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Evaluation of Reservoir Capacity and Reliability for Urban Water Utilization in Dili, Timor Leste

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ABSTRACT The ability to store and distribute water resources is very significant to human activities. Therefore, high importance is placed on the sector to address any adverse impact in the event of major shortfall, particularly in Dili, Timor Leste. A study on the development of effective water resource management mechanisms has been conducted to support government visions. As a consequence, priority strategy was initiated to design the necessary infrastructure, in order to match urban demands. One action plan of this effort is by building reservoirs. The purpose of this study was to evaluate the construction of a minor or large reservoir to meet water consumption rate in Dili. Also, the strategy implementation proposal of the reservoir development in Beemos and Becora rivers was prepared by analyzing the reliability and capacity, using a model known as water release standard operating rules. However, water balance simulation results showed the reliability of clean water services from these two small storage units is unable to approach 100%, due to limited volume. The capacity optimization outcomes of large Beemos reservoir indicated the inflow potential at 90% utilization, and therefore is able to balance the urban water demand up to 2030. Despite impressive simulation results, the government is expected to consistently conduct a detailed feasibility study in the upstream area, prior to implementation. Furthermore, large reservoir construction is highly recommended for effective water resource expansion, in an attempt to match the high consumption rate in Dili. This effort possibly supports Timor Leste's targets and sustainable development goals concerning clean water and sanitation.

KEYWORDS Water Resource Infrastructure; Operating Rules; Reservoir Simulation; Reliability; Reservoir Capacity

1 INTRODUCTION

Timor Leste government has placed high importance on clean drinking water as one of the top priority agendas, under the 2011-2030 strategic development plan (SDP). This provision enables 24 hours portable water access at 100% by 2030 (universal access) (Gov.TimorLeste, 2011). The country is one of the nations to have achieved the millennium development goals (MDG) for urban water supply. Based on WHO/UNICEF joint monitoring program (JMP), the total coverage for increasing this distribution in 2015 was estimated at 91%. However, the figure was known to have exceeded the MDG target of 88% (JMP, 2017). Despite achieving this specification, domestic water distribution in Dili remains very significantly low. In relation to 2015 Timor Leste census data, domestic usage demonstrated a 25% tap water connection, 15% public taps, 11% borehole/ wells and 1% protected springs.

Timor Leste government is faced with inadequate data to formulate specific strategies relating to effective water resource management (ADB, 2015). In addition, previous study on the above subject matter has been conducted in 2019 (Takeleb *et al.,* 2020). The process to determine water resource management strategies involved stakeholders and decision-makers' participation as well as the result analysis, using a decision-making method (Takeleb *et al.*, 2020). Also, the use of SWOT analysis revealed the maximum weighting value as the weakness factor influencing water resource management system in Dili. This indicated a higher water demand, compared to available supply. Based on decision support system study, the results of the formulation of strategic priorities recognized the first and second prospects as the development of water resource infrastructure and surface water sources, respectively (Takeleb *et al.*, 2020). These provisions are very appropriate for implementation by Timor Leste government, in an extensive effort to meet urban water demands. Prior to this realization, critical evaluation appeared very necessary. In the strategy implementation framework, several actions have been defined and are potentially applied. Furthermore, the initial effort referred to the construction of reservoir set up in Comoro watershed, as an additional supply.

Water resource infrastructures, including dam and reservoir are highly recommended for the Comoro project. In particular emerging countries, these prospective facilities appear as viable management strategies in resolving water availability problems (Elarabawy *et al.,* 1998; Ndiritu *et al.*; 2017; Yang *et al.*, 2019). The construction of reservoirs is associated with minimal river flow, but tends to improve stream conditions, particularly during dry periods (Nugroho, 2015; Yang *et al.*, 2019). Dili has a tropical climate with annual wet and dry seasons and the rainfall varies yearly between 481.2-1,716.4 mm (MPSTL, 2016). However, low rainfall places excessive pressure on water resource availability in Comoro watershed (ADB, 2015, DNGRA, 2016; Pinto *et al.*, 2015; Takeleb *et al.*, 2018). The construction of new reservoirs requires initial evaluation of reliability and capacity, based on available river discharge.

Reservoir development forms a significant aspect of surface water system, and changes in availability shows the need for proficient regulation (Mays and Tung, 1992). Also, dams are design to sustain or restrict the river flow or underground water, although are built next to a reservoir to accommodate the current. However, reservoirs tend to reduce flooding, but also provide water for activities, including irrigation, human consumption, industrial use, aquaculture and navigation capabilities (Mays and Tung, 1992; Nugroho, 2015). International standards (e.g International Commission on Large Dams, ICOLD) define extensive dams above 15 m from the lowest general foundation to the crest (Shah and Kumar, 2008). The reservoir capacity and crest length extend beyond 1 MCM and 500 m, respectively. Furthermore, the U.S. Fish and Wild Life Service, under the Dam Safety Program has adopted the following criteria for defining small dams as structures below 13 m high or with impound less than 1.2e106 m3 of water (Shah and Kumar, 2008). Therefore, the benefit of a reservoir development project is dependent on the size and operation.

Particular indicators to assess reservoir performance include reliability, resilience and vulnerability (Hariri-Ardebili, 2018; Ndiritu *et al.*, 2017). One important concern in assessing this function is using operating rules. The optimization of reservoir operating rules and non-linear algorithms are rarely applied in practice (Geressu and Harou, 2019, Mudjiatko *et al.*, 2015; Ndiritu *et al.*, 2017; Ren *et al.*, 2019), but were used in Hluhluwe dam, South Africa, to assess the reservoir yield and hydroelectricity, as well as the municipality demand. In addition, the indicators have consequently improved the dam performance (Ndiritu *et al.*, 2017). Furthermore, the operating rules were employed in reservoir system expansion scheduling in the Blue Nile hydropower storage unit. The results showed the use of these rules assisted decision-makers in considering multiple objectives (Geressu and Harou, 2019), and provided a management template on multi-purpose water reservoirs under climate change and complex human activities (Ren *et al.,* 2019). Moreover, the system optimal operation generated a feasible approach in reducing associated cost and reservoir management risk as well as balanced the beneficial relationship between competing objectives (Mays and Tung, 1992). Furthermore, the operating rules were used to optimize the reliability of small reservoir for irrigation and surface water demand in Java and Sumatra (Jaya, 2019; Mudjiatko *et al.*, 2015). This study was aimed at evaluating the capacity and reliability of a new reservoir, in order to meet urban water demand in Dili. The operating rules was employed to optimize the small and large reservoir with a single objective. Consequently, the characteristic rainfall, evaporation, and watershed flow are believed to influence reservoir reliability.

2 MATERIAL AND METHOD

2.1 Location

The purposed minor reservoir is situated in Beemos, and Becora rivers, sub-watersheds of Comoro, stretching 43.46 and 18.01 km^2, respectively. Currently, these waters serve the population of Dili, and are elevated using check dams, prior to distribution. Figure 1 shows the reservoir location. Also, the catchment boundary was downloaded with ALOS PALSAR's digital elevation model (DEM) data of 12.5 m resolution from National Aeronautics and Space Administration (NASA) website, https://vertex.daac. asf.alaska.edu/.

2.2 Water availability

The rainfall-runoff method was used to estimate the surface water availability based on the absence of discharge recorded data in Beemos, Becora, Maloa, and Culuhun rivers. Also, rainfall data for the past 10 years (2006-2015) has been obtained from six stations. Three stations occurred at the upstream of Comoro, termed Fasenda, Ermera and Aileu, while the other three were situated in downstream, including Dare, Remexio and Aeroportu Dili. Furthermore, the rainfall-runoff mock method principally states the occurrence of rain in the catchment area, where certain volumes were lost due to evapotranspiration, while the others immediately become runoff, with a few portion penetrating into the ground (Mock, 1973). Water availability is also supplied by groundwater, and is obtained from the production data of 25 artesian wells in Dili (ADB, 2015). Table 1 represents the monthly dependable flow of 4 rivers and average production of artesian wells.

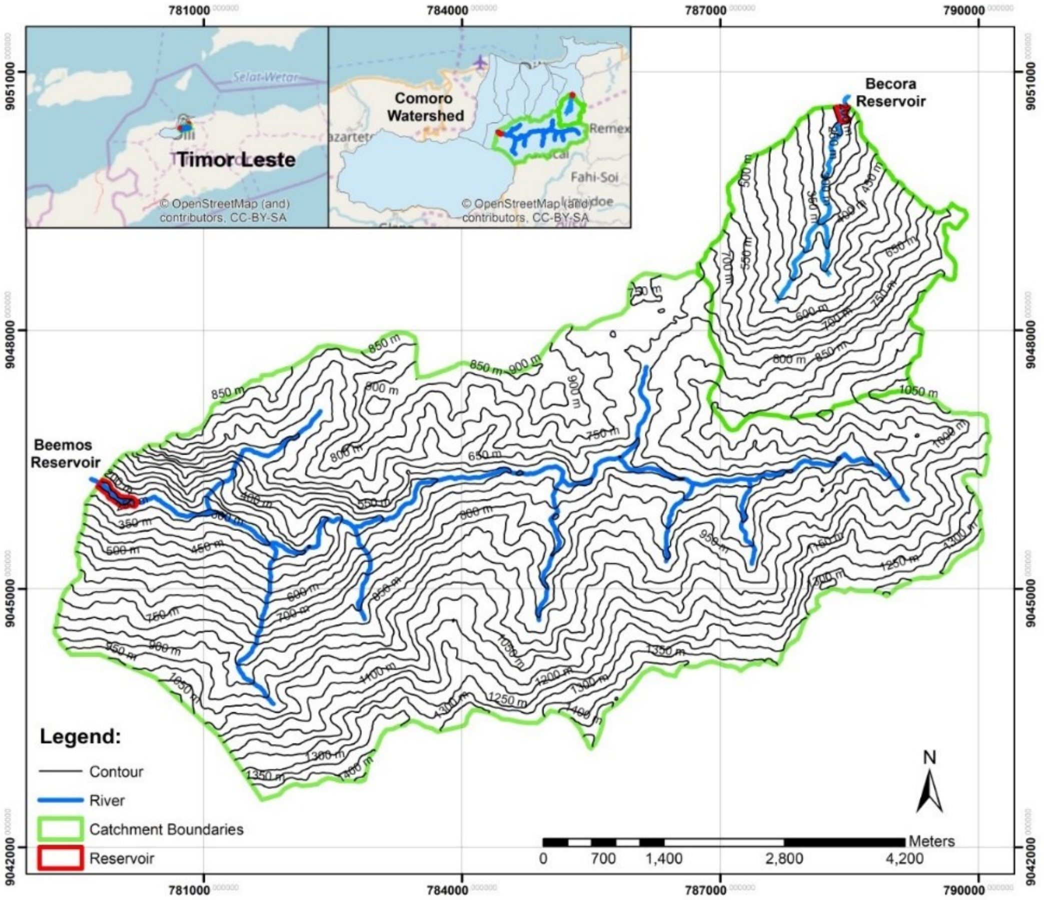


Figure 1. Location of purposed Beemos & Becora reservoir

Table 1. Monthly dependable flow and groundwater

Month	Q_{90} Beemos (L/sec)	Q_{90} Maloa (L/sec)	Q_{90} Culuhun (L/sec)	Q_{90} Becora (L/sec)	Groundwater (L/sec)	Total (L/sec)
Jan	25.55	9.699	4.905	1.083	306.94	348.18
Feb	55.11	8.169	4.932	7.795	326.49	402.50
Mar	38.69	8.795	7.511	3.896	315.48	374.37
Apr	53.30	11.170	6.364	21.494	301.62	393.95
May	29.26	7.934	13.590	2.800	307.62	361.21
Jun	13.43	4.653	0.733	4.369	326.11	349.30
Jul	8.45	0.265	4.140	2.642	312.67	328.17
Augt	3.19	0.000	0.215	1.067	320.11	324.59
Sep	0.81	0.707	1.310	0.740	323.54	327.10
Oct	0.81	0.614	0.391	0.729	315.63	318.18
Nov	3.68	0.539	0.840	2.343	308.97	316.37
Dec	4.78	6.549	5.241	9.772	300.17	326.52

2.3 Water Demand

Dili is the capital of Timor Leste, with total population of 265,000. The water demand is used as the target release/outflow in simulation and is based on domestic and non-domestic purposes. In 2015, 94% of the city registered for water connections, based on National Water and Sanitation Directorate data (Direcao National Saneamento e Agua, DNSA). Also, the domestic consumption includes drinking, washing, and toilet use. However, non-domestic purposes involve institutions, e.g schools, hospitals, and offices as well as commercial needs for hotels, markets, restaurants, and small industries. Figure 2 shows the assumed average water demand from 2015 - 2030.

2.4 Netto Demand

Net water demand is used in the simulation as a target release or water supply to reservoirs, but not provided by existing water resources. However, Dili's channels are provided by four rivers and groundwater. During the analysis of water requirements in Beemos reservoir, the river discharge is not included, similar to the conditions of Becora. Furthermore, Beemos releases with water demands is estimated at 60% of the total, while 40% is attributed to Becora (Table 2.). In the calculation scenario of Beemos reservoir with a large capacity, 100% of the city's water needs is supplied.

2.5 Stream flow Generation

In generating Beemos and Becora stream flows, Thomas- Fiering approach was employed. This method was more reliable in streamflow data and was extensively capable of obtaining daily flow sequences of a historic record (Alfa *et al.*, 2018, Vaghela and Vaghela, 2014). Also, the model was able to collect synthetic data for a required period, similar to the original data. Algorithm model of Thomas-Fiering's is given in the Equation (1) to (5) below (Arselan, 2011; Vaghela and Vaghela, 2014).

$$X_{i+1} = \bar{X}_{j+1} + b_j\left(X_i - \bar{X}_j\right) + t_i S_{j+1}\sqrt{\left(1 - r_j^{2}\right)} \tag{1}$$

$$b_j = r_j \frac{S_{j+1}}{S_j} \tag{2}$$

$$r_j = \frac{C_1}{C_2} \tag{3}$$

$$C_1 = \sum_i \left(X_{ji} - \bar{X}_j\right)\left(X_{j+1,i} - \bar{X}_{j+1}\right) \tag{4}$$

$$C_2 = \sqrt{\sum_i (X_{ji} - \bar{X}_j)^2 \sum_i \left(X_{j+1,i} - \bar{X}_{j+1}\right)^2} \tag{5}$$

where X_{i+1} and X_i are the monthly stream value to be simulated for $i+1$ month and month i, and are mean monthly values during the $j+1$ and jth month; b_j is regression coefficient in $j+1$ from j month; is the serial correlation coefficient between values in jth and $j+1$ month; S_j, S_{j+1} are the standard deviations of monthly values in j and $j+1$ months. t_i is a random normal deviate with zero mean and unit variance. The discharge data of Beemos and Becora between 2006-2015 encompassed the interval between 2021-2030. Figure 3 and 4 show the serial correlation coefficient as well as the monthly mean and standard deviation, respectively, while Figure 5 represents the generated inflow.

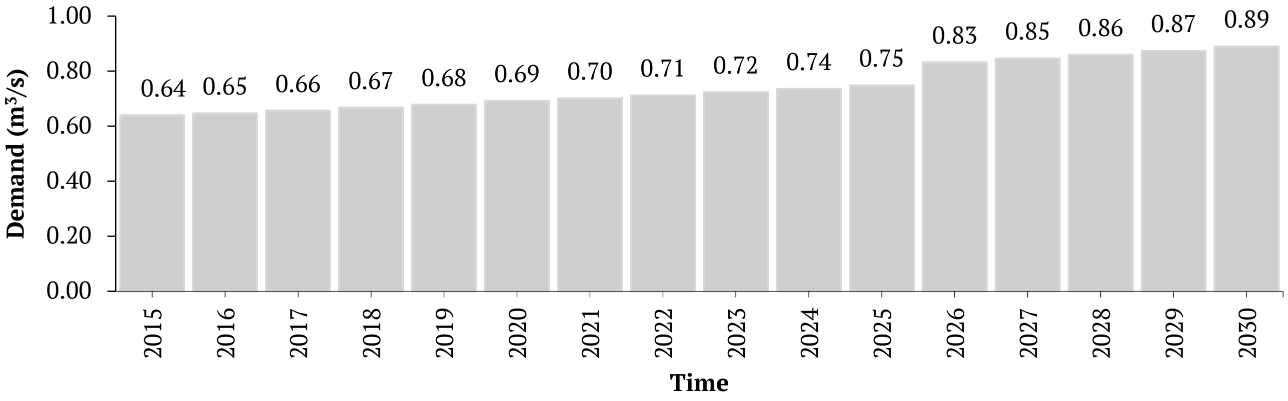


Figure 2. Average Water Demand

Table 2. Netto Demand

Year	60% monthly net demand (m^3/sec)	40% monthly net demand (m^3/sec)	100% monthly net demand (m^3/sec)
2021	0.222	0.148	0.364
2022	0.226	0.151	0.373
2023	0.231	0.154	0.381
2024	0.236	0.157	0.389
2025	0.271	0.181	0.447
2026	0.276	0.184	0.456
2027	0.281	0.187	0.464
2028	0.286	0.191	0.472
2029	0.291	0.194	0.480
2030	0.387	0.258	0.640

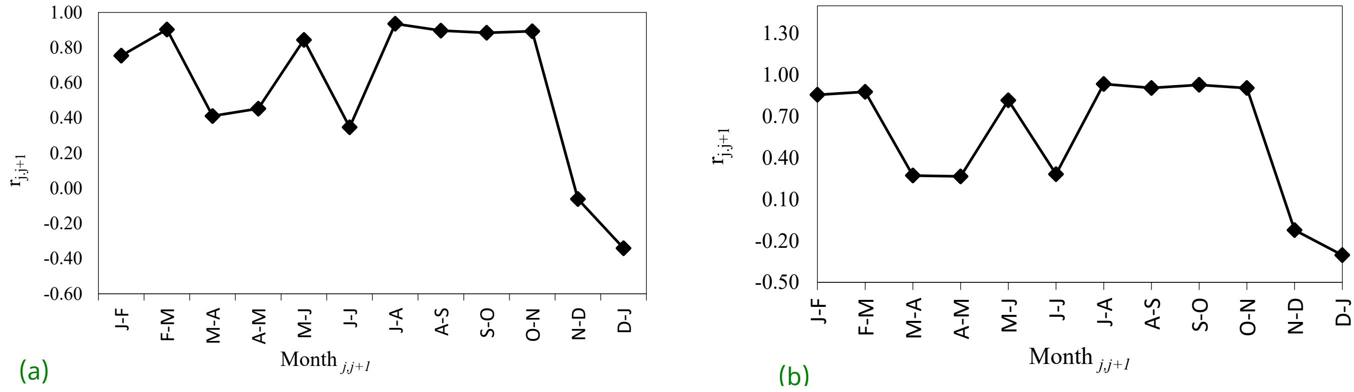
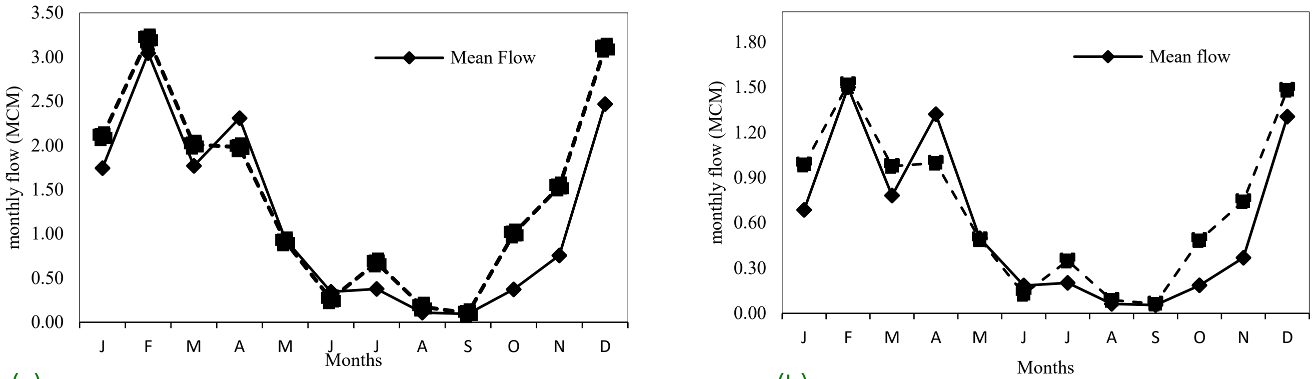
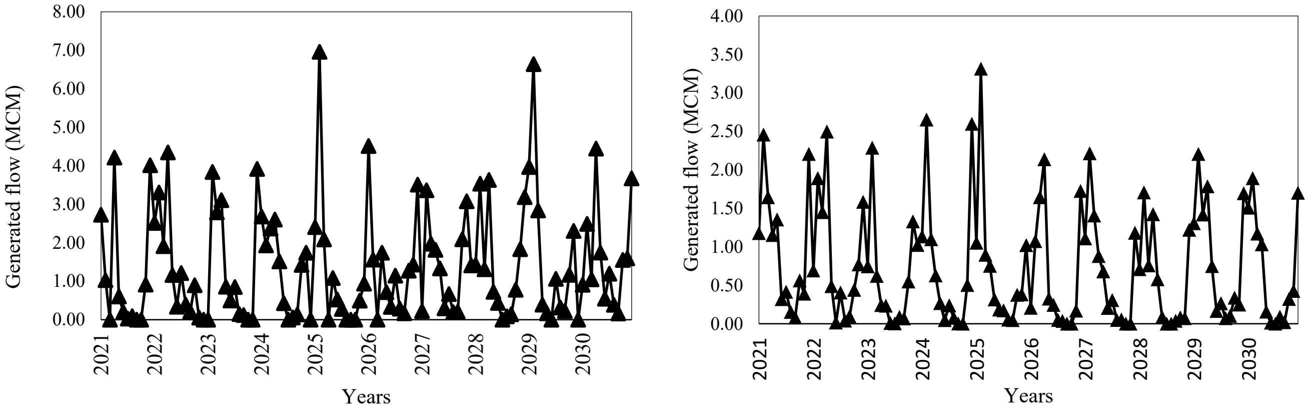


Figure 3. Serial Correlation coefficients a) Beemos; b) Becora



(a) (b)

Figure 4. The monthly mean and standard deviation flow (a) Beemos; (b) Becora



(a) (b)

Figure 5. The monthly generated flow (a) Beemos; (b) Becora

2.6 Characteristics of reservoirs

The reservoir characteristic curves were employed in determining the relationship between elevation, area and storage capacity. Figure 6 shows the characteristic of Beemos and Becora reservoirs. The elevation-volume relationship of Beemos and Becora reservoirs applied the power Equation as in (6) and (7), while the elevation and total area relationship also used Equation (8) and (9).

$$S_{Beemos} = 1256.8(Elev - 192{,}5)^{2{,}1944} \quad (6)$$

$$S_{Becora} = 357.19(Elev - 154)^{1.9567} \quad (7)$$

$$A_{Beemos} = 1565{,}3(Elev - 192{,}5)^{1{,}3503} \quad (8)$$

$$A_{Becora} = 548.83(Elev - 154)^{1{,}0358} \quad (9)$$

where S is reservoir volume (MCM), $Elev$ is the elevation (MSL) and A is the total wetted area (Ha).

2.7 Operating Rules

The purpose of operating rules for water resources systems is to manage outflow from the system. Specific simulations were conducted to determine the limitations of river water availability and demand systems in service areas. Therefore, the simulation objective is to ascertain the reservoir operation over a specific period with known inflow and outflow. In addition, the effort is also used to evaluate reservoir operation strategies and storage requirements (Mays & Tung, 1992). Simulations were conducted by trial and error for reservoir release. Also, particular indicators used to assess the reservoir operation performance possibly include reliability, resilience and vulnerability. The basic equation of the simulation process was developed from the continuity equation. However, the constrain of the reservoir system was formulated, as observed in Equation (10) -(13) (Mays and Tung, 1992; Jayadi, 2012).

Without release

$$R_t = 0;\ if\ S_t + I_t - E_t \leq DS \qquad (10)$$

Fail release

$$R_t = S_t + I_t - E_t - DS;\ if\ DS < S_t + I_t - E_t \leq DS + TR_t \qquad (11)$$

Meet the target release

$$R_t = TR_t;\ if\ DS + TRt < S_t + I_t - E_t \leq C + TR_t \qquad (12)$$

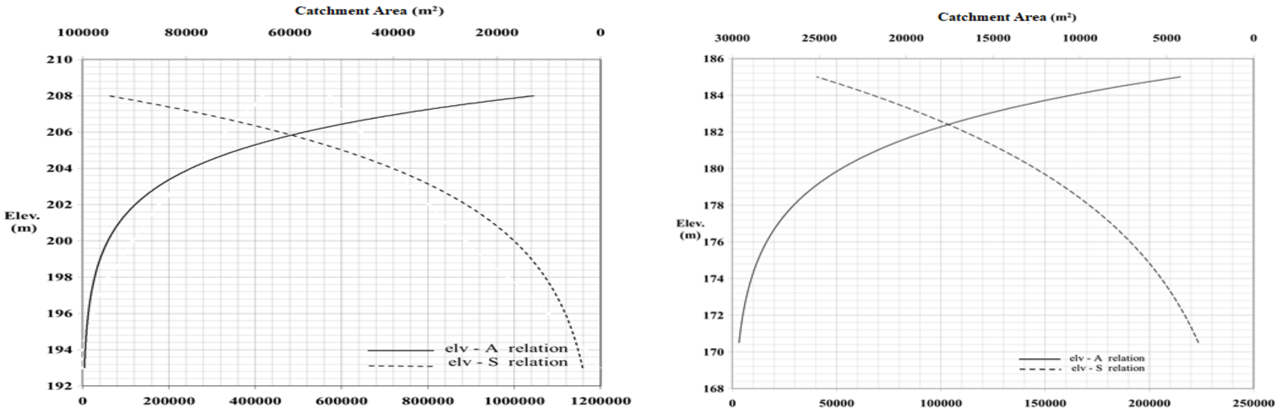
Overflow condition

$$R_t = S_t + I_t - E_t - C;\ if\ S_t + I_t - E_t > C + TR_t \qquad (13)$$

where R_t is the actual release of reservoir t period (m^3), TR_t is the target release of reservoir t period (m^3), S_t is the storage of reservoir t period (m^3), I_t is the inflow t period (m^3), E_t is the daily evaporation t period (mm), DS is the minimum storage (m^3), and C is the capacity of reservoir (m^3).

2.8 Flowchart Research

Figure 7 shows the data analysis and research stages conducted in accordance with the research flow.



(a) (b)

Figure 6. Small reservoir characteristic curve (a) Beemos; (b) Becora

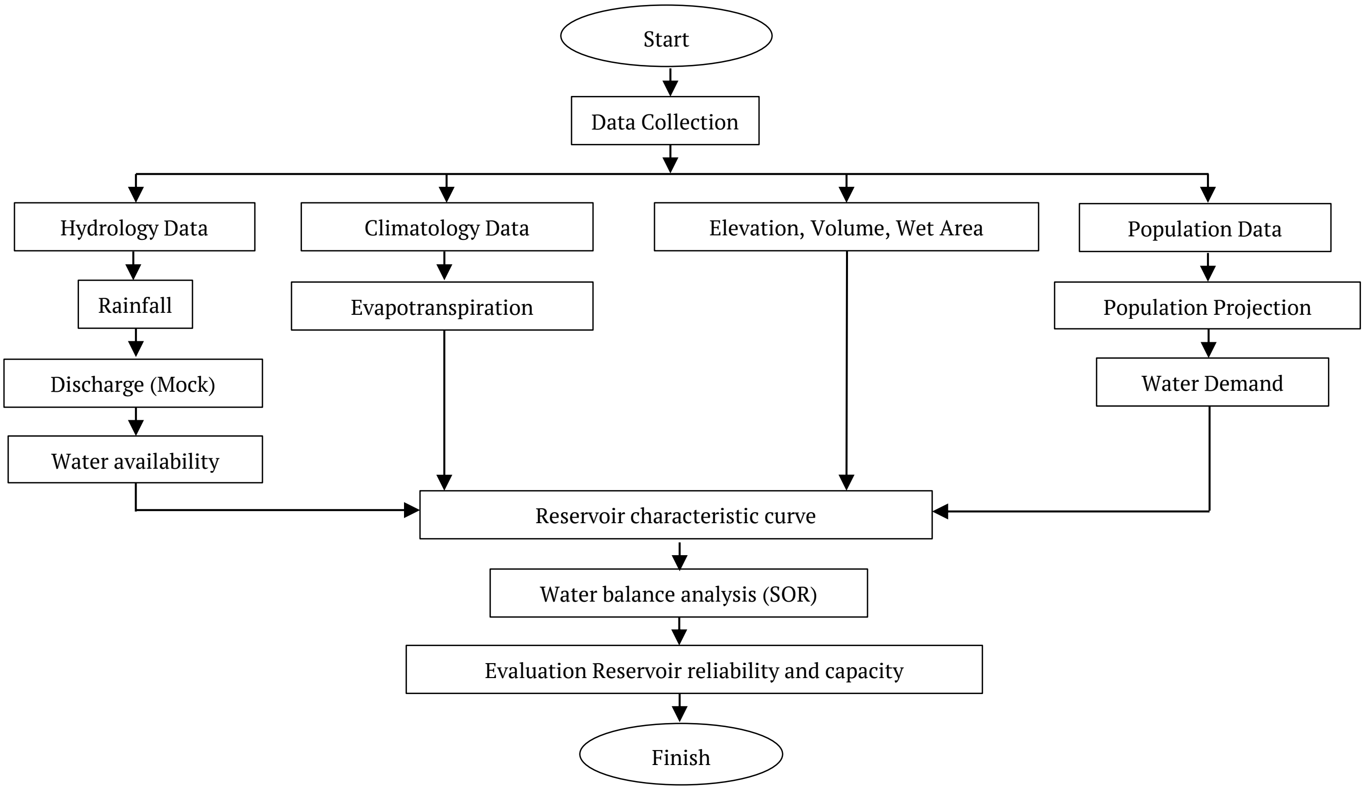


Figure 7. Research flow

3 RESULT

3.1 Water balance

The comparison between water demand and availability in Dili indicated the yearly water demand increase was not accompanied by the available supply in Comoro watershed, as deficits tend to occur for the next 10 years. However, water sources in Comoro are declared unable to fulfill the city's water needs. Table 3 and Figure 8 both represent the water balance analysis.

Table 3. Water demand and availability

Year	Water demand (m^3/sec)	Water availability (m^3/sec)
2015	0.613	0.328
2016	0.617	0.328
2017	0.625	0.328
2018	0.633	0.328
2019	0.641	0.328
2020	0.684	0.328
2025	0.775	0.328
2030	0.968	0.328

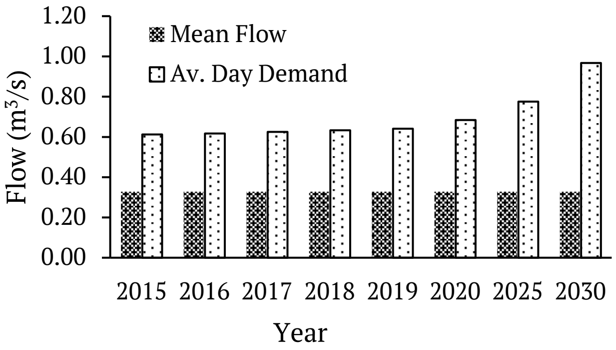


Figure 8. Water Balance Dili

There is a significant need to improve the surface water sources of Comoro watershed, in order to boost water availability. This effort also tends to reduce groundwater exploitation and aims to accommodate minor discharge water. However, the present study developed two reservoir simulation scenarios. Furthermore, the simulation of reservoir potential was categorized into:

1) Build 2 small reservoirs and simulate the reliability based on the inflow and capacity. Beemos is the first unit assumed to serve 60% water demand, while the second is Becora reservoir at 40%.
2) Develop a large volume reservoir (Beemos), and simulate the inflow-outflow as well as the appropriate capacity to meet 100% water demand.

3.2 The small reservoir simulation

The construction of a small reservoir is targeted at exceeding urban demand and the elevation is defined from DEM data, where the maximum and minimum storage capacities were obtained from equations 6 and 7. Meanwhile, the total wetted area is calculated using equations 8 and 9. Furthermore, Beemos and Becora reservoirs are developed to serve 60 and 40% urban water demand, respectively. Table 4 shows the technical data of these small reservoirs.

Table 4. Technical data of small reservoir

Data	Beemos	Becora
Maximum elevation	+210 m	+186 m
Minimum elevation	+194.50 m	+172 m
Total depth	15 m	15 m
Elevation of Spillway	+207.5 m	184 m
Maximum capacity	0.480 MCM	0.110 MCM
Minimum capacity	0.0058 MCM	0.0043 MCM

The simulation feeds of reservoir reliability are the future inflow, net demand, and evaporation. The future inflow was obtained from the algorithm method of Thomas and Fiering. However, the potential release of the reservoir depends on the inflow, storage volume, and evaporation, while the target release is based on net demand. Furthermore, the reservoir demonstrated a sufficient reliability in the entire water release needed to achieve the target. The constrain Equations (4)-(5) were used to determine the reliability of the reservoir simulation. Table 5 and Figure 9 show the results of Beemos small reservoir modelling.

Based on the simulation results, Beemos reservoir reliability between 2021-2030 was estimated at 69.17%. This indicated the water volume was 69%, with the capacity to meet 60% of urban water needs at the specified interval. The reliability did not approach 100%, as not every month of the year achieves the target release.

Also, the total average monthly inflow and outflow were 1.245 and 0.541 MCM, respectively, while for the overflow, 0.645 MCM was reported.

Table 6 and Figure 10 represent the results of Becora's small reservoir simulation.

Table 5. The reliability of Beemos reservoir

Year	Inflow (MCM)	Outflow (MCM)	Overflow (MCM)	Reliability(%)
2021	1.179	0.391	0.788	69.17 %
2022	1.120	0.552	0.607	
2023	1.137	0.412	0.686	
2024	1.075	0.502	0.573	
2025	1.216	0.542	0.674	
2026	1.200	0.610	0.589	
2027	1.282	0.626	0.656	
2028	1.282	0.559	0.722	
2029	1.264	0.672	0.591	
2030	1.694	0.911	0.784	
Average	1.245	0.541	0.654	

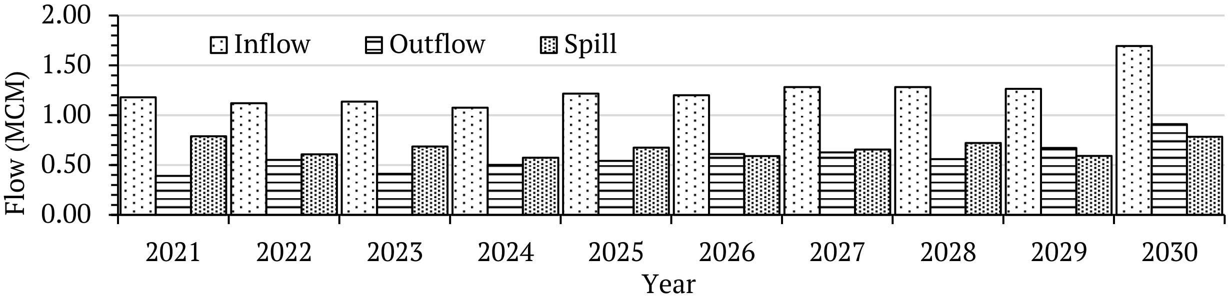


Figure 9. Beemos small reservoir Inflow-Outflow

Table 6. The reliability of Becora reservoir

Year	Inflow (MCM)	Outflow (MCM)	Spill (MCM)	Reliability (%)
2021	0.991	0.348	0.643	52 %
2022	0.863	0.319	0.543	
2023	0.599	0.265	0.334	
2024	0.769	0.267	0.502	
2025	0.712	0.331	0.381	
2026	0.633	0.261	0.372	
2027	0.672	0.304	0.368	
2028	0.555	0.281	0.273	
2029	0.861	0.360	0.501	
2030	0.693	0.373	0.319	
Average	0.735	0.311	0.424	

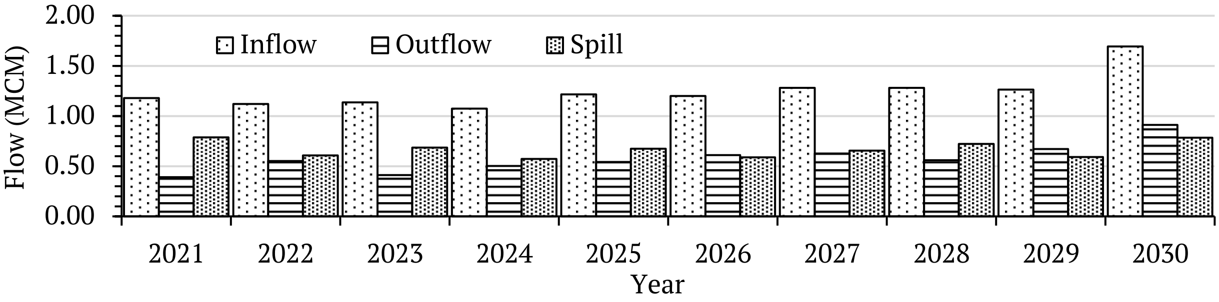


Figure 10. Becora small reservoir Inflow-Outflow

Based on the simulation results of Becora reservoir reliability, the river inflow appeared lesser, compared to Beemos. Therefore, in planning, Becora was designed with a minimal volume to serve barely 40% of city demand. The simulation results also showed the total average monthly inflow of the Becora reservoir was estimated 0.735 MCM, while the annual average outflow was released to meet the target discharge of 0.311 MCM. However, the total monthly average of overflow was achieved at 0.424 MCM, as Becora reservoir reliability obtained 52%, due to the inability to demonstrate 100% performance on a monthly basis.

3.3 The large reservoir capacity simulation

The small Beemos and Becora reservoir simulation results showed the insufficiency to accommodate the inflow of both rivers. Also, the operation of reservoirs were conducted, but due to the limited volume, large overflow wastage was recorded. Therefore, a larger reservoir is highly preferable, compared to the lesser unit. The size or volume of a large reservoir certainly influences construction and operational cost. However, the ability of the infrastructure to meet the water needs in Dili reduces the overflow, and provides several positive benefits. In addition, the reservoirs also exhibit multipurpose operations.

The simulation to determine reservoir capacity is conducted, prior to reliability calculation. Input data include the Beemos river inflow generated data from 2021-2030 and Dili net water demand data. However, evaporation data is not considered in this simple simulation. Meanwhile, the reservoir capacity of 20% served as the minimum storage, in order to accommodate sediment. Therefore, due to its large size and cost considerations, building 1 reservoir in the Beemos river with extensive water discharge was proposed. Table 7 and Figure 11 represents the results of the Beemos reservoir capacity simulation.

Table 7. The Simulation of Beemos large reservoir

Storage Capacity =		7.41	(MCM)
Storage min.volume =		1.5	(MCM)
Years	Inflow (MCM)	Outflow (MCM)	Spill (MCM)
2021	1.179	0.958	0.368
2022	1.120	0.979	0.298
2023	1.137	1.001	0.000
2024	1.075	1.022	0.137
2025	1.216	1.176	0.050
2026	1.200	1.198	0.000
2027	1.282	1.219	0.000
2028	1.282	1.240	0.090
2029	1.264	1.261	0.030
2030	1.694	1.682	0.000
Average	1.245	1.174	0.097

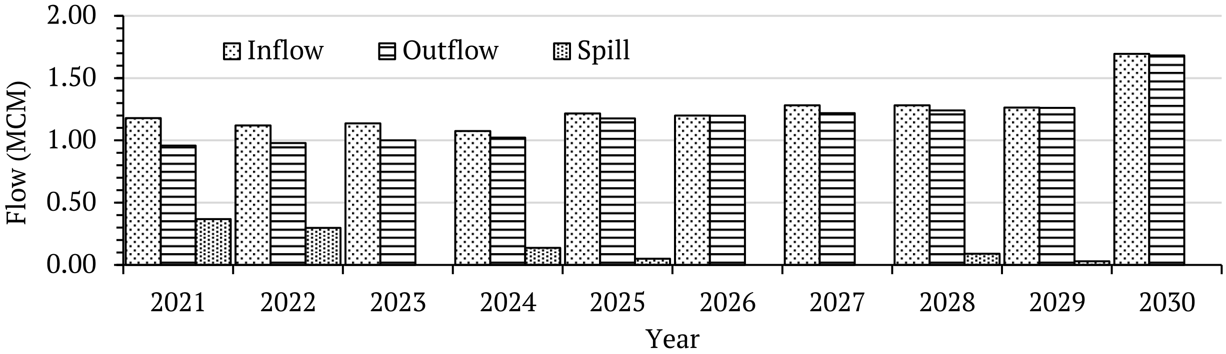


Figure 11. Beemos large reservoir Inflow-Outflow

Based on the simulation results, Beemos large reservoir capacity was achieved at 7.41 MCM. This estimation is greater, compared to Beemos and Becora units. The value is also able to serve 100% water demands in Dili, and is also applied as flood control as well as in hydropower application. However, the minimum reservoir volume was estimated at 1.5 MCM, with the average monthly inflow and outflow reported as 1.245 and 1.174 MCM, respectively.

Also, according to the simulation results, a minimal overflow from the reservoir was observed yearly, with the monthly average overflow of 0.097 MCM. This volume appears very low compared to the inflow. The inflow is utilized by 90% while only 10% tends to spill as an overflow. Figure 12 shows the fluctuations in the reservoirs, and between August to early November, the storage volume was known to decline, due to reduced inflow, but subsequently increased from the end of November to July. Therefore, by estimating the monthly storage fluctuations, the water release arrangements for urban purposes are possibly determined.

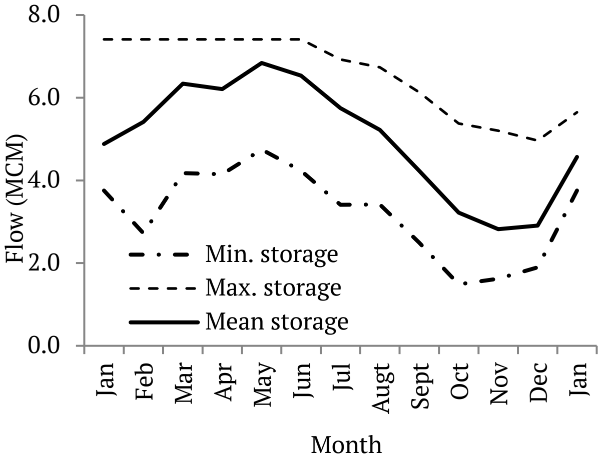


Figure 12. Fluctuation of Beemos storage volume

4 DISCUSSION

Based on the simulation results, the projection of average water demand up to 2030 increased by 0.968 m3/sec, while the total water availability was evaluated at 0.328 m3/sec. The outcomes of water balance analysis showed a deficit supply in Dili during the specified interval, and based on the water balance graph, water availability tends to remain consistent, as the demand graph continues to increase with growing population. However, the assumption of the water availability analysis appeared consistent up to 2030 as no strategic plan for water resource development in Comoro watershed was considered until 2018. Developmental plans in the water sector between 2015-2018 only focus on improving the water supply system in urban and rural areas.

The impact of constructing a small dam and reservoirs to resolve water needs is not very effective. This is due to the small size of the reservoir to accommodate the volume of inflow from Beemos and Becora rivers. Therefore, the overflow tends to occur with a massive volume. In the analysis, the target release was not achieved by the inflow every month, while during dry season with decreased inflow, the reservoir becomes inadequate to approach the target. However, the overflow appears abandoned and is not efficient to utilize in dry seasons. Despite this circumstance, it does not significant denote 100% reservior reliability. Moreover, the reliability remained very minimal up to 2030, due to inadequate reservoir capacity to store the entire inflow volume. Therefore, in dry seasons, the reservoir is unable to achieve the target release. As a consequence, the construction of small reservoirs becomes less effective in meeting the urban water demands by 2030.

The large reservoir construction is a required alternative towards achieving the water demand of Dili by 2030. These volumes are possible to accommodate inflow from Beemos. The result of occurring overflow appears minimal, compared to small reservoirs sources. However, 90% inflow is utilized, and is expected to meet the urban water demand.

The construction of reservoirs to meet urban water needs in Dili city is one of the follow-up actions for implementing the priority strategy, including the development of water resource infrastructure. Also, the capacity and reliability simulation results presumed the water demand between 2021-2030 is possible to achieve, by building a large Beemos reservoir. This effort, therefore, demonstrates a great indication, although, the government is expected to conduct a comprehensive feasibility study related to geological, climatic, hydrological, land use, environmental, and social conditions in the upstream area of the Becora and Beemos, prior to implementation.

This positive implication of the reservoir development helps to guide the government in paying attention to other project plans for this priority strategy. Another recommended proposal in the use of priority strategy is to build and improve water distribution system and availability. This initiative also needs to be implemented, in order to support the function and operation of reservoir development. Therefore, a clean water distribution results in an effective performance, and the reservoir functions tend to also provide greater benefits in fulfilling urban water demand by 2030.

5 CONCLUSION

Based on the simulation of Beemos and Becora reservoir operations in a 10-year forecast, between 2021-2030, the reliabilities of both rivers were estimated to approach 69 and 52%, respectively. These infrastructures were not able to meet the Dili urban demand by 2030, due to low reliability below 100%. The simulation of the large Beemos reservoir capacity exhibited significant ability to accommodate and reduce the overflow. In addition, the inflow was effectively utilized. Therefore, the large reservoir was able to match the water demand up to 2030. Furthermore, the implementation of effective water resource management strategy through the construction of the Beemos reservoir and dam was probably considered by the Timor Leste government. This indicated an effort to develop the surface water source to meet the prospective water demand in Dili. In this study, certain gaps needed further assessment. The reliability of the large Beemos reservoir with multipurpose functions certainly requires future investigations. Direct flow measurement in Beemos river was highly recommended, in order to generate accurate inflow discharge values.

DISCLAIMER

The authors declare no conflict of interest.

AVAILABILITY OF DATA AND MATERIALS

All data are available from the author.

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