

**ASSESSING WATER- USE EFFICIENCY IN THE
AGRICULTURAL SECTOR IN THE MALWATHU OYA
RIVER BASIN UNDER CHANGING CLIMATE
SCENARIOS**

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Degree of Master of Science

Department of Civil Engineering
Faculty of Engineering

University of Moratuwa
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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree
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DECLARATION

I declare that this is my work, and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning, and to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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Name of Supervisor: Dr. P. K. C. De Silva

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ABSTRACT

ASSESSING WATER- USE EFFICIENCY IN THE AGRICULTURAL SECTOR IN THE MALWATHU OYA RIVER BASIN UNDER CHANGING CLIMATE SCENARIOS

Climate change, conventional agricultural techniques and malfunctioning irrigation systems pose significant challenges to efficient water management in the dry zone of Sri Lanka. Agricultural activities in the dry zone mainly depend upon irrigation reservoirs attached to the hydrodynamics of dry zone basins. Assessing the water use efficiency (WUE) of an irrigation scheme in a water-scarce region is paramount for developing a robust water management strategy considering the escalating impacts of climate change.

Nachchaduwa Irrigation Scheme, situated in the Malwathu Oya basin, Sri Lanka, constitutes the required characteristics of a dry zone irrigation system for this research study about climate change impacts on irrigation supply efficiency. The developed methodology includes two primary components: crop water requirement estimation and irrigation supply estimation. The analysis of crop water requirement estimates revealed distinct seasonal variations. During the Maha season, the crop water demand decreased due to increased rainfall events, with the estimated mean crop water requirement dropping from 1,166.87 mm/season in the base period to 1,076.15 mm/season under SSP 1-2.6 and 1,053.17 mm/season under SSP 5-8.5. Conversely, the Yala season experienced higher water demand under the SSP 5-8.5 scenario with 774.41 mm/season, where the base period requirement is 767.18 mm/season, indicating a 0.9% rise.

The HEC-HMS model has been used to simulate river inflow to the Nachchaduwa Reservoir prior to obtaining the irrigation supply through reservoir operation simulations. Results indicated significant variability in future water availability in the upstream catchment, with a projected mean annual inflow decrease of 8.14% under the SSP 5-8.5 scenario and an increase of 43.16% under the SSP 1-2.6 scenario. The increased variability in inflow highlighted the potential for frequent and severe extreme rainfall events under considered climate scenarios. The two-point hedging rule theory was adopted in reservoir operation simulations for irrigation supply estimation. The annual mean irrigation supply during the base period ranged from 866.56 mm/season to 1,148 mm/season, which shows a decline under the SSP 1-2.6 scenario but increases the variability under the SSP 5-8.5 scenario. These findings manifest the need for resilient irrigation management practices to address future climatic challenges in dry zone irrigation schemes in Sri Lanka.

Keywords: Crop water requirement, HEC-HMS, Irrigation supply, Nachchaduwa Reservoir

TABLE OF CONTENTS

Declaration	i
Acknowledgement	ii
Abstract	iii
Table of Contents	iv
List of Figures	vii
List of Tables	x
List of Abbreviations	xi
Introduction	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Scope of the Study	3
1.4 Aim and Objectives	3
1.5 Arrangement of the Thesis	3
Literature Review	4
2.1 Introduction	4
2.2 Crop Water Requirement	6
2.2.1 Reference Evapotranspiration (ET_0)	6
2.2.2 Crop Coefficient (K_c)	7
2.3 Net Irrigation Water Requirement (NIWR)	8
2.3.1 Effective Rainfall	9
2.3.2 Irrigation Scheduling	9
2.4 Irrigation Supply Estimation	10
2.4.1 Hydrological Modelling	10
2.4.2 Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS)	11
2.5 Climate Projections	15
2.5.1 Future Rainfall Estimates	15
2.5.2 Climate Change Scenarios	16
2.5.3 General Circulation Models (GCMs)	18
2.5.4 CERFACS.CNRM-CM6-1-HR Model Details	19
2.6 Bias Correction of GCM	20

2.6.1	Gamma Mapping Method	20
2.6.2	Delta Change Method	21
2.7	Reservoir Operations	22
Chapter 3		24
Methodology		24
3.1	Methodology Statement	25
3.2	Methodology Flowchart	25
3.3	Study Area	26
3.4	Irrigation Water Requirement Estimation	29
3.4.1	Data Collection	29
3.4.2	CROPWAT Model Development	31
3.5	Irrigation Supply Estimation	32
3.5.1	Data Collection	33
3.5.2	Data Checking and Preprocessing	34
3.5.3	HEC-HMS Model Development	38
3.6	Reservoir Operation Modelling	40
3.6.1	Model Development	43
3.7	Bias Correction of GCMs	50
3.7.1	Gamma Mapping Method	51
Chapter 4		53
Results		53
4.1	Bias Correction of GCM Estimates	53
4.1.1	Comparison between GCM estimate, bias-corrected GCM estimate and Observed Rainfall	53
4.1.2	Comparison between GCM estimate, bias corrected GCM estimate and Observed Temperature	59
4.2	HEC-HMS Model Results	63
4.2.1	Model Calibration and Validation	64
4.3	Reservoir Operation	68
Chapter 5		72
Discussion		72
5.1	Crop water requirement of Nachchaduwa Irrigation Scheme	72

5.2	Reservoir Inflow to Nachchaduwa Reservoir	73
5.3	Irrigation supply from the Nachchaduwa Reservoir	74
Chapter 6		76
Conclusions, Limitations and Recommendations		76
6.1	Conclusions	76
6.2	Limitations of Study	77
6.3	Recommendations	77
References		79

LIST OF FIGURES

Figure	Description	Page
Figure 2-1:	Effect of Crop Growth Stage on K_c	7
Figure 2-2:	Crop Coefficient of Paddy	8
Figure 2-3:	Digital Elevation Map of Malwathu Oya Basin	13
Figure 2-4:	Socioeconomic Challenges and Adaptation Aspects Under SSP Scenarios	17
Figure 2-5:	GCMs' Scores and Ranks: (a) final; (b) near-surface temperature; (c) precipitation; (d) 850-hPa wind. In variable scores diagrams, the final top 3 is notified in orange numbers; the final top 10 models are marked with an asterisk (Desmet and Ngo-Duc, 2022).....	19
Figure 2-6:	Graphical Representation of Gamma Mapping-based Bias Correction (Hakala et al., 2019).....	21
Figure 3-1:	Methodology Flowchart.....	25
Figure 3-2:	Major Reservoirs and Meteorological Stations inside the River Basin.....	26
Figure 3-3:	Reservoir Network of Malwathu Oya Basin	27
Figure 3-4:	Nachchaduwa Irrigation Scheme.....	28
Figure 3-5:	CROPWAT Model Development Flowchart.....	31
Figure 3-6:	Irrigation Release Time Series (2020/2021).....	33
Figure 3-7:	Single Mass Curves – Rainfall Data.....	35
Figure 3-8:	Double Mass Curve – Anuradhapura Station Rainfall Data.....	35
Figure 3-9:	Double Mass Curve – Mahailuppallama Station Rainfall Data.....	36
Figure 3-10:	Double Mass Curve – Nachchaduwa Station Rainfall Data.....	36
Figure 3-11:	Double Mass Curve – Pavatkulam Station Rainfall Data.....	37
Figure 3-12:	Compatibility of river discharge observations at Kappachi gauging station with Thiessen Rainfall	37
Figure 3-13:	Reservoir water balance diagram.....	41
Figure 3-14:	Automated water level monitoring system at Nachchaduwa Reservoir.....	42
Figure 3-15:	Reservoir water level vs upstream rainfall	42
Figure 3-16:	Watershed arrangement of Nachchaduwa Reservoir using HEC-ResSIM.....	43
Figure 3-17:	Reservoir Elevation-Storage-Area curve of Nachchaduwa reservoir (Nachchaduwa Dam Operation and Maintenance Manual)	44
Figure 3-18:	Reservoir elevation-seepage curve	45
Figure 3-19:	Right bank primary sluice release rule curve	47

Figure 3-20: Right bank Nuwara Wewa sluice release curve	47
Figure 3-21: Flood discharge curve for right bank ogee spillway.....	48
Figure 3-22: Flood discharge curve for left bank ogee spillway.....	48
Figure 3-23: Meteorological stations and GCM coordinates in the proximity of the Malwathu Oya basin	51
Figure 4-1: Average monthly rainfall estimates of raw GCM model, bias-corrected model and observed data- Mahailuppallama Station	54
Figure 4-2: Average monthly rainfall estimates of raw GCM model, bias-corrected model and observed data - Vavuniya Station.....	55
Figure 4-3: Average monthly rainfall estimates of raw GCM model, bias-corrected model and observed data - Murunkan Station.....	55
Figure 4-4: Comparison between CDF curves of bias-corrected and observed rainfall data of Mahailuppallama station.....	56
Figure 4-5: Comparison between CDF curves of bias-corrected and observed rainfall data of Vavuniya station.....	56
Figure 4-6: Comparison between CDF curves of bias-corrected and observed rainfall data of Murunkan station.....	57
Figure 4-7: Bias corrected Rainfall Estimates – Anuradhapura Station.....	58
Figure 4-8: Bias-corrected GCM estimates for the near future- Anuradhapura Station	58
Figure 4-9: Bias-corrected GCM estimates for mid-future- Anuradhapura Station.....	59
Figure 4-10: Bias corrected GCM estimates for far future- Anuradhapura Station	59
Figure 4-11: Correlation between minimum monthly bias-corrected and observed temperature data- Anuradhapura station.....	60
Figure 4-12: Correlation between average monthly bias-corrected and observed temperature data- Anuradhapura station.....	60
Figure 4-13: Correlation between average monthly bias-corrected and observed temperature data- Anuradhapura station.....	61
Figure 4-14: Variation of minimum, maximum and average temperature under SSP scenarios	61
Figure 4-15: Variation of Potential Evapotranspiration estimates under SSP scenarios.....	62
Figure 4-16: Irrigation requirement variation -Maha Season.....	63
Figure 4-17: Irrigation requirement variation -Yala Season	63
Figure 4-18: Hydrograph for Calibration Period.....	64
Figure 4-19: Hydrograph for Validation Period.....	64
Figure 4-20: Annual river discharge to Nachchaduwa Reservoir under SSP scenarios.....	66

Figure 4-21: Seasonal river inflow to Nachchaduwa Reservoir under SSP scenarios - Maha Season.....	67
Figure 4-22: Seasonal River inflow to Nachchaduwa Reservoir under SSP scenarios - Yala Season.....	68
Figure 4-23: Observed vs Simulated reservoir storage for the calibration period.....	68
Figure 4-24: Observed vs Simulated reservoir storage for the validation period.....	69
Figure 4-25: Varying reservoir storage volumes for future scenarios.....	70
Figure 4-26: Cumulative irrigation supply during Maha Season	70
Figure 4-27: Cumulative irrigation supply during the Yala Season.....	71

LIST OF TABLES

Table	Description	Page
Table 2-1:	Depth of Submergence at Different Stages.....	9
Table 2-2:	Canopy Storage According to Vegetation Type	11
Table 2-3:	Surface Storage According to Surface Cover	12
Table 2-4:	Objective Function Value Ranges.....	15
Table 2-5:	Recent Climate Change Scenarios	17
Table 2-6:	GCM Model Properties	19
Table 3-1:	Climate Data for the CROPWAT Model.....	30
Table 3-2:	Soil Data for CROPWAT Model	30
Table 3-3:	Crop Data for CROPWAT Model	31
Table 3-4:	Submergence Depth of Paddy Fields According to the Crop Growth Stage	31
Table 3-5:	CROPWAT Model Parameterization.....	32
Table 3-6:	Data Collection	34
Table 3-7:	Details of Missing Data.....	34
Table 3-8:	Properties of Major Reservoirs in the Malwathu Oya Basin	38
Table 3-9:	HEC-HMS Model Parameterisation	39
Table 3-10:	Details of Outflow Structures of Nachchaduwa Reservoir	45
Table 3-11:	Meteorological Station and GCM Coordinates.....	51
Table 4-1:	Objective Function Results- Hydrological Model	65
Table 4-2:	Runoff Volumes and Coefficients with Consideration of Significant Tanks	66
Table 4-3:	Performance Rating of Reservoir Operation Modelling	69

LIST OF ABBREVIATIONS

Abbreviation	Description
AMIP	Atmospheric Model Intercomparison Project
CMIP	Coupled Model Intercomparison Project
DEM	Digital Elevation Model
GCM	Global Circulation Model
GMIS	Global Man-Made Impervious Surface
HEC-HMS	Hydrologic Engineering Center's Hydrologic Modeling System
HEC-ResSIM	Hydrologic Engineering Center's Reservoir Simulation
HEIFLOW	Hydrological-Ecological Integrated Watershed-Scale Flow
HLMC	High-Level Main Canal
HydroSHEDS	Hydrological data and maps based on Shuttle Elevation Derivatives at multiple Scales
IPCC	Intergovernmental Panel on Climate Change
LLMC	Low-Level Main Canal
MCM	Million Cubic Meters
NIWR	Net Irrigation Water Requirement
NRCS	Natural Resources Conservation Service
NSE	Nash Sutcliffe Efficiency
PBIAS	Percentage Bias
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RMSE	Root Mean Square Error
RSR	RMSE-Observations Standard Deviation Ratio
SBUH	Soil-Bio-Water-Urban Hydrology
SCS CN	Soil Conservation Service Curve Number
SMA	Soil Moisture Accounting
SRES	Special Report on Emission Scenarios
SRTM	Shuttle Radar Topography Mission
SSP	Shared Socioeconomic Pathways

SWAT	Soil And Water Assessment Tool
UN FAO	United Nations Food and Agricultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WUE	Water Use Efficiency