IMPACT OF CLIMATE CHANGE AND SOCIO-ECONOMIC DEVELOPMENT ON WATER ALLOCATION FOR ECOSYSTEM-WATER-ENERGY-FOOD SERVICES: A CASE STUDY ON MAHAWELI RIVER BASIN, SRI LANKA

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Degree of Master of Science

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UNESCO Madanjeet Singh Centre for

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University of Moratuwa

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ABSTRACT

Impact of Climate Change and Socio-Economic Development on Water Allocation for Ecosystem-Water-Energy-Food Services: A Case Study on Mahaweli River Basin, Sri Lanka

This study was carried out to assess the impacts of climate change on the dynamics of surface water availability for different present and future users in the Mahaweli river basin.

A multi-tier modeling method was applied in the analysis by combining the Soil and Water Assessment Tool (SWAT) and Water Evaluation and Planning Models (WEAP) to mimic stream flow under climate change and evaluate situations of future water accessibility for diverse socio-economic activities by the year 2050. Three standard global circulation models (GCMs), CSIRO Mk3.6, Had, CM2-ES, and MIROCS, were downscaled, rectifying bias using CMHyd.

The SWAT model was successfully calibrated with R^2 equals 0.65 for calibration period and for validation the R^2 equals 0.57. The calibrated model shows a Nash- Sutcliff efficiency (NSE) values of 0.68 during the calibration period and 0.73 in validation period. The SWAT model was initially calibrated using available data to forecast future stream flows. Then those stream flows were used as inputs for the WEAP model to assess water availability for various socio-economic activities. Results from GCMs indicate that an increase in annual mean rainfall within a range of 16-18% can be expected by the 2050s, compared to the rainfall during the period between 2006 to 2009. The average temperature is forecasted to increase by about 2°C compared to the temperature baseline period. Further, there will be an increase of about 10% in long-term average stream flow. However, the model predicted a decrease in peak flows in the 2050s compared to the current average flows. The model forecasted that the overall total water demand in the Mahaweli basin will increase to 3,249.69 Mm^3 in the year 2050, compared to the current demand of 1,879.73 Mm^3. This will create a situation where 51.5% of the total demand amounting to about 1,673.80 Mm^3 will not be met in the 2050s. A severe water shortage is predicted that about 71.12% of future irrigation demand will not be fulfilled in the 2050s. Water for hydropower generation will also be significantly affected as its unmet demand will be around 27.47%. However, the water demand for livestock will be marginally affected by about 1.41% of unmet demand as per the model's forecasts.

The modeling results raise the need for paying attention to future water shortages for various socio-economic activities, which can be caused by climate change, and the need for taking necessary steps to address this situation effectively.

Key Words: Irrigation Demand, Multi-Tier Modelling, Unmet Demand, , Water Resource Management

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LIST OF ABBREVIATIONS

AMDP	Accelerated Mahaweli Development Programme
AOGCM	Atmosphere-Ocean General Circulation Model
CEB	Ceylon Electricity Board
CMIP	The Coupled Model Intercomparison Project
CMIP5	Phase Five of the Coupled Model Intercomparison Project
GCM	General Circulation Model
GHG	Greenhouse Gas
IPCC-TGIC	Intergovernmental Panel on Climate Change – Task Group on Data and Scenario Support for Impact and Climate Assessment
MASL	Mahaweli Authority of Sri Lanka
MCB	Mahaweli Consultancy Bureau
NEM	Northeast Monsoon
NCP	North Central Province
SIM	Second Inter-Monsoon
OFC	Other Field Crops
SRES	Special Report on Emission Scenarios (Stenseth, et al., 2003)
SWM	Southwest Monsoon
R^2 -	R squared
RCP	Representative Concentration Pathways
RMSE	Root Mean Square Error
UNDP/FAO	United Nations Development Program/ Food and Agriculture Organization
WGCM	Working Group on Climate Modelling