# Climate Change Impacts and Adaptation Measures for Pahala Divul Wewa, Anuradhapura, Sri Lanka

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## ABSTRACT

Present study was carried out to identify possible threats of various climate change scenario and suggest the possible adaptation measures for the food and water security corresponding to irrigation reservoir scale. Pahala Divul Wewa with a catchment area 5.12 km2, in Anuradhapura is located within DL1 agro-ecological zone was selected. The Irrigation Guide-line model was optimized for present situation of irrigable area. Five (5) scenarios of climate change were developed based on literature. Change in the precipitation due Climate change were used for a reservoir operation. The worst climate change scenario for Pahala Divul wewa was identified as the with 22% increase in South-East monsoon and 42% decrease in North East monsoon. The cropping intensity under this scenario was reduced from 0.678 to 0.55 a decrease of 13%. Since, Cropping Intensity of Pahala Divul Wewa was noted to reduce, several adaptation measures were identified to minimize the effects. Increasing Canal Efficiency was found to be most effective adaptation measure though it is less economical. It is recommended to incorporate climate change while designing the new schemes and Existing design rainfall, evaporation and other inputs shown in the guidelines need updating.


*KEYWORDS: Prioritization, Community Based Water Supply Scheme, Raster GIS, Spatial Modelling*

## 1. Introduction

Water is the primary medium through which climate change influences Earth's ecosystem and thus the livelihood and well-being of societies. Climate Change danger was first highlighted globally at the UN Conference on Development and Environment (UNCED) in Stockholm (1972). Greatest of all threats is the Human Induced Climate Change, due to the buildup of Green House Gases such as CO2 (Carbon Dioxide), CH4(Methane), N2O (Nitrous Oxide) and some other Industrial Chemicals. Temperature and Rainfall are the main factors on climate change. The intergovernmental Panel on Climate change (IPCC) reports evidence of climate change and put forward 4(four) concerns of climate change: the warming of atmosphere and ocean, diminishing the amounts of snow and ice, rise sea level, and the concentrations of greenhouse gases have increased (IPPC, 2008)

Higher temperatures and changes in extreme weather conditions are projected to affect availability and distribution of rainfall, snowmelt, river flow and groundwater, and further deteriorate water quality. The relationship between water for agriculture and climate is a significant one. More and more, that relationship is falling out of balance jeopardizing water and food security. Climate change is a phenomenon that no longer can be denied as its effects have become increasingly evident worldwide. Climate change is changing our assumptions about water resources. As climate change warms the atmosphere, altering the hydrologic cycle, changes to the amount, timing, form, and intensity of precipitation will continue.

Agriculture is the most important sector of the Sri Lankan economy. Even though its contribution to the gross domestic product declined substantially during the past 3 decades (from 30 percent in 1970 to 21 percent in 2000), it is the most important source of economy for the majority of the Sri Lankans. So, impacts of climate change on agriculture would have immediate effect on national economy of Sri Lanka.

This study was carried out on a minor irrigation scheme to identify the impacts of climate change and to demonstrate that systematic planning and management of water resources can be done to manage climate change effect.

## 2. Study Area

Pahala Divul Wewa, with catchment area of 5.12 $km^2$, in Anuradhapura district was selected for the study. This reservoir falls under DL1 agro-ecological zone of Sri Lanka.

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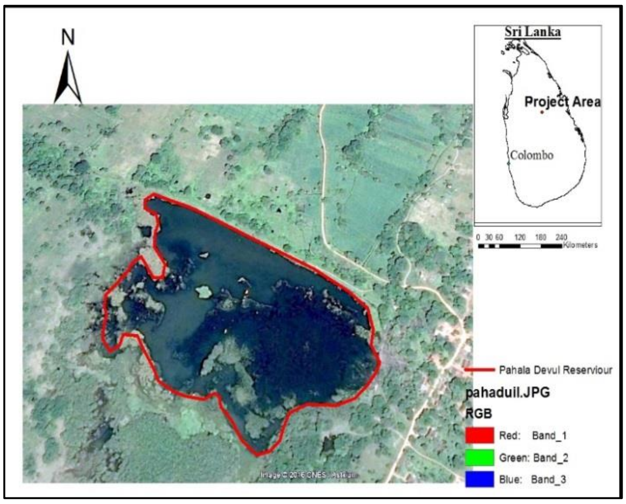


Figure 1. Study Area Inset

## 3. Methodology and Data

### 3.1. Data

For the purpose of this study, Topographic map and Area-Capacity curve of the reservoir were collected from Survey department and Irrigation Department respectively. 75 % probable monthly rainfall data, monthly evaporation, reference crop evaporation and seasonal water yield from Irrigation Guidelines of Sri Lanka (1984) used for water balance computations. Reservoir is with a capacity of 55 Ha.m. Full Supply level was 30.5 m MSL and Minimum operating level was 28 m MSL. The area covered by FSL level is 47.9 Ha.

### 3.2. Methodology

Initially, Irrigation demand was calculated for three stager irrigation. Reservoir operation for water balance was per Irrigation Guideline model was carried out in order to calculate feasible irrigable area both in maha and yala season under the current situation. Data for the computation were fed from the Irrigation department guidelines. Model calibration was done by trial and error optimizing while initial storage at beginning of October is closer to storage at the end of water year. Calibrated model outputs were verified with actual cultivated land area.

With literature, several scenario of climate change were developed. Changes in 75% probable rainfall due to climate change were estimated and tabulated. The tabulated 75% probable rainfall were used for the water balance with calibrated reservoir operation model in order to find impacts on cultivation extent and cropping intensity.

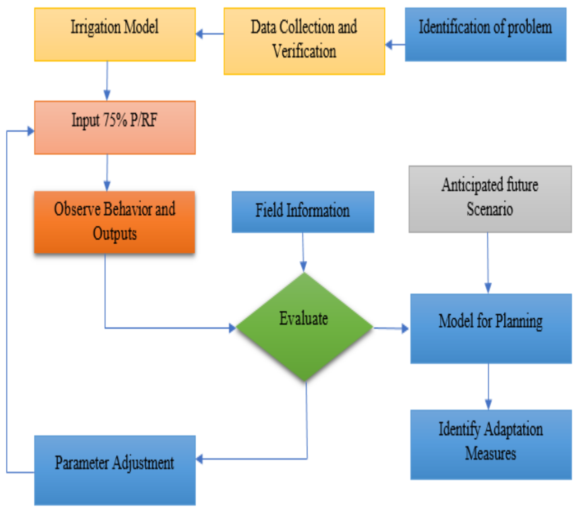


Fig 2. Methodology flowchart of the study

## 4. Analysis

### 4.1. Climate Change Scenarios

With reference of literature, climate change scenario was formulated and are described below:

Scenario-1:
20% rainfall increase for North-East monsoon (December to February) and 30% rainfall increase for South-West monsoon (May to September)

Scenario-2:
30% rainfall increase in South-west monsoon (May to September) and 30% rainfall decrease in North-east monsoon (December to February)

Scenario-3:
10% increase in rainfall in North-east monsoon (December to February) and South-west monsoon (May to September).

Scenario-4:
22% increase of higher rainfall and 42% decrease of rainfall in Lower Rainfall.

Scenario-5:
Rainfall shift by one month backward

### 4.2. Reservoir System Water Balance

Equation-1 and 2 are the reservoir system water balance based on continuity equation used for the purpose of the study

Inflow – Outflow = Change in Storage…………….1

$I - (Ei - Se_i - Sp_i - ID) = Si - Si_{-1}$……………………………2

I is the inflow of water through catchment, E is the surface evaporation from reservoir, Se is the seepage form the bottom of the reservoir, Sp is the spillage form the reservoir and ID is irrigation demand. On the right-hand side, the S denotes Storages. The I in subscript denotes time interval and the tie interval of the monthly model is 1 month.

$Si_{-1}$ denotes at the beginning of the month or Storage at end of the previous month.

Irrigation demand for each month separated as Maha and Yala were calculated according irrigation department guidelines (ID, 1984).

Field water requirement (FWR) = ETc + LP + FL……………………………………………………3
Field Irrigation Requirement (FIR)= FWR-Pe……..4
Irrigation Demand (ID)= FIR/n……………………..5

Above Equation 3, 4 and 5 leads to compute the Irrigation demand of the field where ETc is crop evapotranspiration, LP is land preparation, FL is water requirement to compensate farm losses. With Field Water Requirement (FWR), Field Irrigation requirement can be calculated by subtracting it by effective rainfall Pe and Thus Irrigation demand is calculated by dividing FIR by canal efficiency (n).

## 5. Results

Monthly Storage at beginning of month ($Si_{-1}$), Inflow(Ii), Evaporation(Ei), Seepage (Sei), Demand(D), Seepage(Sp), Storage at the end of the month(Si)for maha and yala Season are given in the Table 4.1 1and 4.2

### 5.1. Present Situation in Paha Divul Wewa

Table 5.1. System Water Balance for Maha Season

| | Oct | Nov | Dec | Jan | Feb | Mar |
|---|---|---|---|---|---|---|
| $Si_{-1}$ | 1.50 | 12.40 | 23.27 | 28.72 | 22.04 | 4.90 |
| Ii | 22.76 | 27.31 | 22.76 | 13.66 | 4.55 | 9.10 |
| Ei | 0.79 | 1.82 | 2.71 | 3.03 | 3.00 | 2.04 |
| $Se_i$ | 0.01 | 0.06 | 0.12 | 0.14 | 0.11 | 0.02 |
| D | 11.07 | 14.55 | 14.49 | 17.16 | 18.59 | 9.07 |
| Sp | - | - | - | - | - | - |
| Si | 12.40 | 23.27 | 28.72 | 22.04 | 4.90 | 2.86 |

Table 5.2. System Water Balance for Yala Season

| | Apr | May | June | July | Aug | Sep |
|---|---|---|---|---|---|---|
| $Si_{-1}$ | 2.86 | 24.37 | 25.91 | 17.75 | 7.92 | 1.56 |
| Ii | 22.76 | 9.10 | 2.28 | 0.00 | 2.28 | 4.55 |
| Ei | 1.24 | 3.71 | 4.01 | 3.20 | 2.54 | 1.09 |
| $Se_i$ | 0.01 | 0.12 | 0.13 | 0.09 | 0.04 | 0.01 |
| D | 0.00 | 3.73 | 6.30 | 6.53 | 6.06 | 2.43 |
| Sp | - | - | - | - | - | - |
| Si | 24.37 | 25.91 | 17.75 | 7.92 | 1.56 | 2.58 |

Irrigation demand, Irrigable area, cropping intensity of all 5 scenarios are given in Table 4.3, 4.4, 4.5. Among which most critical scenario and look after the adaptation.

Table 5.3. Irrigation Demand of Scenarios

| Scenario | Maha | Yala | Total |
|---|---|---|---|
| Present | 1773.57 | 2051.54 | 3825.12 |
| S-1 | 1729.81 | 2029.66 | 3759.48 |
| S-2 | 1707.93 | 1968.88 | 3676.82 |
| S-3 | 1793.02 | 2056.40 | 3849.43 |
| S-4 | 1739.05 | 2071.96 | 3811.02 |
| S-5b | 1773.57 | 1978.61 | 3752.18 |

Table 5.4. Irrigable Area for Scenarios

| Scenario | Maha | Yala | Total |
|---|---|---|---|
| Present | 47.89 | 12.21 | 60.10 |
| S-1 | 51.1 | 15.33 | 66.43 |
| S-2 | 51.1 | 13.03 | 64.13 |
| S-3 | 45.26 | 11.68 | 56.94 |
| S-4 | 40.15 | 10.04 | 50.19 |
| S-5b | 37.96 | 11.39 | 49.35 |

Table 5.5. Cropping Pattern for the Scenarios

| Scenario | Maha | Yala | Total |
|---|---|---|---|
| Present | 0.65 | 0.25 | 0.68 |
| S-1 | 0.7 | 0.3 | 0.73 |
| S-2 | 0.7 | 0.25 | 0.72 |
| S-3 | 0.62 | 0.25 | 0.64 |
| S-4 | 0.55 | 0.25 | 0.57 |
| S-5b | 0.52 | 0.3 | 0.55 |

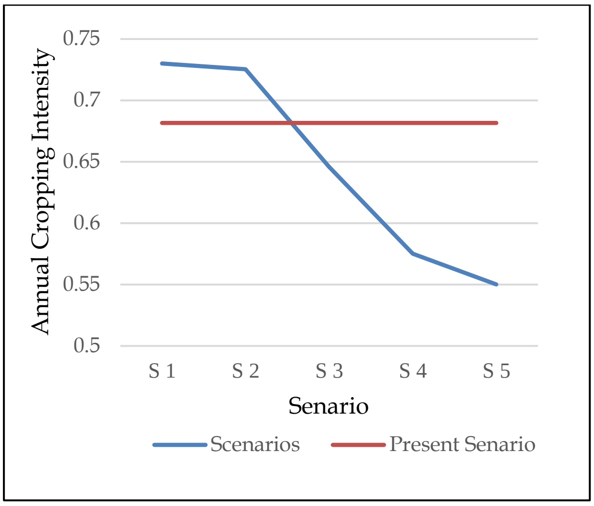


Fig 3. Variation of cropping Intensity with scenario

## 6. Discussion

It is noted that in scenario-1, 20% rainfall increase for North-East monsoon (December to February) and 30% rainfall increase for South-West monsoon (May to September) and scenario-2, 30% rainfall increase in South-west monsoon (May to September) and 30% rainfall decrease in North-east monsoon (December to February) both have

positive impacts on system efficiency as cultivation extent and cropping pattern are rising for these scenarios. Among other three Scenario 5 scenarios backward shift of the rainfall pattern and 22% increase of NE monsoon and 42% decrease of rainfall in WS monsoon are seen critical as cropping intensity drops from 0.68 to 0.55 and 0.57.
The drop in cropping intensity in the most critical scenario: Backward shift of rainfall pattern was 14% from the base present scenario. Hence considering this situation, adaptation measures were identified and quantified. Among various adaptation measures identified, increasing Canal efficiency was found to be most effective. The cropping intensity rose up from 0.55 to 0.67 with the increase in cannel efficiency 0.7 to 0.8.

## 7. Conclusion

According to Climate change prediction and scenario analysis water resources sector in minor irrigation reservoirs are susceptible. Cropping intensity and cultivable extent are mostly like to decrease in most of the scenarios. Shifting the rainfall patterns backward was found to be most critical scenarios where cropping intensity had changed abruptly from 0.68 initial condition to 0.55.

## 8. Recommendations

It is recommended to consider climate change for water resources planning and management for sustainable development. Adaption measures should be taken by the respective authority for avoid the crisis and hazard from the climate change.

## 9. Acknowledgement

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## 10. References

Ponrajh A.J.P, Design Irrigation Headword for small catchment (1984)

IPPC (2008): Climate Change, 2008; Climate change & Water Technical Paper of the Intergovernmental Panel on Climate Change

Jayatillake, H. M.; Chandrapala, L.; Basnayake, B. R. S. B.; Dharmaratne, G. H. P. 2005. Water resources and climate change. In: Proceedings of workshop on Sri Lanka National Water Development Report

Eriyagama, N., & Smakhtin, V. (2010). Observed and projected climatic changes, their impacts and adaptation options for Sri Lanka: a review.