Climate Change Impacts and Adaptation Measures in Giritale Reservoir in Polonnaruwa Sri Lanka

M.Kamran and N.T.S. Wijesekera

ABSTRACT

Climate change is one of the most important global environmental challenges, which affects the overall system by affecting food production, water supply, health, energy, etc. For study purpose Giritale reservoir in Polonnaruwa district of dry zone in Sri Lanka was selected. Catchment area of the reservoir is 24.3 sq.km and command area is 3075 ha. Data for the reservoir was collected from irrigation department, Colombo and 6 year (2010-2015) rainfall data collected also from irrigation department. This study investigated the impact of climate change, adaption and mitigation measures reservoir system. After a review three scenarios were identified. Scenario 1 rainfall increase 15.8% and temperature increase 8% and scenario2 rainfall increase 14% and temperature increase1.6% and scenario 3 is rainfall is projected to increase by 48% for the Southwest Monsoon by 2050 and Northeast Monsoon, which occurs in the drier northern region, is predicted to decrease by 27–29%. For the worst scenario four adaptation measures were proposed. Among the four only two adaptations could be quantified, and the best adaptation measure was identified. Among scenario option's, the scenario 2 is the worst scenario and adaptation measure taken for scenario2consist of two options. Option1 is changing the crop type and option 2 is increasing the canal efficiency. For option 1 105 days paddy for Maha and Yala was taken and also green gram for both Maha and Yala was considered and for option2 canal efficiency increased by 10% . Therefore comparing the results adaptation use of green gram improved the cropping intensity by 13%.For verification of result actual rainfall data is not enough and also for predicting the climate trend. Future climate projections indicate that the climate is changing and impacts on agriculture sector can be expected and Worst climate change scenario for the Gritale scheme is when increasing rainfall 14% and also increase the evaporation 6.4%.

KEYWORDS: Climate change, Irrigation scheme, Adaptation

1. Introduction

Sri Lanka is situated between 6 and 10 degrees to the North of the equator has predominantly monsoonal and tropical climate. A recent review by IWMI on the status of climate change research/activities in Sri Lanka suggests that Sri Lanka's mean temperature by the year 2100 may increase by about 0.9-40 °C over the baseline of 1961-1990, this accompanying change in the quantity and spatial distribution of rainfall. So therefore it is likely that these impacts significantly affect Sri Lanka's food production, water supply, energy production, fisheries and infrastructure etc.

Agriculture accounts for a little over 20 percent of GDP and provides nearly 70 percent of the rural employment. Irrigation is the major user of fresh water consuming over 90 percent of the total annual captured water. The competing demand for water from other water-use, sectors (domestic, industrial, hydro-power and environmental needs) are continuously undergoing an increasing trend. According to the International Food Policy Research Institute (IFPRI) climate change impact had been on agriculture and costs of adaptation forecast that by 2050 rice prices will increase between 32 and 37% climate change also… in rice yield losses in rice could be between 10 and 15%.More than half of Sri Lankan food grain production is dependent on irrigated rice.

Sri Lanka depends primarily on its surface water resources for agricultural, domestic and industrial uses. Amarasinghe et al. (1999) described that one half of all Sri Lanka rivers have either zero or negligible flow during the Yala (dry) season. Agriculture in Sri Lanka is largely sustained by direct rainfall and irrigation water extractions from rivers. However according to Basnayake (2008); Basnayake et al. (2004); Basnayake and Vithanage (2004b); De Silva (2006b) it is difficult to conclude about climate change impacts on water resources due to contradicting rainfall projections. Economic and Social Survey of Asia and the Pacific (2010) stated that climate change certainly would set serious impacts on the food insecurity and vulnerability patterns and Sri Lanka would be one of the of food insecurity hotspots in the Asia-Pacific region .Therefore present work carried out a study to evaluate the potential impacts on agriculture in

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Sri Lanka by carrying out a study of Gritale Tank in Polonnaruwa district and this study expects to contribute towards water management in agriculture sector and develope water management policy for food scarcity under climate change scenario.

2. Literature Review

Jayatillake et al. (2005) stated that though there had not been a significant trend in Sri Lanka's mean annual rainfall (MAR) during the past century, a higher variability is evident. Shantha and Jayasundara (2005) have also observed a 39.12 % decrease in MAR in the Mahaweli upper watershed from 1880 to 1974. Bandara and Wickramagamage (2004) reveal that rainfall on the western slopes of the central highlands has declined significantly from 1900 to 2002 due to reduced SWM rainfall (this region has the highest MAR in the country, often exceeding 5,000 mm). In the country as a whole, the number of consecutive dry days has increased while the number of consecutive wet days has reduced (Ratnayake and Herath, 2005; Premalal 2009).

According to Chandrapala (1996), a temperature increase of 0.016ºC per year between 1961 and 1990 has been observed in Sri Lanka but according to IPCC (2007),this is higher than the global average rate of 0.013°C per year for the period 1956 to 2005 Sri Lanka's 100 year warming trend from 1896 to 1996 is 0.003°C per year, while it is 0.025°C per year for the 10-year period of 1987-1996.Basnayake et al. (2002) described that Seasonal mean temperature for the agricultural seasons Yala (April - September) and Maha (October – March) also display similar warming. Zubair et al. (2005) indicates that highest warming trends in the country have been observed in Anuradhapura and Badulla.

Manawadu & Nelun, (2008) described that climate change will alter runoff patterns in cold and mountainous regions; increasing evaporation with implications for significant changes in runoff variability. Parry & Canziani, (2007) stated in IPCC report 2007 that there is evidence to suggest that the climate of South Asian region has already changed. According to Manawadu & Nelun, (2008) the number of rainy days has decreased at all meteorological stations except for the Nuwara Eliya station while shrinking the 2000mm isohyet – demarcating the wet zone of the country. Herath and Ranayake (2004) revealed that the First inter-monsoon period shows the highest decrease in rainfall and in addition to this the numbers of rainy days have reduced giving rise to an increasing rain intensity trend.

De Silva, (2009) using a climate modeling study that, the North-East monsoon rains are predicted to decrease by 34% (A2, the scenario showing the worst impact of climate change-) across the country. The Sri Lanka Country Report on Climate Change (ADB, 1994) has shown that the increase in temperature by 2070 will be in the range of +0.4 °C to +3.0 °C. As per the rainfall predictions, the Wet Zone will record 10% increase per year in both dry and wet seasons. Basnayake, (2008) stated that unlike in the case of temperature, no clear pattern or trend has been observed in precipitation. Some researchers, comparing the mean annual precipitation of recent and earlier periods, suggest that average rainfall is showing a decreasing trend. According to Chandrapala (1996), temperature increase of 0.016ºC per year between 1961 and 1990 is observed in Sri Lanka.

3. Methodology

For the Gritale Tank water balance calculations 75% probability rainfall data was used as recommended in irrigation guide line (1984). Actual rainfall value compared with 75% probability rainfall for feasibility study. Irrigation model was developed for 75% probability rainfall and the behaviour of reservoir of model was checked and verified with actual rainfall and field data. A literature survey was carried out to find probable climate variations expected future and then irrigation demand and cropping intensity for each scenario was compared to identify the worst climate scenario for the scheme after that for critical scenario adaptation measures proposed for agriculture and food security.

4. Data and Study Area

Actual rainfall data collected from irrigation department from 2010-2015 for Giritale reservoir. For the present study area capacity curve and tank data were collected from irrigation department Colombo. Crop factor and growth stage, evaporation and seepage loss data were obtained from the Irrigation Department guideline (1984). Giritale reservoir in Pollonnaruwa district of Sri Lanka's was selected in dry zone. Catchment area of the reservoir is 24.3 sq.km and command area is 3075 ha. Location of the tank is shown in the Figure 9

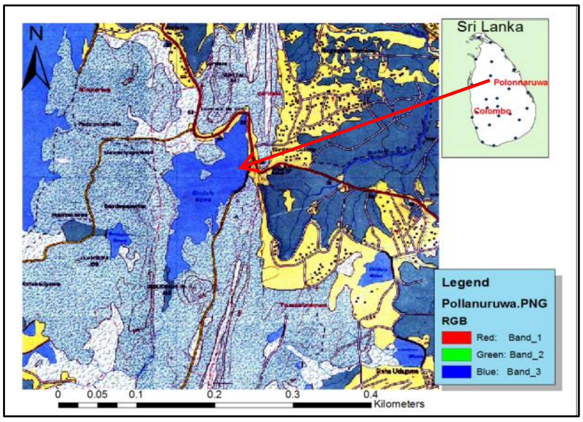

Figure 9: Study area

5. Analysis

In this study for analysis three climate scenarios were selected. Following three scenario were selected

Scenario 1: Ahmed and Supachalasai (2014), based on a RCM, predicted that by 2050.temperature and rainfall could rise by 1.8 °C and 15.8 % respectively under A2, scenario. Result of scenario 1 is shown in figure 2.

Scenario 2: De Silva (2006b) predicted increases of 1.6 °C under A2 and 1.2 °C under B2 by 2050 and that such increases will be mainly in the north, north-eastern and north-western regions (all within the dry zone). Also De Silva (2006b) elaborates that these increases will be 14 % for A2 and 5 % for B2 by 2050 with reference to 1961-1990. . Result of scenario 2 is shown in figure 3.

Scenario 3: According to WMO by 2050 rainfall is projected to increase by 48% for the Southwest Monsoon and for the Northeast Monsoon, the occurs in the drier northern region, the same is predicted to decrease by 27–29%. Result of scenario 3 is shown in figure 3

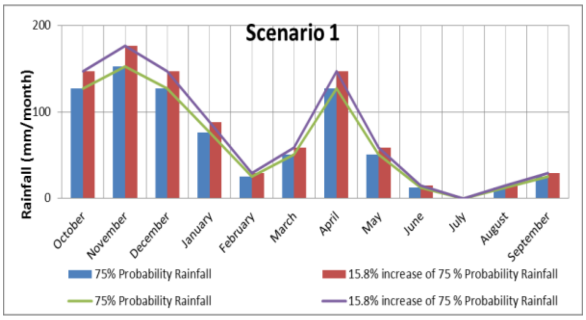

Figure 10: Predicted scenario 1

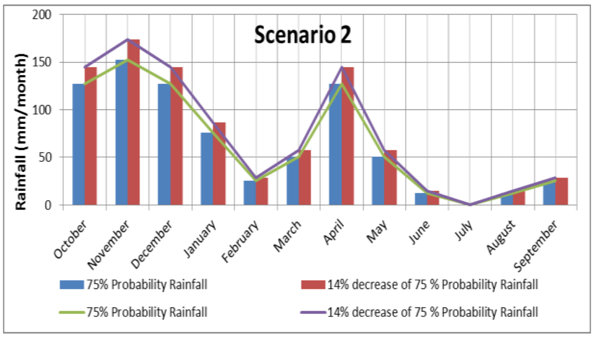

Figure 11: Predicted scenario 2

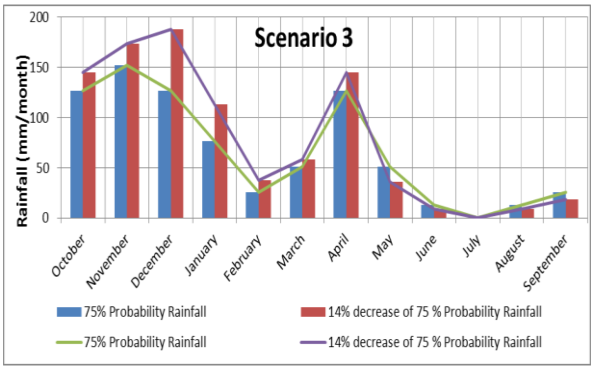

Figure 12 :Predicted scenario 3

5.1. System water Balance

$$I_t - (E_t + S_{ei} + S_{pt} + D_t) = S_t - S_{t-1} \quad (1)$$

In equation (1) I_t is the monthly inflow and t is the time step in month, E_t is the evaporation from the reservoir, S_p is the spillage from the reservoir, D is the irrigation, S_t is the storage at the end of time step and S_{t-1} is the storage at the beginning of time step.

5.2. Irrigation demand

For calculation of irrigation demand following equation is used

$$(\mathrm{FWR})_t = (LP)_t + (E_{tc})_t + (FL)_t \quad (2)$$

$$(\mathrm{FIR})_t = (\mathrm{FWR})_t - (\mathrm{ER})_t \quad (3)$$

$$\mathbf{(FIR)_t = (FIR)_t/n} \quad (4)$$

In these equations, t is the considered as time step in month, FWR is the field water requirement, ER is the effective rainfall, D is the irrigation demand, n is the project efficiency and FL is the water requirement to compensate for farm losses, LP is the water requirement for land preparation and Etc is the water requirement for crop evaporation.

6. Results

6.1. Irrigation demand for present situation

Irrigation demand for situation Irrigation demand is calculated for present situation for each month for 135 paddy days and 105 paddy days cultivation for Maha and Yala season respectively and then compared with Actual rainfall. Comparisons of irrigation demand are shown in figure 5.

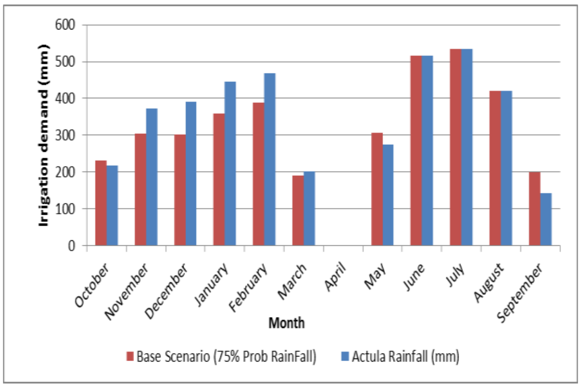

Figure 13: Irrigation demand

6.2. Present situation in Giritale Reservoir

For present situation 75% probability rainfall and diversion inflow is used as an input into the system and monthly storage at the beginning is taken as 1333.1 Ha.m and irrigation demand is calculated for 135 days paddy in Maha and 105 days paddy in Yala seasons. The result shows in Figure 6 and then verified model with actual rainfall data as shown in figure 7. It showed that reservoir spill two times in once a year with actual rainfall data and then once time it is near to the minimum operating level.

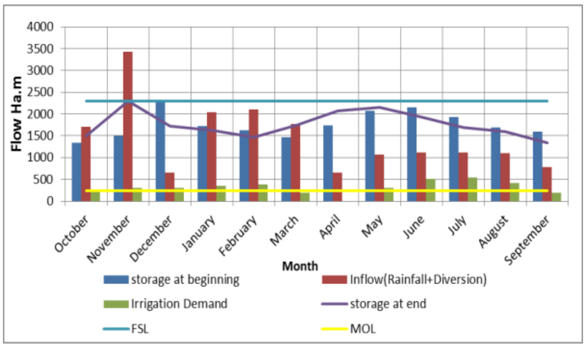

Figure 14: Reservoir operation of present situation Reservoir operation of present situation with 75% probability rainfall

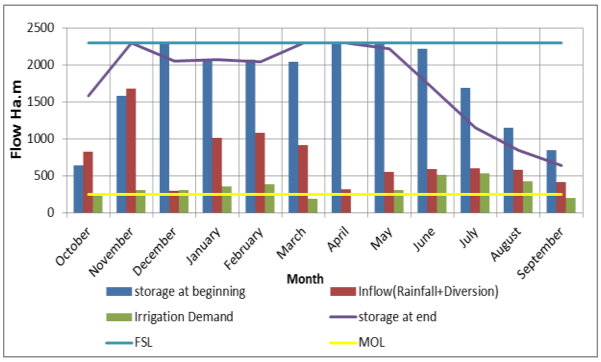

Figure 15: Reservoir operation of present situation with actual rainfall

6.3. Identification of critical scenarios

In scenario 1, temperature increase by 1.8 °c and, 15.8% rainfall increase under A2 scenario in this scenario it was assumed that by increase 2 °c in temperature increased evaporation by 8% and also diversion gets reduced by 10 % and in Scenario 2 temperature increased by 1.6 °c and rainfall is increased by 14% for A2 scenario by a 2050. In this scenario it was assumed that 10% reduction of diversion flow was taken due to climate change. In the 3rd scenario rainfall increased by 48% for Southwest monsoon by 2050 and in North West decrease of 29% was assumed. The result of water balance of each scenario is shown in figure 8 and figure 9

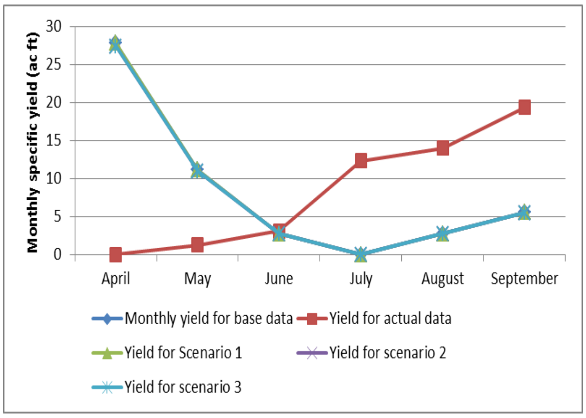

Figure 16: Catchment yield for Yala season under climate scenario

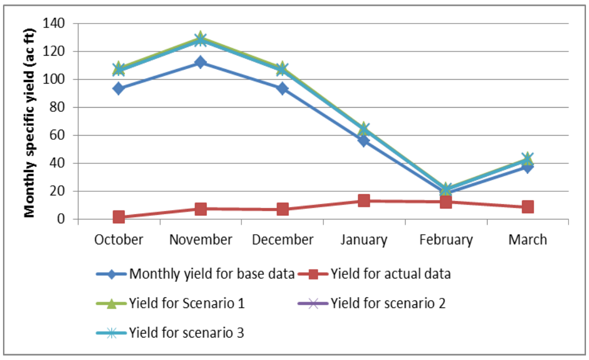

Figure 17 : Catchment yield for Maha season under climate scenario

It could be observed that for scenario 1, 2 and scenario 3 the specific yield is the same and that this increases in Maha season and decreases in yala season.

6.4. Irrigation demand

Irrigation demand was calculated for each scenario assumed 135 day paddy for Maha season and 105 day paddy for Yala season. The figure10 shows that the irrigation demand is increased for scenario 2.

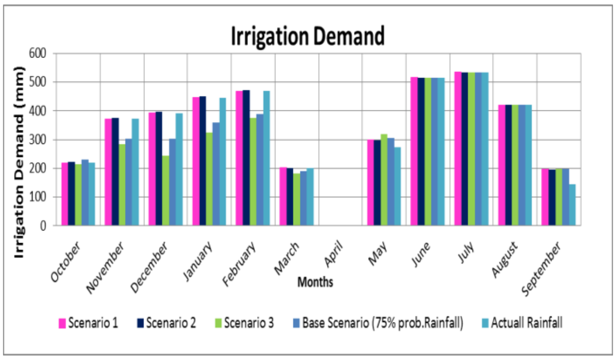

Figure 18: Irrigation demand for each scenario

6.5. Cropping Intensity

Cropping intensity and cultivation extent for each scenario was calculated. Result show that for scenario 2 cropping intensity is less and for Maha season the cultivation extent is less .Therefore this result shows in table1 and figure 11 that scenario 2 is the worst scenario.

Table 5: Cultivation extent and cropping intensity for each scenario

Scenario	Scenario 1	Scenario 2	Scenario 3
Cultivation extent for Maha (Ha)	81	80	100
Cultivation extent for Yala (Ha)	47	47	47
Cropping intensity	1.28	1.27	1.47

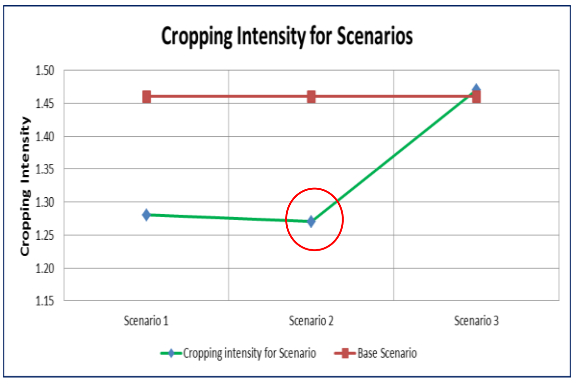

Figure 19 : Cropping intensity result for scenario

7. Climate change adoption

Following four adaptations method were selected. For evaluation crop diversification crop diversion and increasing the system efficiency increase were quantified and compare.

1. Early Warning Systems (EWS)
2. Crop Diversification (CD)
3. Education on Water Management (EWM)
4. Increasing the System Efficiency (ISE)

With crop diversion method two crops were selected: 105 day paddy for Yala and 105 day paddy days for Maha season and the other crops green gram. For system efficiency option canal efficiency is increased by 10 %. The adoption result in the figure 12 shows that the best option is green gram which increasing the cropping intensity up to 1.5.

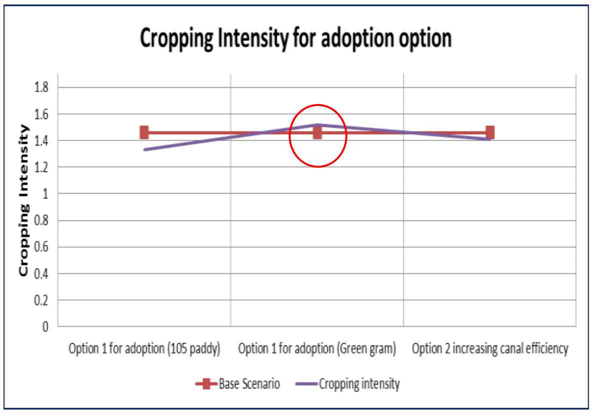

Figure 20: Cropping intensity after adaptation

8. Conclusion and Recommendation

1) Future climate projections indicate that the climate is changing and impacts on agriculture sector can be expected
2) Worst climate change scenario for the Gritale scheme is when rainfall increases by 14% with an increase of evaporation by 6.4%
3) Worst climate scenario will reduce the cropping intensity of from 1.46 to 1.27.
4) Population growth in the future is also expected to increase and hence a food scarcity is predicted in the future
5) Implementing adaptation options for future is essential for Gritale scheme
6) Crop diversification is the most suitable option to minimize the impacts in the scheme
7) Farmer education on water management for farmers and increasing conveyance of efficiency of the system would minimize the climate impacts of the worst climate scenario

9. Acknowledgements

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