can be utilized to supply water for irrigation and drinking purpose. Also, it has been planned to serve as detention reservoir for flood controlling. Hydroelectric power production can be obtained as a by product. Therefore, Aparekka Ara Reservoir can be considered as eco efficient water infrastructure.

1. Background

The proposed reservoir is located in Uda Aparekka village in Dondra Electorate in Matara District and defined by coordinates, O/25 (6.9 x 6.3). Also, the reservoir embankment is on the Aparekka Ara in Kadawedduwa sub catchment in the Nilwala river basin.

The reservoir was originally proposed by the farmers in Aparekka and Galaboda area around 1986 to be included Nilwala Ganga Flood Protection Scheme (NGFPS). It carried out to provide flood control facilities to existing paddy cultivation in the lower Nilwala basin. Later, proposal has been taken for feasibility studies under action plan of Kiralakele Sub-basin Development in 1990s and also proposed to construct a 60 ft (18.3 m) high earthen dam to store 770 ac.ft (0.95 MCM) of water to fulfil the above irrigation requirement. However this reservoir could not be initiated in the project due to financial constraints.

Recently the proposal has taken in to consideration, under rehabilitation of Nilwala Scheme to address the crucial issues of that area such as flooding, water supply and hydropower in addition to irrigation facilities.

2. Hydrology

The tank is located in Agro Ecological Zone WL4. The catchment area (approximately 14.03 km^2) is mostly hilly with steep slopes covered by light to medium jungle.

The stream is perennial however the flow is insignificant during dry months. As there were no flow records available in this stream, the annual Iso-yield curves were used to assess the water availability and to calculate capacity of the reservoir.

3. Objectives

There were three existing anicut schemes on Aparekka Ara, located on downstream of the proposed reservoir site, which were commanding about 1000 acres of lands. Those lands were cultivated under water scarce situation due to insufficient stream flow during dry periods. Productivity of these lands was normally low and the crop failures were also

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experienced during dry seasons. Aparekka Ara reservoir will fulfil the irrigation requirement for those paddy lands.

Flood bunds were built besides of the river under Nilwala Ganga Flood Protection Scheme to prevent water flow from the upper catchment. Since implementing Nilwala project (NGFPS), the surplus water from Aparekka Ara catchment has to be pumped out by Magallagoda pumping station during flood seasons incurring enormous costs (fuel cost is around Rs.10 million per annum at present). Considerable portion of that can be saved if the Aparekka Ara reservoir is designed to store the entire flood volume, of Aparekka Ara, resulted from 10 year flood. There is land of nearly 300 acres, near the confluence of Kadawedduwa and Aparekka Streams, which has been abandoned due to frequent flooding and water logging. This area also can be cultivated if the reservoir capacity is increased to retain minor floods. Also, there are some other proposed reservoirs to minimize the effect of flood such as Digili Oya, Batuwita Ara and Kadukanna (Nape-udawathura).

Figure 1 - Location of Uda Aparekka

This reservoir can fulfil drinking water demand of nearby villages by increasing the storage capacity slightly. Politicians of that area continuously struggle to have water through several water supply projects from existing Ellewela tank in the adjacent sub-basin. This problem can be easily solved with the aid of Aparekka reservoir and also drinking water requirement in that area can be addressed by considering that requirement at the design stage.

Hydropower production is not a major objective of this project. Although, power can be produced only with scheduled water issue for irrigation and water supply. In addition to that retained flood water also can be used for hydropower production.

4. Operation Study

An operation study is an imaginary study, that assumes the proposed schemes was available in past and check weather scheme could be meet the demands such as irrigation, hydropower generation and drinking water.

4.1 Irrigation Requirement

Tank bed contour survey had been carried out under Kiralakele Sub-basin Development Project.

As there are no flow records available for the stream, 75% probability rainfall relevant to WL4 zone and annual Iso yield curves are used to assess the water availability.

Considering the similarity in climate, evaporation values of Colombo are selected.

The low land paddy for both Maha (135 day variety) and Yala (105 day variety) was assumed.

Evapo-transpiration, application efficiency, conveyance efficiency and other essential data were collected from Irrigation Department.

Providing drinking water at the rate of 2000 m^3 per day is also included in the operation study.

A Water Balance Equation is used to study, whether available water resource could be able to meet the demand for irrigation and drinking water or not.

Storage at beginning of a month + Inflow – Losses – Demand – Spillage
= Storage at end of the month
= Storage at beginning of next month ……. (1)

Refer Table 1 for result of operation study.

The storage capacity required for irrigation and water supply is about 1310 ac.ft (1.62 MCM). According to the results of operation study, around 850 acres (3.44 km^2) can be provided with irrigation water in Yala (SW monsoon) and Maha (NE monsoon). However it should be more than that since those lands are provided with irrigation only in dry spells and the cultivation is mainly rain-fed.

4.2 Flood Detention Requirement

Since flow records are not available, runoff was computed with relevant rainfall data using Curve Number Method.

Rainfall values relevant to flood of 10 year return period were used to design pumping stations of the Nilwala Scheme and those values were used to analyse the +capacities required for flood detention.

Following parameters are selected for computation.

- Land use or cover – Woodlands
- Hydrological condition – Good
- Hydrological soil group – Group B
- Antecedent Moisture Condition (AMC) – AMC II

The storage capacity required for retaining 10 year flood volume is 1628 ac.ft (2.01 MCM).

4.3 Sizing the Reservoir

Adding irrigation and flood detention requirements together, the total capacity become 2938 ac.ft (3.63 MCM). Also corresponding reservoir level is 116.9 ft (35.64 m). Therefore height of the dam is around 100 ft (30.5 m).

4.4 Hydropower

It is necessary to release 1.62 ac.ft/day (2000 m^3/day) to fulfil the domestic water requirement. That is about 50 ac.ft/month (60,000 m^3/month). Irrigation requirement varies from zero to 945 ac.ft./month (1.17 MCM/month) depending on the crop stage and weather. According to above data, water issue per month from the reservoir fluctuates between 0.023 cumecs to 0.44 cumecs. Water level of the reservoir, normally varies between 40 ft (12.19 m) to 90 ft (27.44 m) as observed in

Table 1 - Operation Study of Aparekka Ara Reservoir

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Storage at 1st of the month -ac.ft	35.8	1082.1	1311.4	844.1	232.2	41.6	277.8	828.8	1034.4	746.0	40.2	240.4
Inflow -ac.ft	1097.8	751.1	288.9	231.1	173.3	288.9	606.7	808.9	606.7	303.3	252.8	303.3
Evaporation loss -ac.ft	1.2	10	13.2	11.0	5.4	2.2	5.8	10.3	11.4	10.2	2.2	5.6
Seepage	0.2	5.4	6.6	4.2	1.2	0.2	1.4	4.1	5.2	3.7	0.2	1.2
Demand (Irrigation) -ac.ft	0	361.1	686.2	777.5	312.1	0	0	538.6	830.0	944.9	0	0
Demand (Drinking water) -ac.ft	50.2	48.6	50.2	50.2	45.4	50.2	48.6	50.2	48.6	50.2	50.2	48.6
Spillage -ac.ft	0	96.7	0	0	0	0	0	0	0	0	0	0
Storage at end of the month -ac.ft	1082.1	1311.4	844.1	232.2	41.6	277.8	828.8	1034.4	746.0	40.2	240.4	488.3

operation study. Turbine is assumed to be kept at 15m level.

The power produced, P (kW) is related to the flow, Q (cumec), and the available head, H (m) by the following equation.

$$P = g\,\eta_t\,\eta_g\,H\,Q \quad \text{..............................} \quad (2)$$

Where g is the gravitational acceleration (9.81 m/s^2) and η_t & η_g are the efficiencies of turbine and generator respectively. In this case overall efficiency was taken as 60%. Using above facts and figures, the average capacity of hydropower production has calculated as 10.62 kW.

Potential head is very low in February, March and August; therefore those three months were not taken into account.

5. Operation Rules

When a reservoir serves different functions, it is nearly impossible to operate each function at its maximum level. For an example, a reservoir that provides irrigation and drinking water might conflict demands on its users during dry season. Farmers who need water for irrigation from reservoir when dry conditions are present and at the same time drinking water need to be supplied to the area.

During dry seasons we have experienced conflicts between different users. There won't be fix solution for such issues and hence each issue has to be addressed accordingly.

Maximum storage of the reservoir is allowed only for 1310 ac.ft (1.62 MCM). The reason to limit the capacity is to reserve the retention capacity required to absorb entire volume of 10 year flood at any time. Extra amount of flood volume can be detained above Full supply level (FSL) in cases of higher floods.

When supplying the drinking water requirement to the National Water Supply and Drainage Board (NWS & DB), average demand of 2000 m^3/day was considered.

6. Conclusion

A reservoir that serves more than one function is known as multipurpose reservoir. Aparekka Ara as a multipurpose reservoir well address most of the water related issues in that particular area. Hence, multipurpose reservoirs are suitable and well suited for the developing country like Sri Lanka.

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