Introduction

CHAPTER I

INTRODUCTION

Climate change is a long-standing process observed since ancient times, but has notably sped up recently due to human activities like burning fossil fuels and deforestation (IPCC, 2021). Climate change refers to changes in climate patterns, mainly caused by greenhouse gas emissions. These gases trap heat in the atmosphere, leading to global warming. Climate change results from increased greenhouse gas emissions, especially carbon dioxide; alters the atmospheric composition and affects the global and local climates. This phenomenon is often studied using General Circulation Models (GCMs) called climate models, which simulate earth's climate system and its response to various factors, including greenhouse gas emissions (Mohan and Ramsundram, 2014).

Climate models are the primary means for scientists to understand how the climate has changed in the past and may change in the future. These models generate climate projections based on different future scenarios. But these climate models are constantly being updated by different modelling groups. These modelling groups coordinate the updates around the schedule of The Intergovernmental Panel on Climate Change (IPCC) Assessment Reports (ARs). These coordinated efforts are part of the Coupled Model Inter-comparison Project (CMIP). The fifth assessment report (AR5) featured the climate model from CMIP5 based on Representative Concentration Pathway (RCP) scenarios. But the sixth assessment report (AR6) featured a new set of emission scenarios driven by different socio-economic assumptions called Shared Socio-economic Pathways (SSPs) in addition to RCP scenarios. Thus, CMIP6 models project the future climate based on different SSPs and RCPs and they are represented as SSP 1-2.6, SSP2-4.5, SSP3-8.5 etc. (Lovino *et al.,* 2021; Yue *et al*., 2021; IPCC 2022).

CMIP5 projections based on various Representative Concentration Pathways (RCPs) indicate that India would experience a temperature increase of 1.5–4.3 °C by 2080s compared to the baseline period of 1961–1990 (Chaturvedi *et al.,* 2012). Similarly, precipitation is expected to rise across most regions of India, except for a few areas in short-term projections (2030s). Annual precipitation in India could increase by 6–14% by 2080s compared to the baseline period (Abeysingha *et al.,* 2020). These changes in temperature and rainfall could impact water availability for various sectors, especially agriculture, posing serious challenges for livelihood security.

Climate change significantly impacts the hydrologic cycle. As temperatures increase, evaporation rates from oceans, lakes, and rivers rises, leading to more water vapor in the atmosphere. This can result in intensified precipitation events, causing heavier rainfall and more frequent and severe storms in some regions (Dagbegnon *et al.,* 2016). Conversely, higher temperatures can also escalate evapotranspiration rates from plants and soil, resulting in drier conditions and droughts in some areas. Additionally, alterations in precipitation patterns can change the timing and quantity of snowmelt, affecting water availability for ecosystems and various human activities such as agriculture, industry, and drinking water supply (Allan *et al.,* 2020).

Various studies have projected that the impact of climate change on agriculture could be severe, leading to significant reductions in crop yields and increases in food prices. For example, research suggested that future irrigation water demand and grain yields could decrease by 13-42% and 7-30%, respectively, during the 2050s and 2090s for RCP4, which is a scenario that assumes moderate efforts to reduce greenhouse gas emissions (Kaini *et al.,* 2022).

Rice is a crucial crop in India, covering about 23.3% of the country's cultivated land and contributing to 43% of overall food grain production (GOI, 2021). It's a staple food in Kerala, with an annual consumption of around 40 lakh tons (Financial Express, 2017). However, climate change, with its high temperatures and erratic rainfall, threatens rice yields and food security (Aswathi *et al.,* 2022). Ansari *et al.,* (2021), projected that future rice production could be reduced by up to 11.77% under RCP 8.5 during the 2050s, which is a scenario that assumes high levels of greenhouse gas emissions. Rice cultivation is very water-intensive and accounts for 24–30% of global freshwater consumption (Bouman *et al.*, 2007). Climate change alters precipitation patterns and temperature, directly affecting rice crops' water availability and stress levels, thus influencing irrigation needs. Shifts in water productivity can impact food security, economic stability, and environmental sustainability (Ding *et al.,* 2020). Strategies like sustainable irrigation practices, climate-resilient crops, and water conservation are crucial. However, limited availability of research and information on climate change impact on agriculture underscores the need for further investigation and dissemination of findings.

Climate scenarios and models can be used to assess the impacts of climate change on various sectors, including agriculture, water resources, and human health. They can also be used to evaluate the effectiveness of different adaptation and mitigation strategies. Integration of climate models and growth simulation models are essential tools for studying the impacts of climate change, providing valuable information on future climate conditions, ecosystem responses, policy decisions, and improving our understanding of the earth system (Balkovic *et al.,* 2014). Crop growth simulation models simulate crop growth under various climate conditions, helping researchers predict how temperature and precipitation changes will affect yields. By integrating climate data with plant biology, these models can identify adaptation strategies to mitigate negative effects, such as adjusting planting schedules or crop varieties (Peng,*et al.,* 2020, Jägermeyr *et al.,* 2021).

In developing countries like India, there is still a significant gap in getting various information and research studies related to the impacts of climate change on crop water requirement and productivity. There is a pressing need to enhance capacity building to develop resilient systems that can effectively integrate and manage climate threats, thereby providing guidelines for adaptation. Hence, a better understanding of climate change and its effects on crop productivity is essential. The AquaCrop growth simulation model is a useful tool to estimate the effects of climate change on rice cultivation. The findings offer valuable insights into the vulnerability of rice farming to climate change in a region, guiding adaptation and resilience-building strategies in agricultural systems. To ensure food security and maintain the integrity of water resources there is a growing call for specific research on agricultural water resource use and rice productivity under climate change. Thus, this project focuses on assessing the impact of climate change on irrigation water requirement and crop water productivity of rice in Pattambi, region of Kerala.

Given the backdrop outlined above, the project entitled "Climate change impact on irrigation water requirement and crop water productivity of rice" was undertaken with the following specific objectives.

1. To investigate the changes in historical and future climate variables for the study area
2. To assess the impact of climate change on irrigation water requirement and crop water productivity of rice under climate change scenarios
3. To develop and evaluate possible adaptation strategies for combating the effects of climate change.