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Climate Change Impacts for Multipurpose Reservoir Planning: Basnagoda Reservoir, Sri Lanka

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Abstract: Climate change via rainfall and temperature changes poses threats to water resources. Traditionally, these variations are rarely considered in irrigation infrastructure planning. Integrating climate impacts into early irrigation planning ensures resilience and sustainability.This study aims to assess the climate change impacts on Basnagoda reservoir using a reservoir operation study, system designing and sizing, water use strategies and making recommendations as mitigation and adaptation strategies.This study employed reservoir operation model recommended in the Irrigation guideline, Sri Lanka to assess four climatic scenarios derived from predicted temperature and rainfall changes. Sensitivity analysis included reservoir sizing for the most critical scenario. Mitigation and adaptation methodologies such as 1) Reservoir capacity enhancement 2) Seasonal shifting 3) Conveyance enhancement were analyzed. Reservoir operations currently meet 100% of domestic demand, irrigating total 950 ha annually (380 ha Maha, 570 ha Yala) with environmental flow. Design capacity fulfils 78% of domestic demand, with environmental flow for projected period. The maximum cultivable area at the design stage while providing 25% of design domestic demand is 544 ha in Maha and 680 ha in Yala season. With a 20% rainfall reduction posing the worst scenario, domestic water fulfilment reduced to 20% (Maha) and 19% (Yala). Optimal reservoir capacity enhancement is 15%, expanding cultivable area to 390 ha, while providing 25% of design domestic demand. Conveyance enhancement increases cultivable area from reservoir water by 15%. This study is unique for integrating climate change impacts into reservoir infrastructure planning and design stages.

Keywords: Adaptation methods, Basnagoda Reservoir, Climate change, Reservoir operation

1. Introduction

Global climatic changes severely affect water resources, and significant changes are predicted in temperature, frequency, and intensity of rainfall [1,2]. Dramatic changes in the water sector [3] will impact the economy and human well-being in the future [4, 5]. Due to the uncertainty of climatic conditions, the reliability of water resources has also been reduced, and the gap between water demand and supply has increased [6]. Climate changes and mitigation and adaptation strategies are necessary for reservoirs and water infrastructure design [1, 5, 6].

In general, reservoirs and other major water infrastructure are designed for long return periods [7], and the system sensitivity to future climate scenarios needs to be assessed [6]. The most important requirements to predict and assess the climate change effects are: 1) the need to reliably identify the climate change predictions and 2) the need to have a reliable models to use when making the predictions. The reservoir operation model outlined in Irrigation guideline, Sri Lanka, which uses the continuity equation, is well-established and recommended for irrigation projects. Despite calls for updating, comparative studies indicate better irrigation water yield outcomes compared to contemporary models [8-10], hence can be used to study the water balance of reservoirs in Sri Lanka. At present there is sufficient literature to evaluate and identify the climate change predictions for Sri Lanka [5,11-15]. However, there is a clear lack of studies evaluating the climate change impacts and proposing mitigation measures while using time tested models, acceptable model parameters and literature supported climate change predictions. In order to fill the gap of having either little or no case studies, the present work was carried out as a case study for the proposed Basnagoda reservoir. The work, while addressing the gap when assessing the suitability under the projected climate change scenarios, made recommendations for future work pertaining to planning and design of multipurpose reservoirs.

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2. Literature Review

2.1 Climatic Change Impacts for Water System

Intergovernmental Panel on Climate Change (IPCC) presents several climate change scenarios and most researchers consider A2 and B2 as relevant to Sri Lankan conditions. The IPCC A2 scenario suggests a decreasing trend in annual rainfall, a trend that has been identified by many researchers for Sri Lanka [12,16-18]. According to IPCC, global temperatures are projected to increase by 1.4°C to 5.8°C by 2100 [19]. The Sri Lanka Country Report on Climate Change [21] has shown that the temperature increase by 2070 will be in the range of +0.4°C to +3.0°C. Sri Lanka's average temperature is 27°C, but there is a wide variation in minimum and maximum, ranging across different topographic and climatic zones [20]. The summary of temperature predictions for Sri Lanka is shown in Table 1.

Rainfall reductions were predicted for future and the highest reduction is predicted for first inter monsoonal period [17]. Number of rainy days will decrease and the rainfall intensity will increase [22]. Due to an increase in extreme rainfall events [23], reservoir siltation can increase. High-intensity rainfall can often lead to significant erosion and runoff, reducing retention and recharge. Unusual flash floods can also damage headworks of irrigation schemes and infrastructure, including canal structures, which can affect a reliable water supply [24]. Consequently, reservoirs may not be able to store the design water capacity. The summary of rainfall predictions for Sri Lanka is shown in Table 2.

Climate change significantly affects economies based on agriculture, and the Asian region is facing significant challenges regarding food security due to its dependence on irrigation and agriculture [4]. The variability of rainfall and changes in the frequency and severity of storms have been predicted [3, 19-20], leading to potential yield reductions [2], [5]. Severe droughts and floods will impact agriculture, environmental flows, and hydropower capacities [25]. Changes in land use patterns and population increments will further increase the adverse effects of climatic changes [3].

2.2 Predictions of GCMs and RCMs

General Circulation Models (GCMs) and Regional Climate Models (RCMs) are used to assess the impacts of climate change on water resource systems [2, 4, 26]. These models are downscaled to a local scale using statistical or empirical relationships, which depend on historical meteorological data and the uncertainties related to GCMs [4].

IPCC has projected several global average climate scenarios using GCMs, as shown in Table 3. A warming of 0.2°C is projected for a range of SRES scenarios for the next two decades. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected [27].

3. Data

The proposed impounding reservoir is planned to be constructed across Basnagoda oya, one of the main branches of Attanagalu oya (Figure 1). The reservoir site is located at Waharaka and has a catchment area of 37 km². The catchment area falls under the agro-ecological zone WL1 of Sri Lanka. Details of the data collection are presented in Table 4.

For monthly water balance calculations, the 75% probable rainfall data of Irrigation guideline, Sri Lanka [7] was considered, due to its proven efficacy in design, supported by time-tested performance and comparatively better irrigation yield outcomes in recent model comparisons [8-10] while monthly average evaporation data of Colombo meteorological station was used for the study.

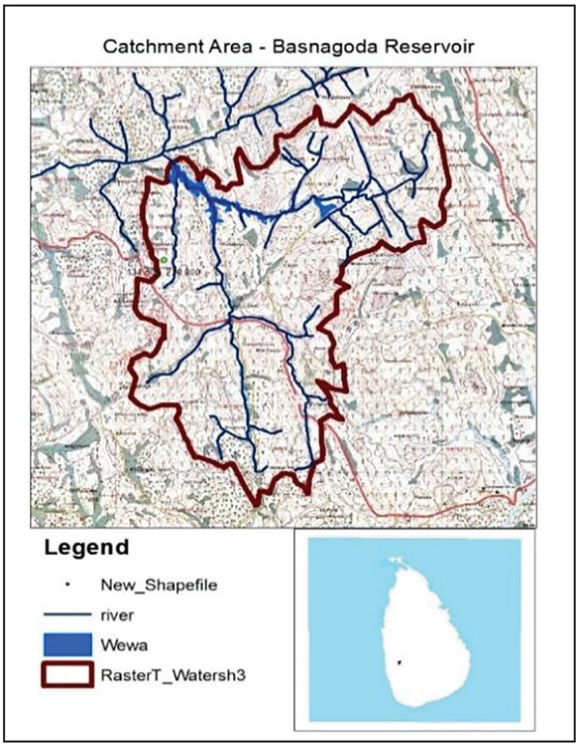

Figure 1 - Study Area Map

Table 1 - Climate Change Predictions Related to Temperature

Reference	Basin	Period	Temperature trends
[13]	Badulla, Ratnapura, Diyatalawa, Kandy and Nuwara Eliya	1896-2006	mean annual temperature increase of more than 1^0C in Nuwara Eliya, increasing temperature trends in all stations
[18]	intermediate (IL1)	1932- 2001	decreasing annual rainfall and diurnal temperature trends, increasing maximum and minimum temperature, 1.4% increase in maximum temperature
[28]	Sri Lanka	1961-1990	annual mean air temperatures have shown significant increasing trends with the mean air temperature of 0.016^0C
[11]	Puttalam		annual mean maximum air temperatures increasing trends in almost all stations with the maximum rate of increase about 0.021^0C per year
[29]	Sri Lanka	1961-1990	Sri Lanka's mean temperature to increase by approximately $0.9\text{-}4^0$C over the baseline
[14]		1961-1990	consistent increases for future temperature with an increase of 2.3^0C to 3.6^0C
[19]			global mean temperature is projected to be risen in the range of 1.4 – 5.8 °C by the year 2100, the mean temperature during the northeast monsoon and southwest seasons is projected to increase about 2.9 °C and 2.5 °C, respectively
[30]	Northern province	2020-2100	temperature increase would total 1.13°C - 1.81°C
[31]	Sevanagala	2010-2019	by 2090, the average annual minimum and maximum temperatures would increase by 1.2 °C and 1.4 °C
[32]	Dry zone (North and North central provinces)	1970-2020	Temperature exhibits warming of approximately 1.0 ◦C , a trend of significant warming by 0.02 ◦C/year, RCP4.5 and 0.03 ◦C/year, RCP8.5 from 1950 to 2100
[33]	Sri Lanka	2020-2090	temperature in $0.7\text{-}1.2^0$C, $1.0\text{-}1.6^0$C, and $1.5\text{-}2.3^0$C can be expected during 2020-2040, 2040-2060, and 2070-2090 for moderate emission scenario

Table 2 - Climate Change Trends for Rainfall in Sri Lanka

Reference	Basin	Period	Rainfall trends
[17]	Sri Lanka	1963-1993	daily rainfall decreases with highest decrease in the first inter-monsoon period March-April, significant decrease in the number of rainy days and increase in their intensities
[15]	upper Mahaweli		significant decrease in rainfall area of about 39.12 % and have predicted a further 16.6 % reduction in the next 21 years (2025)
[22]	Sri Lanka 22 stations	1961-2002	number of rainy days has significantly decreased but the total annual rainfall will not be changed, increased duration of dry spells
[13]	Badulla, Ratnapura, Diyatalawa, Kandy and Nuwara Eliya	1896-2006	significant reduction in the annual rainfall, South West monsoon rainfall showed decreasing trends and increasing temperature trends
[18]	intermediate (IL1)	1932 -2001	reduction of 9% in annual rainfall after 1986
[29]	Sri Lanka	1961-1990	changes in quantity and spatial distribution of rainfall
[23]	Dry zone, Sri Lanka		24 hour heavy rains will increase, uncertainty of timely rainfall, changes in rainfall in monsoons
[30]	Nothern province	2020-2100	106.19 mm of augmented rainfall - SSP2 4.5 scenario 159.6 mm increase in rainfall - SSP5-8.5 scenario
[31]	Sevanagala	2010-2019	The annual rainfall is expected to increase by 6.0% in 2090
[32]	Dry zone (North and North central provinces)	1950-2100	upward trend of rainfall (2.0 mm/year, RCP4.5 and 2.9 mm/year, RCP8.5) by 2100
[33]	Sri Lanka	1980-2015	increasing trend for annual precipitation at a 5% or 10% level, increment of South West Monsoon and decrease of North East Monsoon rainfall

Table 3 - IPCC Scenarios for Global Average Climate Temperature and Sea Level Rise

	2090- 2099 relative to 1980-1999		
	Temperature change (^{0}C)		sea level rise (m)
case	Best estimate	Likely range	Model based range in ice flow
constant year 2000 concentrations	0.6	0.3-0.9	NA
B1 scenario	1.8	1.1-2.9	0.18-0.38
A1T scenario	2.4	1.4-3.8	0.2-0.45
B2 scenario	2.4	1.4-3.8	0.2-0.43
A1B scenario	2.8	1.7-4.4	0.21-0.48
A2 scenario	3.4	2.0-5.4	0.23-0.51
A1F1 scenario	4	2.4-6.4	0.26-0.59

4. Methodology

Four main steps were followed in the methodology of the present study: 1) Conducting reservoir water balance studies for current and design scenario of the prefeasibility study, according to Sri Lanka's Irrigation Guideline [7]; 2) Establishing four climate change scenarios for the year 2100, based on research for Sri Lanka and conducting reservoir water balance studies for climate scenarios; 3) Performing sensitivity analyses on reservoir sizing and groundwater impacts; 4) Analysing mitigation and adaptation strategies. A monthly water balance for a water year was conducted to meet design requirements, emphasizing: 1) Prioritizing domestic water supply alongside cultivating a minimum of 4ha (DR1); 2) Allocating 25% of the domestic demand from Basnagoda reservoir while supporting full irrigation during Maha and Yala seasons (DR2).

4.1 Reservoir Water Balance Present Scenario

Monthly reservoir water balance studies were conducted for both present and design scenarios (prefeasibility study design scenario - 2030), validated against NAM model outcomes from prefeasibility study. Current domestic water demand (36,000 m^3/day) was calculated from population data [35] and National Water Supply and Drainage Board (NWSDB) consumption rates. Design domestic demand for 2030 was calculated from Feasibility report of Basnagoda reservoir [34], while industrial and other water (institutional/public areas/offices) demands estimated at 30% and 20%, respectively, due to data limitations. The water balance equation was used for reservoir water balance as,

Table 4 - Data Collection Details

Data	Data source
Reservoir data	Irrigation Department (EIA report) [34]
Estimated Inflow, outflow data	Irrigation Department, Meteorological department
Domestic water intake estimations	National Water Supply and Drainage Board
Hydraulic data	Irrigation Guideline [7]
Atmospheric data	Irrigation Guideline [7]
1:50 000 Topo sheets	Survey Department
Population data	Department of Census and Statistics [35]
Climate data	Department of Meteorology, Department of Irrigation

$$S(t) - S(t-1) = I(t) - \big(E(t) + Se(t) + Ef(t) + WD(t) + Ir(t) + Sp(t)\big) \quad \text{... (1)}$$

where, S = Storage of the reservoir, I = Reservoir inflow, E = Evaporation, Se = Seepage from reservoir, Ef = Environmental flow requirement, WD = Domestic demand, Ir = Irrigation demand, Sp = Spillage.

4.2 Water Balance and Climatic Scenario

Four climate scenarios were developed in Table 4 based on the climatic predictions in Table 5 with literature survey results for the year 2100. The predictions were mainly based on two parameters as rainfall and temperature. Modelled evaporation rates and the temperatures obtained using observed meteorological variables for the period of 1990-2010 in Australia [36] due to unavailability of literature for Sri Lanka. Blaney Criddle formula was used for calculating the reference crop evapotranspiration value according to scenario changes as,

$$Potential\ crop\ evapotranspiration = p(0.46T + 8) \quad \ldots(2)$$

where, p = mean daily percentage of annual daytime hours and T = mean daily temperature [37-38]. Seepage factor that the rate which seepage takes place from water flow [7, 39] and runoff coefficient that the ratio of the volume of water superficially drained during rainfall to the total volume of precipitation during a certain period [7,40-41] remained same as the present scenario due to difficulty of prediction of land use changes.

The first scenario projected a 30% increase in seasonal rainfall and a 3.5°C temperature rise by 2080 [14], extended linearly to 2100. The second scenario for a 15% rainfall reduction over 20 years, adjusted to a 30% reduction by 2100 by nonlinear projections. The third scenario directly forecasted temperature increases up to

2100 [42]. Fourth prediction was done up to 2050 and the linear projection is not reasonable for 2100. Therefore, considering the previous three scenarios fourth scenario has developed. Data from the Department of Census and Statistics were utilized for projecting the domestic water supply demand for the year 2100, Industrial water demand was considered as 50% of the domestic water demand, while other water demand was assumed to be 20% of the water demand for houses.

Table 3 - Climate Predictions for Sri Lanka

	Prediction	Reference
1	• 30% increment of the seasonal rainfall for 2080 • 3.5°C temperature increment in 2080	[14]
2	• 15% rainfall reduction in next 20 years	[43]
3	• Southwest monsoon - 2.5°C, North East monsoon 2.9°C by 2100	[42]
4	• 1.1– 2.4 °C by 2100, depending on the emission scenario • Rainfall is projected to increase by 48% for the Southwest Monsoon by 2050 • Northeast Monsoon, which occurs in the drier northern region, is predicted to decrease by 27–29%.	[44]

Table 4 - Climatic Scenarios Considered

Scenario	Scenario description	Scenario Justification
Scenario 1	• 46% of the seasonal rainfall increment • 5°C temperature increment	De Silva et al. (2007) have predicted scenario up to 2080. There fore a linear projection was done up to 2100.
Scenario 2	• 30% rainfall reduction	Herath and Ratnayake, (2004a) have predicted the scenario for next 20 years. When projecting to 2100, it gives around 75% rainfall reduction. This rainfall reduction is not reasonable and predicting the linearity for 80 years further is also not reasonable. Therefore 30% rainfall reduction was considered as scenario 2. [22]also states that there is a trend of 30% decrement in Colombo rainfall from 1961-1990.
Scenario 3	• 2.5°C Southwest monsoon, 2.9°C Northeast monsoon increment	Scenario 3 was directly predicted for 2100[42]
Scenario 4	• 2°C temperature increment • 50% increment of Southwest monsoon, 30% reduction of Northeast monsoon	Scenario 4 was predicted for 2050 and 50 years of linear interpolation might not produce reasonable accurate results. Therefore, by considering scenario 1 and 2, 3 predictions, scenario 4 was established.

4.3. Sensitivity Analysis to the Effect of Ground Water

Runoff coefficient is a key parameter affecting surface water quantity. Though the seepage factor is small in magnitude, it was considered for the evaluation considering the variation in seepage, because of the present tendency to desilt the existing reservoirs to enhance storage. There is an ambiguity about the seepage coefficient that is presently used for computations [45]. Accordingly, various combinations of runoff coefficients and seepage factors were analysed to assess the criticality of situations.

The reference values for runoff coefficient and seepage factor were set at 0.35 and 0.005 per Irrigation Department guideline [7]. Runoff coefficients of 0.4 and 0.6 were adopted to reflect land use and catchment changes. Literature predicts seepage factors will range from 0.05 to 0.12 [46-47], with climate change and potentially enhancing groundwater recharge. Nawarathne and Gunawardana [48] estimate 25-35% seepage for dry zone minor tanks. Sensitivity analysis considered seepage factor values of 0.05 and 0.25 accordingly.

Reservoir operation results for critical scenario considering selected runoff coefficients and seepage factors are in Table 5.

4.4. Climate Adaptation Options

Three climatic adaptation options were checked: 1) Reservoir capacity enhancement, 2) Seasonal shifting, 3) Conveyance efficiency improvement for the identified worst scenario. A sensitivity analysis was done for the reservoir sizing to identify the optimum productive capacity enhancement with the climatic changes.

Seasonal shifting was checked considering one month shift frontward and backward. Water conveyance efficiency for the design condition was considered as 0.65 and the option of increment of conveyance efficiency up to 0.75 was checked.

5. Results and Discussion

5.1 Present and Design Scenarios

In the present scenario, full domestic demand is met while irrigating 380 ha in Maha and 570 ha in Yala seasons. Prefeasibility study design scenario reveals Basnagoda reservoir can meet 78% of domestic demand, with the need of additional water sources. Results compared to NAM model show 74% fulfilment verifying calculation results. With 25% of Prefeasibility study design domestic demand, irrigation supports 544 ha – Maha and 685 ha – Yala.

Considering water usage sectors, higher priority is given to drinking water, with a necessity to maintain balance among other sectors due to water stress and the limited availability of water. Paddy cultivation predominantly utilizes water in the Attanagalu basin throughout the year, emphasizing the importance of prioritizing agricultural water usage. Assumptions used for the study include: 1) Industry water requirement assumed as 30% of residential demand, 2) Other water demand for institutes, public areas, and offices calculated at 20% of residential demand, 3) Irrigation demand calculated for 135-day Maha and 105-day Yala rice seasons, and 4) Irrigation assumed for rice cultivation without consideration for other field crops (OFC). Results indicate the necessity to identify additional water resources to meet design domestic demand.

5.2 Analysis for Climatic Scenarios

Monthly rainfall and evaporation variations across different climatic scenarios with prefeasibility study design and present conditions are compared in Figure 2. Reservoir storage and spill variations, highlighting higher unpredictable spillage from February to April in SC1, is indicated in Figure 3. Other scenarios show approximately same spillages with a cyclic pattern while spilling in two main seasons (Maha, Yala) during same period of the year.

DR1 condition shows differences in considered scenarios (Figure 4). The maximum achievable domestic demand is 37.5% that is in SC1 for Maha season. Highest achievable domestic water demands (32.5%) in Yala season were obtained in SC1 and SC4. This observation highlights rainfall's critical impact on irrigation infrastructure and water supply, necessitating additional water sources for future domestic demands in the Attanagalu basin. DR2 condition (Figure 4) indicates that more water can be provided for agricultural lands, for scenarios SC1 (900 ha), SC3 (562 ha) and SC4 (753 ha) in Yala season, than Maha season. In SC1, 539 ha can be cultivated with the water from the reservoir in Maha season while in other scenarios the irrigable area from reservoir water is less (SC2 – 365 ha, SC3 -385 ha, SC4-305 ha). Considering the cultivable areas and water availability for both conditions (DR1 & DR2) in scenario analysis, SC1, SC4, SC3 and SC2 can be categorized from the best to the worst.

Located in the wet zone, the proposed Basnagoda reservoir receives higher Yala season rainfall but limited Maha season rainfall, hence functions as a flood control retention pond while supplying drinking water and supporting agriculture. Wet zone paddies are less affected by negative climate change impacts like temperature and water scarcity, crucial for maximizing rice cultivation potential [49]. Several effects of the climate change on reservoir operation can be expected: 1) Due to average rainfall reduction, evapotranspiration increment and crop water requirement increment, while population growth and reduced groundwater wells, reservoir will not be able to produce the full irrigation demand, balancing with other water need sectors, 2) Extreme events can occur and flash floods can be expected.

Uncertainties in the research may include:

1) Predicting climate change over 100 years based on researcher forecasts, may differ from actual climate due to long period of time. 2) Assumed linearity in scenarios may differ from actual climatic change 3) Industry's assumed water demand at 50% of future domestic demand, subject to variability, 4) Future population estimates lacking migration factors, potentially impacting water demand calculations. 5) Agricultural water usage practices that can differ from the considered pattern 6) Use of Australian research on temperature-evaporation relationship [36] can differ from future Sri Lankan conditions.

5.3 Effect on Ground Water

Higher spillage is indicated for scenarios with higher runoff coefficients, controlled to some extent by seepage increments, but sudden flood-prone situations are expected. The water availability for domestic demand shows a slight increment (from 18% to 22%) in Maha and a considerable increment (from 19% to 33%) in Yala season.

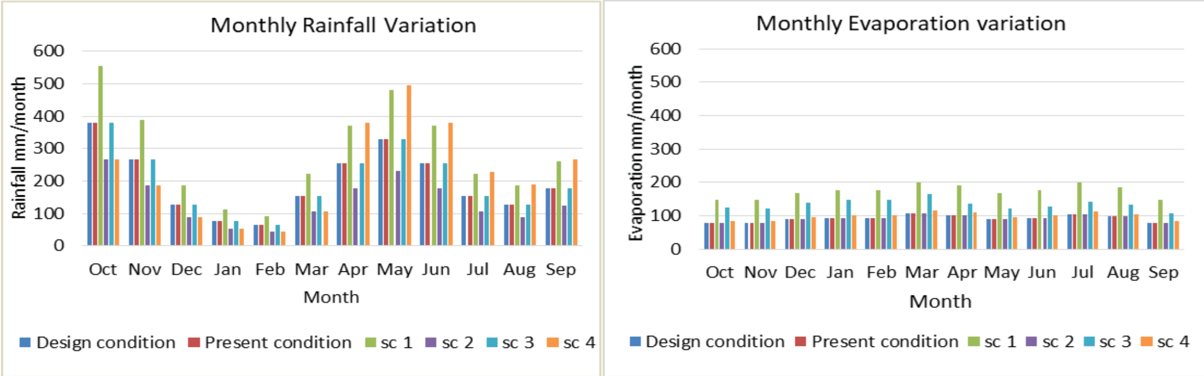

Figure 2 - Monthly Rainfall and Monthly Evaporation Variation in different Scenarios

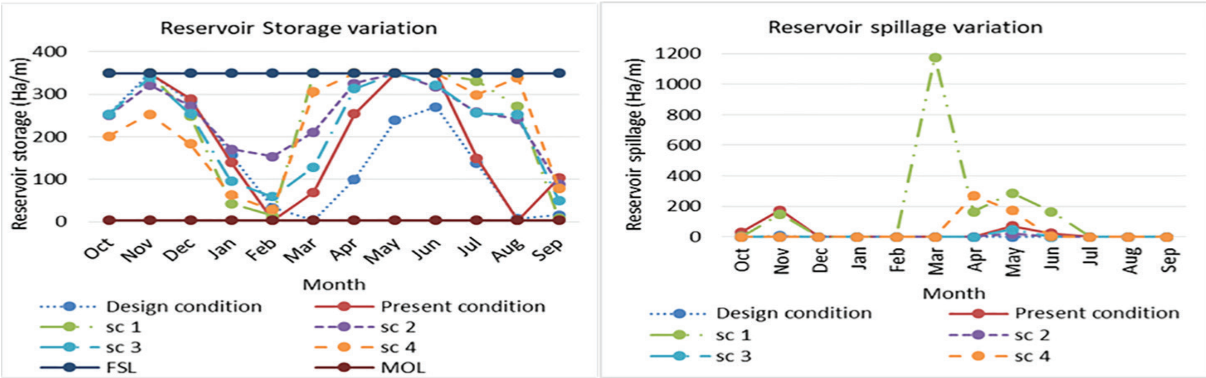

Figure 3 - Monthly Reservoir Storage and Spillage Variation

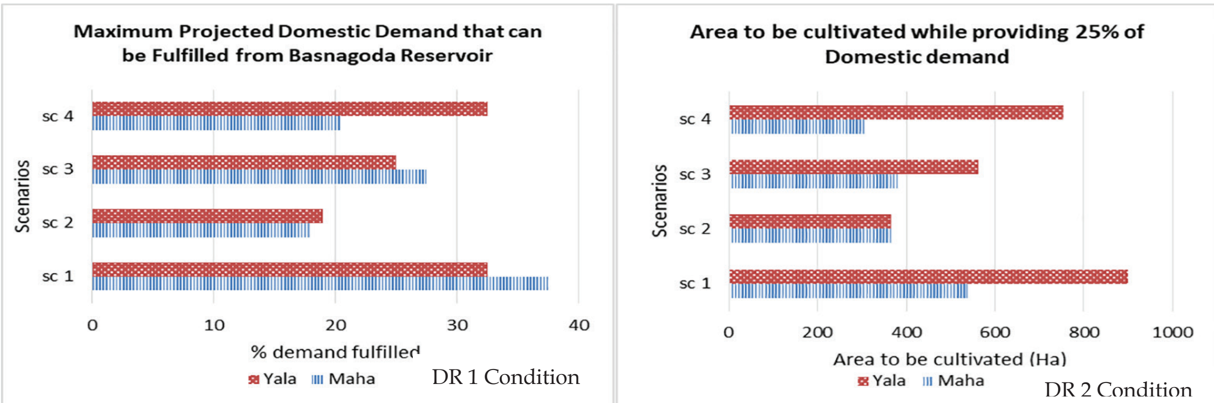

Figure 4 - Maximum Domestic and Irrigation Demands that can be Fulfilled from Basnagoda Reservoir

The results of water availability for irrigation show an increment of cultivable area with the increment of runoff coefficient and seepage factor.

The results indicate a higher surface water availability with selected runoff coefficient and seepage factor combinations will cause for reduction of groundwater replenishment. Being a vulnerable basin for floods, Basnagoda reservoir will be used for as a retention detention purposes in Attanagalu basin and it will be an additional benefit.

5.4 Climate Adaptation Option Analysis

Climate adaptation option analyses for DR1 and DR2 conditions are in Figure 5 and Figure 6, respectively. Sensitivity of the reservoir capacity was calculated by considering different spill levels and reservoir capacities for the worst climatic scenario (SC2). Results are shown in Table 8 and indicate that highest productive capacity enhancement is 15%. Therefore a higher percentage of capacity increment will not highly productive due to 1) water reduction by evaporation with increased reservoir area 2) infrastructure construction cost which is much higher comparative to benefits. Hence, increment of reservoir capacity and spill height might not effectively address the challenges posed by climate change. However, catchment yield, reservoir inflow, evaporation, and irrigation requirements seem to be influenced by the climate changes.

Table 5 - Percentage of Domestic Water Fulfilment Considering the Effect to Ground Water

	Runoff coefficient	Seepage factor	Percentage fulfilled of domestic demand (Maha) (DR1)	Percentage fulfilled of domestic demand (Yala) (DR1)	Area to be cultivated fulfilling 25% of design domestic demand (Maha) (ha) (DR2)	Area to be cultivated fulfilling 25% of design domestic demand (Yala) (ha)(DR2)
1	0.35(R)	0.005 (R)	18 (Estimated)	19 (Estimated)	365	365
2	0.4 (~15% increase)	0.05 (~900% increase)	22	21	388 (~6.3% increase)	485 (~32.8% increase)
3	0.6 (~70% increase)	0.25(~4900% increase)	22	33	365 (no increase)	547.5(~50% increase)

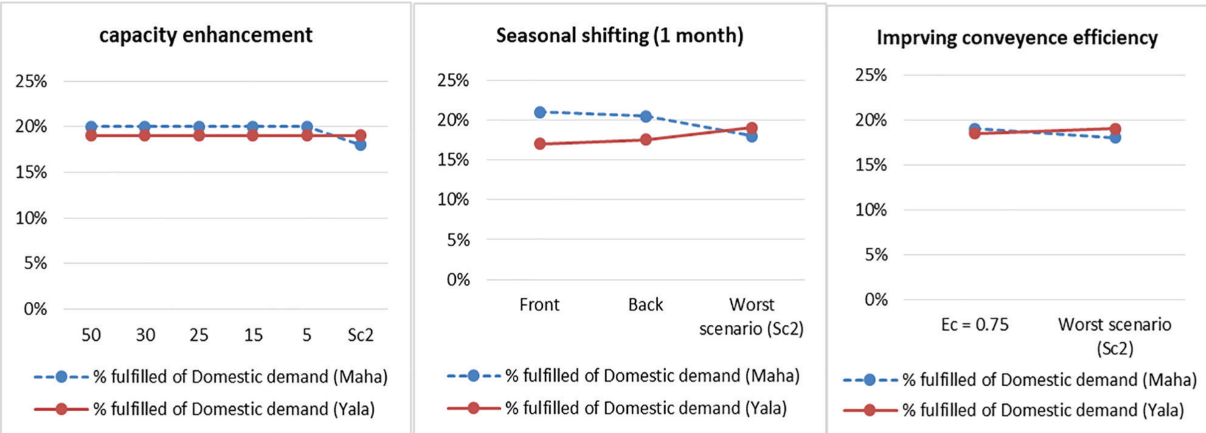

Figure 5 - Effect of Climate Adaptation Options for Domestic Demand

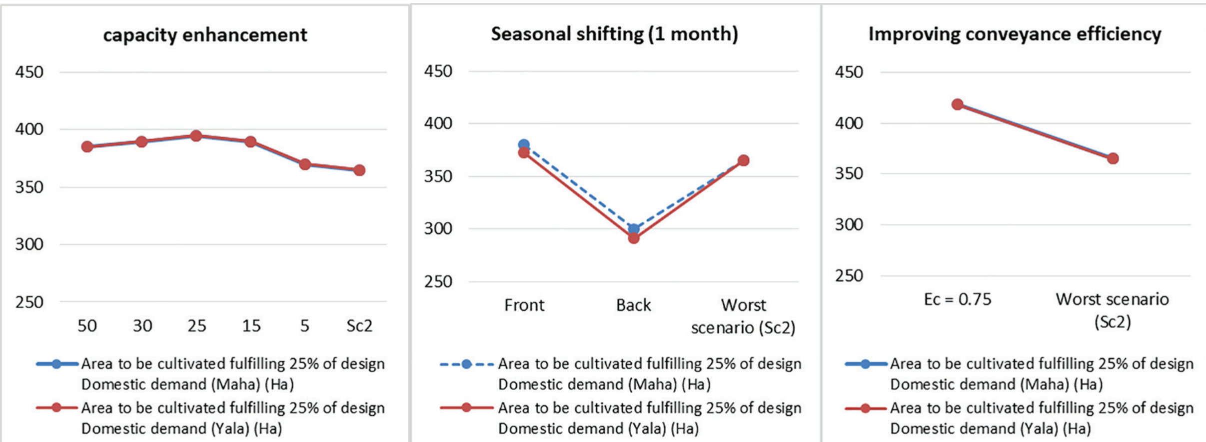

Figure 6 - Effect of Climate Adaptation Options for Irrigation Demand

Table 6 - Analysis of Reservoir Capacity Enhancement

Capacity enhancement percentage	FSL capacity	Spill level	% fulfilled of domestic demand (Maha) (DR1)	% fulfilled of domestic demand (Yala) (DR1)	Area to be cultivated fulfilling 25% of design domestic demand (Maha) (ha) (DR2)	Area to be cultivated fulfilling 25% of design domestic demand (Yala) (ha) (DR2)
50	525	51.76	20%	19%	385	385
30	455	50.88	20%	19%	390	390
25	437.5	50.66	20%	19%	395	395
15	402.5	50.22	20%	19%	390	390
5	367.5	49.78	20%	19%	370	370
Worst scenario	350	45.77	18%	19%	365	365

The results of cultivation pattern changes by one month forward and backward (Figure 6) show that forward shifting increases the irrigable area by reservoir water (4% - Maha, 2% - Yala) while backward shifting reduces it (18% - Maha, 20% -Yala). The cultivation pattern changing does not show a recognizable relationship with domestic demand.

Policies and operational rules demonstrated significant sensitivity to irrigation water requirements, with backward seasonal shifts yielding negative outcomes and forward shifts slightly enhancing cultivable areas. Enhancing water conveyance efficiency improved irrigation supply, increasing cultivable area by 15%. Therefore, prioritizing conveyance efficiency enhancement as a climate adaptation strategy is recommended, supplemented by exploring additional water sources to meet domestic demand. Integrated water resources management and the awareness enhancement will also be good strategies with many uncertainties.

This study is unique due to considering climate change effect to the reservoir infrastructure at the planning and design stage, as addition to the common procedure of analysis of 1) Future population increment, 2) Future land use changes for future water demand. The irrigation reservoirs are designed for higher return periods and it is worthwhile analysing climatic changes when planning and designing new reservoirs due to the easiness of taking preventive and preparation measures for climate change adaptation.

6. Conclusion and Recommendations

1. Proposed Basnagoda reservoir will be able to fulfil 100% of present domestic demand of Attanagalu basin while providing irrigation water for 380ha in Maha season and 570 ha in Yala season in the present condition.
2. Rainfall reduction affects water resources more than the temperature increment.
3. The reservoir capacity will not be sufficient to fulfil future domestic demand of Attanagalu basin.
4. Climate change adaptation methodologies need to be followed for a sustainable development are reservoir capacity enhancement by 15% and increasing the water conveyance efficiency.

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