IMPACT OF PROJECTED CLIMATE CHANGE ON CROPPING PATTERN OF DIFFERENT AGRO ECOLOGICAL UNITS OF CENTRAL KERALA

By

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(2012-20-117)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

BSc-MSc (integrated) Climate Change Adaptation

Faculty of Agriculture

Kerala Agricultural University, Thrissur

ACADAMY OF CLIMATE CHANGE EDUCATION AND RESEARCH

VELLANIKKARA, THRISSUR – 680 656

KERALA, INDIA

2017

DECLARATION

I hereby declare that the thesis entitled **"Impact of projected climate change on cropping pattern of different agro ecological units of central Kerala"** is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENT

At times our own light goes out and is rekindled by a spark from another person. Each of us has cause to think with deep gratitude of those who have lighted the flame within us. I sincerely thank all those who directly or indirectly made this research possible.

I feel immense pleasure to express my gratefulness towards each and every member of my advisory committee and I consider myself fortunate to have enjoyed the privilege of being guided by them during my research program. First of all, I wish to place on record my deep sense of gratitude and respect to **Dr. K. M. Sunil** Chairman of my advisory committee and Assistant Professor of Agricultural Meteorology, KVK, Pattambi for his inspiring and precious suggestions, untiring interest and constructive criticisms throughout the course of my study period. I am greatly indebted to his for the immense help extended for the completion of my research programme.

I consider it as my privilege to express my deep-felt gratitude to **Dr. A. V. Santhoshkumar,** Professor and Head, Department of tree breeding, College of Forestry for his constant support, valuable suggestions, cooperation throughout the research programme and expert advices. I sincerely thank **Dr. S. Sandeep,** Scientist (Soil Science), KFRI for his expert advice, constant inspiration, precious suggestions, generous support and constructive criticisms during my entire study which helped in successful completion of this work. I am deeply obliged to **Dr. (Prof.) Indira Devi P.,** Special officer, Academy of Climate Change Education and Research, for his invaluable help, guidance and critical assessment throughout the period of work. I thank him for all the help and cooperation he has extended to me.

It is with immense pleasure I avail this opportunity to express my deep sense of whole hearted gratitude to **Dr. Israel Thomas M.,** programme coordinator, KVK, Pattambi for the valuable advices and ever-willing help.

I wholeheartedly thank my friends, **Sukanya K. S., Yasser E. K., Abishna P. V., Gopi krishnan and** all other batch-mates for their love, co-operation and help.

I sincerely acknowledge the help and support of all the staffs of the Academy of Climate Change Education and Research for all sorts of helps rendered by them.

Lastly, I record my heartfelt gratitude to my beloved parents for being the pillars of strength for me. I am forever beholden to **my family**, for their boundless affection, support, prayers, blessings and personal sacrifices for me.

Once again, I thank all those, who extended help and support during the course of study and a word of apology to those, I have not mention in person.

Above all, I gratefully bow my head before the **Almighty**, for the blessings showered upon me in completing the thesis successfully.

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SYMBOLS AND ABBREVIATIONS

AET	- Actual Evapotranspiration
AEUs	-Agro Ecological Units
AEZ	-Agro Ecological Zones
CWR	-Crop Water Requirement
DSR	-Direct Seeded Rice
ET	-Evapotranspiration
ET_0	-Reference Crop Evapotranspiration
ETc	-Crop Evapotranspiration
FAO	-Food and Agriculture Organization
GCM	-General Circulation Models
GDP	-Gross Domestic Product
GFDL	-Geophysical Fluid Dynamics Laboratory
GHG	- Greenhouse Gases
ha	-Hectare
IARI	-Indian Agricultural Research Institute
IPCC	-Intergovernmental Panel on Climate Change
Kc	-Crop Factor
mm	- Millimeter
NBSS & LUP	-National Bureau of Soil Survey and Land Use Planning
NIR	-Net Irrigation Requirement
P	-Precipitation

PET	-Potential Evapotranspiration
RCP	-Representative Concentration Pathway
WD	-Water Deficit
WS	- Water Surplus
Wm^{-2}	-Watts per square meter

CHAPTER 1. INTRODUCTION

Climate change poses an emerging threat to sustainability of social and economic development, livelihoods, and environmental management across the globe. The rise in Green House Gases especially CO_2 in the atmosphere causes rise in temperature which in turn leads to unpredictable weather including flash floods and drought, and rise in sea level. Weather and its associated seasonal patterns are critical components of agricultural production systems. Rising temperatures linked with climate change will likely have a detrimental impact on crop production, livestock, fishery and allied sectors. With the ever increasing need for food, shelter and energy, the subject of maximizing the produce from land by agriculture has become the most important problem for the entire human race. India is highly vulnerable to climate change because of high physical exposure to climate related disasters and also the Indian economy and population depends more on climate sensitive sectors like agriculture, forests, tourism and fisheries.

Agriculture faces hastily growing challenges because it must supply food to an increasing population under shifting climate conditions. Furthermore, water scarcity is likely to increasingly limit crop production in many areas, and some analysts suggest that it is already doing so. To cope with these multiple challenges, researchers, policy makers, and farmers urgently need to consider different levels of agricultural adaptation. To stabilize the negative effects of climate change, researchers have generally emphasized incremental adaptation to existing cropping systems, such as the adjustment of planting window, suitable variety and improved agronomic practices. Although these adaptations might indeed be effective in terms of improved grain yield, a growing sensitivity of crop production to water shortages has also been observed. Considering the possibility of further reductions in water availability for agriculture, such incremental adjustments are unlikely to provide long-term solutions to the problems of inadequate food and water supplies. Thus, more extensive changes in cropping systems should be considered.

Recently, AEZ classification has proved to be useful in the impact analysis of climate change on agriculture (Fischer *et al.,* 2005). It also turned out to be a useful concept in explaining adaptation behaviors to climate change. So characterization of the ecosystems using the AEZ concept is a good decision making approach for variety of farming activities performed by the farmers and is a useful tool for the studying the impact of climate change. Crop diversification is a practical means to increase crop output and income.

Kerala state is considered to be highly susceptible to climate change due to its high dependency of climate sensitive sectors like agriculture, fisheries, forest, water resource and health. These sectors have immense contribution of evolving current socio-economic condition and unique development scenario of the state. Same time climate change impacts on these sectors might cause drastic change in the development process of the state.

Climate change, especially changes in rainfall patterns, is particularly important for rainfed agriculture. Soil moisture limitations reduce crop productivity and increase the risk of rainfed farming systems. Although the risk of climate variability is reduced by the use of irrigation, irrigated farming systems are dependent on reliable water resources; therefore they may be exposed to changes in the spatial and temporal distribution of rainfall in a location. So purpose of this project is to study the effects of climate change on regional water availability, changes in the cropping pattern and water requirement at agro ecological unit level of central Kerala. It is need to apprehend the impact of climate change on the local environment for taking timely preventive actions or adaptive measures. Local strategies have to be developed for ensuring resilience against climate change in all major sectors.

In order to understand the impact of climate change in major cropping systems of Kerala, the present investigation was taken up with the following objectives:

1. To study rainfall variability and to determine water availability periods of Agro ecological units of central Kerala under different climate change scenarios.
2. To study the impact of projected climate change on cropping pattern, crop calendar and the possible changes in the water requirements of major cropping systems prevailed in the various Agro ecological units of central Kerala.

Climate change experienced over the past several decades is consistently associated with changes in a number of components of the hydrological cycle and hydrological systems such as: changing rainfall patterns, intensity and extremes; widespread melting of snow and ice; increasing atmospheric water vapour; increasing evaporation; and changes in soil moisture and runoff. There is significant natural variability – on inter annual to decadal time-scales – in all components of the hydrological cycle, often masking long-term trends. There is still substantial uncertainty in trends of hydrological variables because of large regional differences, and because of limitations in the spatial and temporal coverage of monitoring networks. Climate change does not only affect water resources but also water demand. Future water and food security will depend, among other factors, on the impact of climate change on water demand for irrigation.

An agro ecological zone (AEZ) is a land resource mapping unit, defined in terms of climate, landform, and soils, and has a specific range of potentials and constraints for cropping. The future climate change will lead to significant local changes of AEZs and the overall pattern of AEZs. Climate change alters weather variables and there by affect the production of rice. General Circulation Models (GCM's) are very useful in predicting the future climate. In this chapter we are going to review the impact of projected climate change n cropping patterns of agro ecological units of central Kerala is being reviewed.

2.1. Climate change

A doubling of carbon dioxide from the current level would result in approximately 2.0°C increase in global temperature (Manabe and Wetherald, 1967).

IPCC was established in 1988 by two United Nations organizations, the World Meteorological Organization and the United Nations Environment Programme. In first report, they predict that under a "business as usual" scenario, global mean temperature will increase by about 0.3°C per decade during the 21st century. They judge that global mean surface air temperature has increased by 0.3 to 0.6 °C over the last 100 years, broadly consistent with prediction of climate models, but also of the same magnitude as natural climate variability.

The greenhouse gases (GHGs) are presently increasing at the rate of one percent for CH_4, 0.4-0.5 percent CO_2 and 0.2-0.3 percent for N_2O (Baker, 1989). General Circulation Models (GCMs) used to study climate changes project variable magnitude of change particularly on a regional basis (Mitchell *et al.*, 1990).

Giorgi *et al.*, (1998) showed for most regions of the world, the inter-GCM model range of simulated temperature increase for a doubling of CO_2 was about 3.0-5.0°C. For South-east Asia different GCMs predicted an increase of 0.8 to 3.2°C for a doubling of CO_2.

Climate change results in changes in long-term weather conditions globally. More explicitly, climate change denotes a significant statistical variation either in the average condition of the climate or in its variability that continues for long periods, typically decades or longer (VijayaVenkata Raman *et al.*, 2011).

The Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) reported that the future greenhouse gas emission will keep on rising, and the global average temperature is likely to be increased from 0.3 to 4.8°C, based on various scenarios (Stocker *et al.*, 2013).

The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85°C, over the period 1880 to 2012.Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP 2.6. It is likely to exceed 2.0°C for RCP 6.0 and RCP 8.5, and more likely than not to exceed 2.0°C for RCP 4.5. Warming will continue beyond 2100 under all RCP scenarios except RCP 2.6. Warming will continue to exhibit inter annual-to-decadal variability and will not be regionally uniform (IPCC, 2013).

2.2 Climate change impacts on agriculture

Chakraborty and Maity (2004) conducted a study to determine the water requirements of both paddy and different winter crops (wheat, Indian mustard, groundnut, sesame, sunflower, lentil, gram, potato, sweet potato, chilli, tomato and brinjal) in West Bengal, India. Seasonal water requirement varied widely with the type of crops. Paddy utilized the highest amount of water (1470 mm), while the lowest water use (121 mm) was observed in sunflower. The rest of the crops required water between 155 and 333 mm. The rate of water use of the crops also varied to a great extent. The water consumption rate of paddy was 8.56 mm/day. For the other crops it ranged from 1.42 to 5.27 mm/day. Water use efficiency was a maximum in tomato (79 kg ha^{-1} mm^{-1}) and minimum in paddy (4 kg ha^{-1} mm^{-1}). The water use index was also highest in tomato (Rs. 393.33 ha^{-1} mm^{-1}) and lowest in paddy (Rs. 18.86 ha^{-1} mm^{-1}). Crop yield was highest in tomato (23.17 t/ha) and lowest in sunflower (0.81 t/ha).

Dev (2005) reported the use of groundwater for irrigation in crop production particularly for cereal crops in West Bengal, India. The study aimed to bring down the harvest of groundwater through reallocation of agricultural land to cereal crops. Based on water requirement of different crops the study suggested for reallocation of agricultural land to the crops which require relatively low quantity of water. The paddy crop was observed to require the highest quantity of water among the cereal crops using ground water.

Kuo *et al*., (2005) reported that irrigation water requirements and deep percolation in Taiwan were 962 and 295 mm, respectively, for the first rice crop, and 1114 and 296 mm for the second rice crop. Regarding the upland crops, the irrigation water requirements for spring and autumn corn are 358 and 273 mm, respectively, compared to 332 and 366 mm for sorghum, and 350 and 264 mm for soybean.

Lorenzo *et al*., (2006) found that green-house shading improved the quality of tomato and increased yield of cucumber in Egypt. It reduced crop transpiration and thus water uptake, and improved water use efficiency by 47 per cent and 62 per cent for the crops grown in open fields in a semi-dry climate subjected to direct sunlight, high temperatures and wind resulting in high crop evapotranspiration (ETc). Shade-houses favored plant growth; since plants were less stressful, direct sunlight was avoided, temperature was lower, humidity was higher, wind speed reduced, and ETc was low.

Ambuja (2006) mentioned that rice crop water requirement and water supply was analyzed with the help of meteorological data and irrigation data. The crop water requirement of rice crop was computed with the help of reference evapotranspiration (pan evaporation method) and crop coefficients. It was found that the water demand for rice crop exceeded the irrigation supply.

Morison *et al.,* (2008) reported that agriculture accounts for more than 80 per cent of all freshwater used by humans, most of that is for crop production. Currently most of the water used to grow crops is derived from rain fed soil moisture, with non-irrigated agriculture accounting for about 60 per cent of production in developing countries. Though irrigation provides only 10 per cent of agricultural water use and covers just around 20 per cent of the cropland, it can vastly increase crop yields, improve food security and contribute about 40 per cent of total food production since productivity of irrigated land is almost three times higher than that of rain fed land.

Antle and Capalbo (2010) conducted a study on the changes in crop production and yield associated with climate change. Climate-induced water scarcity from changes in temporal and spatial distribution of rainfall could lead to increased competition within the agriculture sector and with other sectors.

Lobell (2011) and Nelson *et al.,* (2010) reported that climate change will influence crop distribution and production and increase risks associated with farming. Crop yields have already experienced negative impacts, underlining the necessity of taking adaptive measures.

Mo *et al.*, (2013) reported that impact of climate change on crop evapotranspiration becomes important for water management and agricultural sustainability. The warmer climate may increase the ET_0 of crops leading to greater demand for irrigation water. Climatic factors like radiation, humidity, wind speed and rainfall also influence the ET_0. Consequently, any variation in those factors will also modify the ETc.

Kumari *et al.*, (2013) reported remote sensing based approach of large-area crop water requirement using vegetation indices as proxy indicator of crop coefficient (Kc). It was an attempt to estimate the reasonably proper Kc for lowland rice and wheat and subsequently crop evapotranspiration (ETc) in rice-wheat system using multi temporal IRS P6-AWiFS data integrated with meteorological data following FAO-56 approach. Geometrically and radiometrically corrected multi-temporal AWiFS images were classified by rule based classifier to discriminate rice-wheat system from other cropping system.

Falguni and Kevin (2013) reported that climate change is likely to have impact on the hydrological cycle and consequently on the available water resources and agricultural water demand. There were concerns about the impacts of climate change on agricultural productivity. Industrialization and the extended use of fossil fuels have lead to a great increase in the atmospheric concentrations of greenhouse gases. With respect to the relations between the hydrological cycle and the climate system, every change on the climate could affect parameters such as precipitation, temperature, runoff, stream flow and groundwater level. This could lead to changes in the crop water requirement in agriculture and also industrial and domestic water consumption demands will also change.

Surendran *et al.*, (2014) reported that rise in temperature is one of the predicted impacts of climate change with significant implications on water resources management. An attempt has been made to calculate the water requirement of crops in different agro-ecological zones of Palakkad district in humid tropical Kerala using the CROPWAT 8.0 model. Sensitivity analysis was done for a simulated rise in temperature from 0.5 to 3.0°C keeping other parameters the same. The analysis showed that the total crop water requirement of all the major crops, like coconut, paddy and banana, increased with rising temperature thereby increasing the simulated irrigation water demand.

Chattaraj *et al.,* (2014) conducted a study which was directed to assess the on-farm water requirement in wheat crop in semi-arid Indo-Gangetic Plains of India, through field and computer simulations. Field simulation using temperature gradient tunnels show 18 per cent higher crop evapotranspiration (ETc) and 17 per cent increase in root water extraction at 3.6° C elevated temperature compared to 1.5° C increase over the ambient temperature. Time series model (ARIMA) with long-term (1984–2010) weather data of the experimental site and a global climate model (IPCC-SRES HADCM3) were used to simulate the potential ET (ET_0) of wheat for 2020–2021 and 2050–2051 years.

Banavath *et al.,* (2015) reported that the amount of Crop Water Requirement (CWR) for different crops grown in the Araniar reservoir basin command area was calculated by using CROPWAT model.

2.2.1 Climate change impact on Indian agriculture

Naresh *et al.,* (2011) reported that Indian agriculture is facing challenges due to several factors such as increased competition for land, water and labour from non-agricultural sectors and increasing climatic variability. The climate variability associated with global warming will result in considerable seasonal or annual fluctuations in food production. Carbon dioxide enrichment experiments had shown that in the field environment, 550 ppm carbon dioxide leads to a benefit of 8–10 per cent in yield in wheat and rice, up to 15 per cent in soyabean, and almost negligible in maize and sorghum; but increase in temperature may alter these results.

Pratap *et al.,* (2014) analyzed the changes in climate variables, viz. temperature and rainfall during the period 1969-2005 and has assessed their impact on yields of important food crops. A significant rise was observed in mean monthly temperature, but more so during the post-rainy season. The changes in rainfall, however, were not significant. An increase in maximum temperature was found to have an adverse effect on the crop yields. A similar increase in minimum temperature had a favorable effect on yields of most crops, but it was not sufficient to fully compensate the damages caused by the rise in maximum temperature.

Surendran *et al.,* (2014) reported that, rise in temperature is one of the predicted impacts of climate change with significant implications on water resources management. An attempt has been made to calculate the water requirement of crops in different agro-ecological zones of Palakkad district in humid tropical Kerala using the CROPWAT 8.0 model. Sensitivity analysis was done for a simulated rise in temperature from 0.5 to 3.0°C keeping other parameters the same. The analysis showed that the total crop water requirement of all the major crops, like coconut, paddy and banana, increased with rising temperature thereby increasing the simulated irrigation water demand. The simulated gross water demand for an increase in temperature of 0.5, 1.0, 2.0 and 3.0°C will be 1,523, 1,791, 1,822 and 1,853 Mm^3, respectively.

2.3. Climate change and agro ecological zones

Most Indian workers have adopted the classification strategies based on techniques developed by Koeppen (1936), Thornthwaite (1931, 1948), Thornthwaite and Mather (1955), Cochevne and Franquien (1967), Papadakis (1970) and Hargreave (1971) for delineation of climate using quantitative averages of climatic parameters.

Using Koeppen's classification, Bharucha and Shanbhag (1957) determined the climatic types for 104 stations in Indian sub-continent. The study has emphasized on thermal factors than on moisture factor and the parameters used were mean annual temperature and mean annual precipitation. Thornthwaite classification has been widely used by Shanbhag (1956); Bharucha and Shanbhag (1957); Subrhmanyam (1957, 1963); Subrahmanyam and Murthy (1968); Subrahmanyam and Sastry (1969); and Krishnan (1969).

Other workers such as Krishnan and Thanvi (1972); Subramaniam and Umadevi (1979); Subramaniam and Vinayak (1982); Bora (1983); have applied Thornthwaite (1948) method in one form or the other for defining the agro climates of various regions of India. Krishnan and Singh (1968) using moisture and thermal index and super-imposing them on soil maps have divided India into 64 soil climatic zones.

Sarkar and Biswas (1986) modified Hargreave's technique (1971) to suit dry farming tract of Indian subcontinent using two productivity levels of moisture adequacy index and agro climatic zoning was performed on weekly basis as against monthly by Hargreaves. Sarkar and Biswas (1988) worked out agro climatic classification for entire India.

Raman and Murthy (1971) worked out water availability periods for 200 Indian stations using Cocheme and Franquine (1967) method. Subramaniam and Umadevi (1983) have also used this method to designate water availability periods for a few stations in Orissa arid Andhra Pradesh.

Many studies have been conducted on agro climatic aspects on regional scales in India. To mention a few significant studies are the water balance approach in drought studies done by Subrahmanyam and Ram Mohan (1979, 1984), Bora (1976), Ram Mohan (1978), Vinayak (1991), Lekha (1992).

Nair (1973) delineated thirteen agro climatic zones and identified cropping patterns in Kerala State based on rainfall, altitude, topographical features and soil characteristics. Kerala state Agricultural University under the National Agricultural Research Project has brought out status report of five agro climatic zones in the year 1984 and another report in the year 1989 based on physiography and climate for broad agricultural planning.

Information on the agro climatology of Kerala is scanty. Murthy (1982) has made a beginning in this direction on Kerala. Still the application of agro climatology in crop land use study in Kerala has not been carried out. Thus, the present study is aimed at to fulfill this requirement by studying the cropping pattern, cropping intensity, crop diversification and concentration, crop combination and finally to delineate the agro climatic regions of Kerala. This study will form as a basic resource inventory/document for the State and will provide a sound basis for broad crop land use planning and developing agriculture on a sustainable basis.

Dickinson, (1983) and Schlesinger, (1997) concluded that Climate change will affect the terrestrial biosphere through changes in the regional energy balance and play a primary role in determining the ecology of a region.

A critical examination of the AEZ classification and its applicability to a climate change impact analysis has never been conducted, albeit its popularity in climate literature (Easterling *et al.,* 2007).

The impact of climate change on water resources seems apparent since it alters precipitation and temperature; factors such as population growth and land use change often have a more substantial impact (IPCC, 2007).

Several agricultural researchers identified most vulnerable agricultural zones to climate change and weather factors using the AEZ concept (Butt *et al.,* 2005, Kazianga and Udry, 2006; Thornton *et al.,* 2008; Seo, 2012).

Studies conducted by Fischer *et al*., 2005 and Tubiello *et al*., 2007 found that Agro Ecological Zone classification has proved to be useful in the impact analysis of climate change on agriculture and it also turned out to be a useful concept in explaining adaptation behaviors to climate change.

According to Naik and Sastry (2001) precision in research in agriculture could be much accurate and extension recommendations would be much successful as one move from macro level to micro level approaches for classification of agro ecological zones.

Griffin *et al.,* (2013) used the water stress indicators are used to categorize the sub-watersheds as water rich, water stressed, or water scarce and concluded that scenarios incorporating regional predictions of climate change indicate a decrease in summer soil moisture minima and increases in summer water deficit and also there is a shift toward water stress in the Lower Cape Fear River basin, due to a warming climate as well as increased demand.

According to Seo, N.L. (2013) the Agro Ecological Zones classification identifies the land's suitability for crop farming and adaptive decisions such as diversification and risk management are difficult to capture by the Agro Ecological Zone methods.

Ecological conditions in turn have profound impacts on the types and scales of various economic activities performed therein. Economic activities lead to greenhouse gas emissions or reductions which have consequences on the earth's climate (IPCC, 2007; Seo, 2012).

According to Fischer *et al.,* 2005 and Tubiello *et al.,* 2007 this AEZ classification has proved to be useful in the impact analysis of climate change on agriculture and it also turned out to be a useful concept in explaining adaptation behaviors to climate change.

The concept of growing seasons of crops is applied to the statistical examination of an individual crop's yield vulnerability to climatic change and agricultural researchers also identified most vulnerable agricultural zones to climate change and weather factors using the AEZ concept (Butt *et al.,* 2005; Kazianga and Udry, 2006; Thornton *et al.,* 2008).

The shifts in the AEZs under different climate change scenarios were modeled using statistical methods. However, a critical examination of the AEZ classification and its applicability to a climate change impact analysis has never been conducted, albeit its popularity in climate literature (Easterling *et al.*, 2007).

2.4. Climate change and water balance

The concept of water balance was put forth by Thornthwaite in (1948). Thornthwaite evolved a book keeping procedure from which it is possible to calculate actual evapotranspiration (AET), water surplus (WS) and water deficit (WD), by comparing PET and rainfall.

Subramaniam (1964) in an attempt to use the knowledge of applied climatology in order to examine as to what extent Thornthwaite's scheme could be used for explaining the natural vegetation of the Mysore state, observed that, despite the scarcity of stations and scantiness of data, the correspondences were so marked and convincing that they justified the applicability of water balance concepts to practical problems and thus there established the rationality of the approach.

Pinto and Preuss (1975) prepared a computer program in FORTRAN for the evaluation of water balance according to the method proposed by Thornthwaite and Mather. The maximum water storage term can be modified according to the crop considered. Monthly values of soil water retention were calculated on a mathematical basis.

Queiroz and Correa (1979) calculated the water balance for 10-day periods in Ponta Grossa using the method of Thornthwaite and Mather. Several periods of water deficiency and excess were identified.

Subramaniam *et al.,* (1980) presented the climatic water budget for Andhra Pradesh as a whole. Subramaniam and Murthy (1982) calculated the climatic water balances of five stations of Kerala state. They also classified climates of Kerala both on thermal and moisture regimes following Thornthwaite's scheme. Subramaniam and Rao

(1982) presented the water balance and crops in Karnataka. They calculated climatic water balance elements and water balance indices for all the meteorological stations in the state. They compared the general distribution of crops and IMA to identify the limits for certain crops.

For studying about water balance of any region, invented by Thornthwaite (1948), is the climatic water balance approach, and later it was modified by Thornthwaite and Mather (1955), (Subramanyam, 1982).

Hanna (1983) discussed the following (a) the water balance of crops, (b) the measurement of soil water in the field, (c) relationships between the environment and growth, (d) statistical models of climate and yield, (e) moisture indices, (f) application of statistical models and (g) models of the soil-plant-atmosphere.

Vinayak (1983) computed water balance and indices for six stations in Kerala for finding the impact of soil moisture conditions on crop yields.

Amorirn and Silva (1989) defined the water balance according to Thornthwaite and Mather. Its calculation was described and examples of its application to different regions of Brazil were presented with the help of tables and graphs.

Agnese *et al.*, (1989) computed water balance using Eagleson water balance model and a comparison with the more simplified Thornthwaite model showed marked differences in results.

Victor *et al.*, (1991b) observed that crop water use estimated from the FAO water balance model which can be used to quantify the crop yields. Their analysis can permit evaluation of the suitability of a given crop for production at the planting site.

The term 'water balance' expresses overall mass conservation for all rain falling in any given period. However, the water potential can never be assessed from precipitation alone. To assess such potentiality, it is essential to have reliable information on the balance between inflows and outflows of water for each situation and analysis of water balance for the study area was done according to Thornthwaite book keeping technique (Sudhishri, 2007)

Water balance is a concept used to understand the availability and the overall state of water resources in a hydrological system which forms the basis of the principle of mass conservation applied to exchanges of water and ensures the magnitudes of the various water exchange processes (Das, Y. 2015)

2.4.1. Precipitation

On globally averaged basis, precipitation over land increased by about 2% over the period from 1900–1998 (Dai *et al.,* 1997 and Hulme *et al.,* 1998).

Hurd *et al*., (1999), reported that in the southern United States may see an overall increase in precipitation, but will also see alteration in the yearly distribution, such that the increase will likely come more in the form of intense precipitation events, causing water quality and flooding problems.

According to Katz (1999) the probability of occurrence of substantially more extreme precipitation events could increase dramatically if there are increases in both the mean and the variance of precipitation amounts.

In a warming climate, this could result in increased moisture content in the atmosphere, likely increasing the intensity and/or frequency of precipitation events, often referred to as the intensification of the hydrologic cycle. At the same time, increased temperature and energy content of the atmosphere could drive increases in evaporation that could also increase the moisture content of the atmosphere and enhance precipitation events (Trenberth, 1999).

It is now well established that surface air temperatures and precipitation over land have increased during the 20th century Results from recent simulations using one of about 20 coupled ocean–atmosphere–land models based on the IS92A mid-range emission scenario indicate that global mean surface air temperature, precipitation, evaporation, and runoff will increase 2.3 °C, 5.2, 5.2, and 7.3%, respectively, by 2050 (Wetherald and Manabe, 2002).

Karl and Trenberth (2003) reported the increases in precipitation intensity with increasing mean annual surface air temperature for a fixed precipitation amount.

Air temperature is a determining factor for many hydrologic processes and variables, so fluctuations in temperature should be expected to alter the hydrologic cycle. This is due in large part to the sensitivity of saturation vapor pressure, which increases with an increase in temperature (Milly, *et al.*, 2005)

Huntington (2006) analyzed historical data to see if trends exist supporting the hypothesis of intensification of the hydrologic cycle with warming. While results indicated intensification, the analyses showed some spatial and temporal uncertainty that relates to incomplete data and some contradictory results.

Climate change is expected to affect precipitation and evapotranspiration patterns (Tsanis *et al.*, 2011)

2.4.2. Dependable precipitation

The best method to determine the rainfall probability is to fit the data to incomplete gamma distribution (Stern and Coe, 1982; Mondel *et al.*, 1983; Chan, 1984; Sarker *et al.*, 1978). However, the simple ranking method described by Doorenbos and Pruitt (1977) does not involve complicated statistics and hence, is used for computing rainfall probabilities for all the stations in the central zone. Use of probabilities of monthly total rainfall for agronomic purpose has been reported by Manning (1956); Baliga and Sridharan (1968).

Hargreaves (1975) defined dependable precipitation as the amount that is normally equaled or exceeded three-fourths of the time. It is the 75 percentage statistical probability of occurrence. Mean rainfall data has little value in rainfed agriculture. It gives only trends of certain climatic patterns and can be useful as a tool to indicate agro climatic homogeneous zones, to some extent, but does not give any information on rainfall variability (Hargreaves, 1977; Neuwolt, 1981). In rainfed agriculture, for understanding the probability of success in cropping, one must consider the assured rainfall received in three out of four years, which is otherwise known as dependable precipitation (DP), dependable rainfall or 75 percent probability rainfall.

Virmani (1975) considered crop growth period for three different available water storage capacities and worked out length of growing season at different probabilities of assured rainfall. Virmani *et al.*, (1978) reported the use of initial and conditional rainfall probabilities for obtaining agronomically relevant information.

Sarker *et al.*, (1978) have analyzed weekly rainfall in the dry farming tract of Karnataka by fitting gamma distribution probability model.

Dickinson, (1983) concluded that Climate change will affect the terrestrial biosphere through changes in the regional energy balance.

Hargreaves *et al.*, (1985) determined precipitation probabilities from the monthly values of precipitation for the 30 years period (1931-60) ranked by the World Meteorological Organization and stated that the accuracy of the analysis depends more on the length of record than on the method used.

The regional water balance is distributing the precipitation to runoff and evapotranspiration from the land surface, and soil moisture storage. Seasonal shifts in water balance occur as a function of precipitation and other climate conditions. Climatic factors, such as temperature, humidity, and wind, affect the water balance by influencing evaporation and transpiration (Eagleson, 1986)

Santhosh and Prabhakaran (1988) applied a first order Markov chain model to daily rainfall data to characterize the rainfall pattern of five selected stations of northern Kerala. Suitable probability distributions were fitted to estimate the rainfall probabilities.

According to Brubaker *et al.*, (1993) alterations in precipitation recycling, the redistribution of water locally that was evaporated from the surface will increase the frequency of localized precipitation and also the contribution of regional evaporation to regional precipitation varies substantially with location and season.

Analysis of the lowest assured weekly rainfall at different probability levels using the incomplete gamma distribution was found suitable for planning rainfed crops and related rainwater conservation measures for hilly regions of Himachal Pradesh (Verma *et al.*, 1994).

According to Guo and Yin, 1997 in the hydrological cycle, the runoff is more sensitive to variation in precipitation than to variation in temperature.

Decreases in pan evaporation have been observed over most of the USA and the former USSR between 1950 and 1990 and such decreases are generally thought to be inconsistent with observed trends towards increasing temperature and precipitation, resulting in an 'evaporation paradox' (Brutsaert and Parlange, 1998).

Rao, *et al.,* (1998) assessed the probability of receiving adequate rain for successful crop establishment by using daily rainfall data for Anantapur, Nandyal and Lam from 1969-1984. The implications for crop production were discussed and the probability of receiving a minimum monthly rainfall of 50, 75 and 100 mm at each location was calculated.

2.4.3. Potential evapotranspiration (PET)

There are many methods developed from time to time by various workers to estimate PET. Some of them are by Thornthwaite (1948), Penman (1948), Montieth (1965), Van Bavel (1966), Linacre (1967), Taylor (1972), Hargreaves (1977) etc. The widely accepted concept of potential evapotranspiration was put forth by Thornthwaite (1948) and Penman (1948) independently. Thornthwaite (1948) defined potential evapotranspiration as 'the maximum amount of water that would evaporate and transpire from a thickly vegetated extensive territory with no deficiency of water for full use at any time'. Thornthwaite (1948) described the biological and physical importance of evapotranspiration in climatic delineation. He developed an equation for estimating potential evapotranspiration.

Sanderson (1950) reported that measurements of daily evaporation at Toronto over a vegetated soil surface were favourably compared with the PET estimated by the Thornthwaite formula.

Thermal efficiency (same as PET) for several Indian stations according to Thornthwaite formula was first reported by Subrahmanyam (1956a). Palmer and Havens (1958) provided a graphical solution for Thornthwaite's equation.

Matejka (1972) mapped and tabulated Thornthwaite's potential evapotranspiration estimates calculated for 141 meteorological stations throughout

Czechoslovakia, discussing their distribution in relation to bioclimatic zones and altitudinal zones of forest associations.

Coulter (1973) compared the estimates of potential evapotranspiration by the Penman formulae with estimates based on evaporation tank data and found to agree well at a number of stations, but tank estimates were greater when the aerodynamic term was large. Potential evapotranspiration values calculated for months and for five day periods were closely correlated with corresponding tank evaporation values. Except when ET was near that corresponding to wet conditions over a wide area, Thornthwaite's estimates were considerably lower than those derived from combination formulae or tank estimates.

Tarsia (1975) reviewed the commonest methods of measuring potential evapotranspiration, with special reference to the formulae of Thornthwaite, Turc and Penman, and provided evidence for concluding that Penman's formula gives the best results.

Ulehla and Smolik (1975) simplified the Thornthwaite method for estimating potential evapotranspiration using the linear relationship between monthly totals of potential evapotranspiration and the respective monthly mean temperatures. Data from Pohorelice during 1952-69 were used as an example.

Thermal efficiency values for thirteen stations in Andhra Pradesh have been reported by Subrahmanyam and Hemamalini (1977).

Subramaniam and Rao (1980) reported that the PET values computed using the Thornthwaite formula were in better agreement in per humid (in Vengurla), humid (in Bombay) and sub humid (in Chanda) climate whereas the deviations were more from and arid climates.

Dumario and Cattaneo (1982) used Penman's equation for estimating potential evapotranspiration for data from 186 Sites in Argentina. Charts for the whole year were presented and compared with values obtained by the methods of Thornthwaite, Papadakis and Grassi- Christiansen and with estimations of ETo (reference crop evapotranspiration) obtained from evaporation measurements corrected for variable zonal factors according to the probable magnitude of the oasis effect.

Stone (1988) developed a BASIC computer programme for calculating daily potential evapotranspiration by the method of Thornthwaite and Mather.

Roth and Gunther (1992) measured the water consumption of winter wheat, spring barley, potatoes and sugar beet in weighable lysimeters, situated in farm fields in Germany. The results obtained with the lysimeters are compared with the pan-evaporation (two different pans) and the results of four evapotranspiration equations.

Global climate change will affect the terrestrial biosphere primarily through changes in regional energy and water balance Changes in soil moisture and evapotranspiration particularly affect water and forest resources. (Marks *et al.,* 1993).

According to Mulholland *et al.,* 1997, warming trends in the climate will increase evapotranspiration in the region which will decrease runoff.

A warming climate can change precipitation and evapotranspiration rates while also altering the frequency, intensity, and location of precipitation. (Arnell, 1999)

2.5. Climate change and water requirement

Crop water requirement is defined as the depth of water needed to meet the water loss through evapotranspiration of a disease free crop, growing in large field under non-restricting soil conditions including soil water and fertility and achieving full production potential under given growing environment.

FAO (1984) has defined ET_0 as "the rate of ET from an extensive surface of 5–15 cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water". ET of a crop is defined as "the rate of ET from a disease-free crop, growing in large fields under no restricting soil water and fertility conditions and achieving full production potential under the given growing environment" (James, 1993).

Water demand for rice during the entire growth period varies from 950 mm to 1050 mm for three month duration crop and 1120 to1250 mm for four month duration crop. It depends on crop growth stage, climatic condition and soil characteristics. For different conditions, it varies from 1000-1500 mm for heavy soils with high water table, short duration variety, Kharif season; 1500-2000 mm for medium soils *Kharif* or early spring season and 2000-2500 mm for light soils, long duration varieties during *Kharif*, medium duration varieties during summer (Indiaagronet, 2005).

Food and Agriculture Organization has predicted a net expansion of irrigated land of about 45 million hectares in 93 developing countries reaching a total of 242 million hectares by 2030. The projected water withdrawals by the agriculture sector will increase by about 14 per cent during 2000 – 2030 to meet food demand (FAO, 2006).

Jadhav *et al.*, (2006) conducted investigations in basmati rice (*Oryza sativa* cv. Basmati-370) to evaluate the water requirement in Maharashtra, India. The consumptive use of basmati rice grown under upland irrigated condition during the *kharif* season of 1998-99 on Vertisol, as estimated by modified Penman, radiation, pan-evaporation and Hargreaves methods showed a variation from consumptive use estimated by the gravimetric methods. The variability was observed in all the growth stages of crop. The variation was highest during flowering and was lowest during grain filling and maturity stage of the crop.

Pedro *et al.*, (2007) conducted research to determine the water requirements of the pineapple crop in Brazil, using a sprinkler irrigation system as complementary water supply. Crop evapotranspiration (ETc) was estimated by the Bowen ratio-energy balance and reference evapotranspiration (ET_0) by the Penman-Monteith method. The mean daily crop evapotranspiration was too variable throughout the pineapple crop development cycle, with values decreasing from (ETc = 4.6 mm day^{-1}) in the vegetative growth to 3.5 mm day^{-1} in the fruits harvesting phenological stage. On the overall, ETc was lower in the beginning of the vegetative growth and fruits harvest and higher in the middle of the productive cycle. The cumulative water used during the crop growing cycle was 1421 mm while the cumulative reference evapotranspiration was 1614.9 mm.

2.5.1. Crop water estimation

The model CROPWAT for Windows is a decision support system developed by the Land and Water Development Division of FAO, Italy with the assistance of the Institute of Irrigation and Development Studies of Southampton, UK and National Water Research Centre, Egypt. This model carries out calculations for reference evapotranspiration, crop water requirements and irrigation requirements in order to develop irrigation schedules under various management conditions and schemes of water supply.

Doorenbos and Pruitt (1977) presented a method for the prediction of crop water requirement based on Penman evaporation equation. Doorenbos and Pruitt (1977) method used a slightly modified version of the equation with a revised wind function, where the evapotranspiration (ET_0) from reference short grass was determined.

Adam and Farbrother (1984) presented a method for predicting the crop water requirement. The method was based on the calculation of water needed by plants to satisfy evapotranspiration losses measured from soil moisture depletion through daily gravimetric sampling. The sampling was done on 10-20 cm depth intervals up to 1 m. The calculated ET values were related to the original Penman evaporation from free water surface via a crop factor (k_f).

One of the most important aspects of water balance is evapotranspiration (ET); unfortunately this is also one of the most difficult parameters to measure in the field. A lot of research has been undertaken to estimate a kind of reference ET from meteorological data and convert this to the actual ET. The most frequently used in this sense is the so-called FAO-24 concept (Doorenbos and Pruitt, 1977), which is recently updated.

Allen (2000) and Akio *et al.,* (1999) used Penman-Monteith reference crop evapotranspiration with derived crop coefficients from the phenomenological stages of cotton to estimate the crop water requirement. The results were compared with the current practice that uses Penman evaporation from free water surface and crop factors. Penman - Monteith equation was found to be better in terms of the total predicted crop water requirement, coefficient of determination (r^2), and the slope of the linear regression line and the standard error of estimate with both basal and derived (Kc) values. The trends of weather examined for the period 1966 -1993 showed an increasing ET_0 during the rainy season due to the recent drought conditions that prevailed in the region.

Kar and Verma (2005) computed the crop water requirement of rice using CROPWAT 4.0 model as 450- 550 mm, 600-720 mm, 775-875 mm for autumn rice, winter rice and summer rice respectively in different agro-ecological sub-regions. Sheng-

Feng Kuo (2006) conducted field experiments to calculate the reference and actual crop evapotranspiration, derived the crop coefficient, and collected requirements input data for the CROPWAT irrigation management model to estimate the irrigation water requirements of paddy and upland crops. In the paddy fields, the irrigation water requirements and deep percolation were 962 and 295 mm, respectively, for the first rice crop, and 1114 and 296 mm for the second rice crop. For the irrigated single and double rice cropping patterns the CROPWAT model simulated results indicate that the annual crop water demands are 507 and 1019 mm, respectively, and the monthly water requirements peaked in October at 126 mm and in January at 192 mm, respectively.

Manjunatha *et al.*, (2009) conducted a study during the *kharif* season of 2005 in Karnataka, India, to determine the effect of different systems of rice intensification on yield, water requirement and water use efficiency. The grain yield of rice was significantly the highest with modified SRI method (6342 kg/ha)). Crops grown with 9- and 12-day-old seedlings recorded the significant highest grain yields (6017 and 6018 kg/ha, respectively), over the rest of the treatments.

Rakesh *et al.,* (2012) used different methods of crop establishment in basmati rice. A field experiment was conducted during *kharif* season of 2009-10. The basic infiltration rate under puddled and unpuddled soil condition was recorded as 0.020 mm/min and 0.049 mm/min, respectively. There was a saving of 8-26 per cent irrigation water under different methods of direct seeded rice (DSR) as compared to puddled manual transplanted rice and different methods of mechanical transplanted rice. There was 19 per cent saving of water under puddled as compared non puddled mechanical transplanted rice, respectively. The grain yield in mechanical transplanting varied from 29.5 to 32.6 q/ha. The grain yield recorded in the range of 31.2 to 32.1 q/ha when crop was sown with DSR techniques.

Falguni and Kevin (2013) cited that reference crop evapotranspiration (ET_0) was determined using mean monthly meteorological data with the help of CROPWAT 8.0 and then crop water requirement (ETc) was determined. Results showed the clear effect of climate change on crop water requirement of *rabi* and hot weather crops. Results showed that crop water requirement of all hot weather crops of millet, ground nut, maize, small vegetables and tomato increased.

Mamta *et al.,* (2013) used remote sensing based approach for determining large-area crop water requirement using vegetation indices as proxy indicator of crop coefficient (Kc). This study was an attempt to estimate the reasonably proper Kc for lowland rice and wheat and subsequently crop evapotranspiration (ETc) in rice-wheat system using multi temporal IRS P6-AWiFS data integrated with meteorological data following FAO-56 approach. Monthly biophysical parameters viz., fractional canopy cover (f_c) and water scalar factor (Ws) were derived from spectral indices in order to adjust Kc for the different growth stages in rice-wheat system. The results showed that after including Ws with *fc* for rice, degree of fit (R^2) has been significantly improved from 0.72 to 0.94 for Kc estimation of rice. The estimated crop water requirement was 241.66, 531.34, 440.86 and 192.63 M ha.m for rice and 127.43, 135.77, 305.55, 262.84 and 204.5 M ha.m for wheat at various growth stages.

Babu *et al.*, (2014) estimated water requirement of different crops using CROPWAT 8.0 model. The crop water requirement for the groundnut k*harif* and r*abi* crops in the Anantapur region was estimated at 591.3 mm and 443.3 mm, respectively and for the vegetables, cotton, rice, grains and maize in the Anantapur region were estimated to be 594.1 mm, 878.6 mm, 1110.6 mm, 699.9 mm and 679.3 mm, respectively. Efficient water management becomes crucial and critical in normal or deficit rainfall years

Banavath *et al.*, (2015) reported that determination of reference crop evapotranspiration (ET_0) by using Penman-Monteith method through the help of CROPWAT model using climatic data of Pichatur Station in Andhra Pradesh, the probability of exceedance functions on rainfall data to obtain the dry year condition for optimal development of irrigation projects, determine crop water requirements by using a CROPWAT model for the present scenario, prediction of climatic data by using ANN-Back Propagation Feed Forward Function to determine the future CWR, prediction of climatic data by using IBM-SPSS model to obtain future CWR, validate models for the predicted data and estimation of future crop water requirements.

Rapid industrialization over the last century has brought out industrial and agricultural emissions of carbon dioxide (CO_2), Methane (CH_4), chlorofluro carbon

(CFC), nitrogen oxide (NOx) and other gases. It resulted in an increase of greenhouse gases in the earth's atmosphere. General circulation models (GCM) describing the dynamic processes in the earth's atmosphere have been used extensively to provide potential climate change scenario (Grotch.1998; Gutowski *et al.*, 1988; Smith and Tarpak. 1989; Cohen. 1990).

Saini and Nanda (1987) found that increased temperature hastened the rate of leaf senescence resulting in reduction in leaf area. The model simulation revealed that warming scenarios will have an adverse effect on rice production through the advancement in maturity and reduction of source size coupled with poor sink strength in state of Punjab. Similarly the decrease in crop life span and grain yield with increase in temperature was also reported (Wardlaw *et al.,* (1989); Hundal *et al.*, (1993).

Watson *et al.*, (1996) reported that the changing climate may accelerate the hydrological cycle resulting in changes in precipitation, evapotranspiration, run-off, and in the intensity and frequency of floods and droughts. Both changes in rainfall and temperature affect crop growth and development.

Global climate change is a change in the long-term weather patterns that characterize the regions of the world. The term 'weather' refers to the short-term (daily) changes in temperature, wind, and/or precipitation of a region (Merritts *et al.,* 1998).

Atmospheric carbon dioxide concentration has risen and the general circulation models have predicted a global temperature rise of 2.8-5.2°C for a doubling of atmospheric carbon dioxide concentration. Doubling of carbon dioxide will decrease leaf stomatal conductance to water vapour to about 40 per cent. Water use efficiency by C_3 crop plants under field conditions has usually seen to be decreased. A yield enhancement of 30-35 per cent for C_3 crops occurred for a doubling of carbon dioxide. Transpiration rates were found to increase for an increase in the atmospheric temperature. Under well-watered conditions evaporation will increase about 4-5 per cent per 1°C rise in temperature (Allen, 2004).

Schmidhubber and Tubiello, (2007) investigated the spatial and temporal variation of the water requirement, water consumption and water deficit as affected by the changing weather patterns in the period from 1976 to 2005. Most agricultural climate change impact studies have focused on the impact on crop productivity. Changes in temperature, radiation and precipitation not only affect productivity but also have an impact on plant water use. Agriculture being the number one water user across the globe, changes in agricultural water use will have large impacts on water availability.

Supit *et al.,* (2010) analyzed the trends in European seasonal weather conditions and related crop water requirements, crop water consumption and crop water deficits during the period 1976–2005. The impacts of the changing weather patterns differed per crop and per region. In various European regions, the wheat water requirement showed a downward trend which can be attributed to a shorter growing season as a result of higher temperatures in spring. Changes in these variables can be attributed to the combined effect of variations in crop water requirements and rainfall.

Nguyen (2012) had reported that rainfall pattern is a very important limiting factor for rain-fed rice production. Higher variability in distribution and a likely decrease in precipitation will adversely impact rice production and complete crop failure is possible if severe drought takes place during the reproductive stages. In upland fields, if the rice crop receives up to 200 mm of precipitation in one day and then receives no rainfall for the next 20 days, the moisture stress will severely damage final yields.

Singh *et al.,* (2012) reported that the research conducted by Indian Agricultural Research Institute (IARI) has shown that the grain yield of rice was not impacted by a temperature increase less than 1°C. However from an increase of 1-4°C the grain yield reduced on average by 10 per cent for each degree of temperature rise. Thus, higher temperatures accompanying climate change will impact world rice production creating the possibility of a shortfall. Basmati varieties of rice were particularly vulnerable to temperature induced pollen sterility, and thus to lower grain formation.

Vaidhyanathan (2012) studied the impact of night time temperature rise on rice yields. It was reported that the warmer nights have an extensive impact on the yield of rice, every1°C increase in night time temperature led to a 10 per cent reduction in yield.

According to a study done by the Indian agricultural Research Institute, the impact of climate change with increased temperature and decreased radiation will lead to decrease productivity in rice in the North Eastern region (IARI.2012).

Shakhawat (2013) investigated possible implications of climate change on crop water requirements from 2011 to 2050 in Saudi Arabia. Crop water requirements were predicted for four scenarios: (i) current temperature and rainfall (ii) temperature in 2050 and current state of rainfall (iii) rainfall in 2050 and current state of temperature and (iv) temperature and rainfall in 2050. On an average, 1^0 C increases in temperature may increase the overall crop water requirement by 2.9 per cent in this region.

Chattaraj *et al.,* (2014) reported that the crop water requirement under the projected climate change could be mediated through changes in other weather parameters including the air temperature. Field simulation using temperature gradient tunnels shows 18 per cent higher crop evapotranspiration (ETc) and 17 per cent increase in root water extraction at 3.6^0 C elevated temperature compared to 1.5^0 C increase over the ambient. A time series model (ARIMA) with long-term (1984–2010) weather data of the experimental site and a global climate model (IPCC-SRES HADCM3) were used to simulate the potential ET (ET0) of wheat for 2020–2021 and 2050–2051 years. The CWR and NIR (Net Irrigation Requirement) are likely to be less in projected years even though air temperatures increase. It may be likely that the effect of temperature increase on CWR is manifested mostly through its relation with crop phenophase and not the temperature effect on ET_0 per se.

2.6. Water availability periods

Though, rainfall is the main source of water, the actual availability does not depend on rainfall alone as it should be balanced against the amounts due to evapotranspiration. Based on this, Cocheme and Franquin (1967) classified water availability periods. George and Krishnan (1969) and Raman and Murthy (1971) attempted for assessing the water availability periods based on climatic and soil conditions. Murthy (1973, 1976) determined water availability periods using actual evapotranspiration (AET) and potential evapotranspiration (PET), All these methods utilized monthly or weekly mean rainfall.

Gadre and Umrani (1972) used monthly rainfall data for various tahsils in Sholapur district, Maharashtra, and balanced against potential evapotranspiration values of Jeur and Sholapur for the Western and Eastern regions respectively and the water availability periods for each tahsil were delineated. The cropping pattern for each tahsil based on these periods was indicated.

Oswal and Saxena (1980) presented the analysis of rainfall data in the dry land districts of Haryana and revealed that only one crop is possible yearly on rainfall alone. The meteoric water availability period was found to be twelve, nine, seven and four weeks respectively at Mohindergarh, Hissar, Biwani and Sirsa.

Subramaniam and Rao (1981) assessed the water availability periods for crop planning in Rajasthan on the basis of monthly rainfall and monthly potential and actual evapotranspiration during 1901-77.

Subramaniam and Rao (1983) presented a method using PET and dependable rainfall to determine water availability for optimization of crop growth in Karnataka.

2.7. Crop planning

Sastry (1976) presented the interaction of the rice crop with climate and discussed with particular reference to both rainfed and irrigated rice crops in South and South East Asia.

Saksena *et al.,* (1979) made an attempt to study the distributions of dry and wet spells and the pattern of occurrence of rainfall in short intervals of 5, 10 and 15 day periods. Expected lengths of dry and wet spells for various levels of conditional probabilities were obtained through empirical relations. The use of these expected lengths and pattern of occurrence of rainfall in crop planning was shown with the Jowar crop for Jalgaon district, Maharastra.

Krishnan *et al.,* (1980) used systems analysis approach for crop planning in Jodhpur district of Rajasthan. The analysis of rainfall data during 1901-70 showed the presence of 3 main subsystems (early, normal and late) in the rainfall pattern. Information on crops suitable for cultivation in these subsystems in Bilara and Shergarl regions was given.

Budhar and Gopalaswamy (1988) suggested improved cropping system for Barur tract of Dharmapuri district in Tamil Nadu on the basis of rainfall data from 1947-83.

Rao *et al.,* (1988) carried out the rainfall probability analysis of three stations in Andhra Pradesh for crop planning. Daily rainfall data for Anantapur, Nandyal and Lam from 1969-1984 were used to assess the probability of receiving adequate rain for successful crop establishment.

Chakraborty *et al.,* (1990) studied rainfall and its impact on cropping pattern in Hooghly district of West Bengal. Assured rainfall analysis, probability of having a specified amount of 20 mm rainfall/week (one-third the potential evapotranspiration ratio of the region) and a water balance approach were found quite effective to assess the water availability period for crop planning under rainfed condition.

Maliwal and Chatrola (1991) studied the rainfall pattern for crop planning in Bhal zone Gujarat. Maraviya et al. (1991) analyzed rainfall data for crop planning under dry land agriculture at Rajkot, Gujarat.

Budhar *et al.,* (1991) suggested rainfall based cropping system in PalacodeTaluk of North Western region of Tamil Nadu. The severity of drought was determined by the prevalent soil type in various regions. Drought prone areas were classified based on precipitation (P), potential evapotranspiration (PET) and soil type to provide more precise information in rainfall and to develop suitable crop plan. The P/PET ratio provides a measure of whether certain crops can be grown at a place or not. Based on the ratio, a climatic index was developed and the values were super imposed on a soil map to identify local drought prone areas, and to classify them as mild, moderate or severe.

Shranker *et al.,* (1992) analyzed rainfall data for 1981-89 recorded at Jabalpur, Madhya Pradesh to suggest strategies for crop planning during the rainy season. Budhar and Gopalaswamy (1992) presented annual, seasonal, monthly and weekly rainfall data and suitable cropping systems for the Uthangaraitaluk of Dharmapuri district in Tamil Nadu.

Kavi (1992) studied rainfall characteristics in relation to crop planning at Raichur in Karnataka. Data were presented on seasonal rainfall and its percentage contribution to annual rainfall from 1961 to 1990.

Sehgal *et al.,* (1993) presented generalized ranges of moisture availability periods for average deep soils in India, for cereal, cotton, legume, oil and fibre crops which is very useful in crop planning.

Krishnasamy *et al.,* (1994) carried out rainfall analysis and presented rainfall pattern and cropping system for dry land areas of Avanashi block of Coimbatore district.

Rout *et al.*, (1994) studied rainfall pattern and suggested cropping system for sustainable production in Umerkote block of Koraput in Orissa. Chaudhary (1994) suggested a crop plan through rainfall analysis in Bastar district of Madhya Pradesh. The probability of rainfall occurrence and the consequences for crop production are studied with particular reference to rice.

Singh *et al.,* (1994) studied rainfall variability and its relationship with rainfed crop planning at Rewa, Sidhi, Satna and Shahdol districts in Madhya Pradesh. Rainfall and number of rainy days recorded for the period from 1968 to 1990 were analyzed with respect to monthly, seasonal and annual variations and drought, normal and abnormal months were calculated using frequency analysis. It is concluded that rabi cereals and pulses are more suited to Rewa and Satna districts, whereas [than] oilseeds and pulses and rabi oil seed crops are more suited to Shahdol and Sidhi districts.

2.8. Climate change projection

The realistic models of climate which combined atmospheric and oceanic models indicated global warming to the tune of 0.5° to 0.7° K for the period 1850-1980.This warming agrees well with the observed Northern Hemisphere warming of 0.6 K in this period. During next century, average rate increase in global temperature is projected as 0.3°C per decade with a range of 0.2 to 0.5°C (Kellogg 1983).

The increased temperature will lead to forced maturity and poor harvest index due to limited water supply. The water stress during grain filling period may result in decline of grain yield. Higher temperature coupled with increased CO_2 concentration could result in photosynthetic acclimation because of the imbalance in the source/sink ratio (Yadav*et al.* 1987).

During next 60 years the concentration of greenhouse gases will result in a situation equivalent to a CO_2 doubling in the first half of the 21st century which indicates changing trend of the global climate over a longer period. The Intergovernmental Panel on Climate Change (IPCC) has reported that global mean surface air temperature has increased by 0.3-0.6°C over the last century with the warmest year being in 1980 (Martin 1993).

Geethalakshmi *et al.,* (2011) reported that the results of the projected climate change over Cauvery basin of Tamil Nadu for A1B scenario using regional climate models showed an increasing trend for maximum, minimum temperatures and rainfall. The yields of ADT 43 rice simulated by decision support system for agricultural technology transfer withCO_2 fertilization effect had shown a reduction of135 kg ha^{-1} $decade^{-1}$ for providing regional climates for impact studies (PRECIS) output, while there was an increase in yield by 24 kg ha^{-1} $decade^{-1}$ for regional climate model system. Suggested adaptation strategies included, system of rice intensification, use of temperature tolerant cultivars and application of green manures/ bio fertilizers for economizing water and increasing the rice productivity under warmer climate.

In India, it is predicted that, physical impact of climate change will be seen as an increase in the average surface temperature by 2-4° C, changes in rainfall during both monsoon and non-monsoon months, a decrease in the number of rainy days by more than 15 days, an increase in the intensity of rain by 1-4mm/day and an increase in the frequency and intensity of cyclonic storms. Temperature and its associated seasonal patterns are critical components of agricultural production systems. Rising temperatures associated with climate change will have a detrimental impact on crop production, livestock, fishery and allied sectors. It is predicted that for every 2° C rise in temperature, the GDP will reduce by 5 per cent (Anna and Richa, 2012).

2.8.1. General circulation models

Gleick (1987) used his water balance model to investigate the potential impacts of climate change on the Sacramento River Basin, using hypothetical GCM based climate scenarios. His results for the GFDL based scenarios show decreases in summer soil moisture by between 33 and 36%), depending on the scenario, and a shift in the seasonality of runoff from spring to winter.

Currently general circulation models (GCMs) are considered to be the most comprehensive models for investigating the physical and dynamic processes of the earth surface-atmosphere system and they provide plausible patterns of global climate change. However, it is not yet possible to make reliable predictions of regional hydrologic changes directly from climate models due to the coarse resolution of GCMs and the simplification of hydrologic cycle in climate models (Arora, 2001).

In a study conducted by Galvincio *et al.*, 2008, to assess the impact, of climate change on hydrological cycle and water resources planning a semi-distributed monthly water balance model was proposed and developed to simulate and predict the hydrological processes. GIS techniques were used as a tool to analyze topography, river networks, land-use, human activities, vegetation and soil characteristics.

A warming climate can change precipitation and evapotranspiration rates while also altering the frequency, intensity, and location of precipitation and also a modeling approach utilizing Hadley Centre (HadCM2 and HadCM3) climate projections indicates that North Carolina would see increased precipitation due to a warming climate, but it will come in the form of more intense precipitation events (Arnell, 1999).

The present work was undertaken with the Study the impact of projected climate change on cropping pattern, crop calendar and the possible changes in the water requirements of major cropping systems prevailed in the various Agro ecological Units of central Kerala. Agro-Ecological Units Maps of Kerala shows the location of weather stations in the State (Fig. 1).

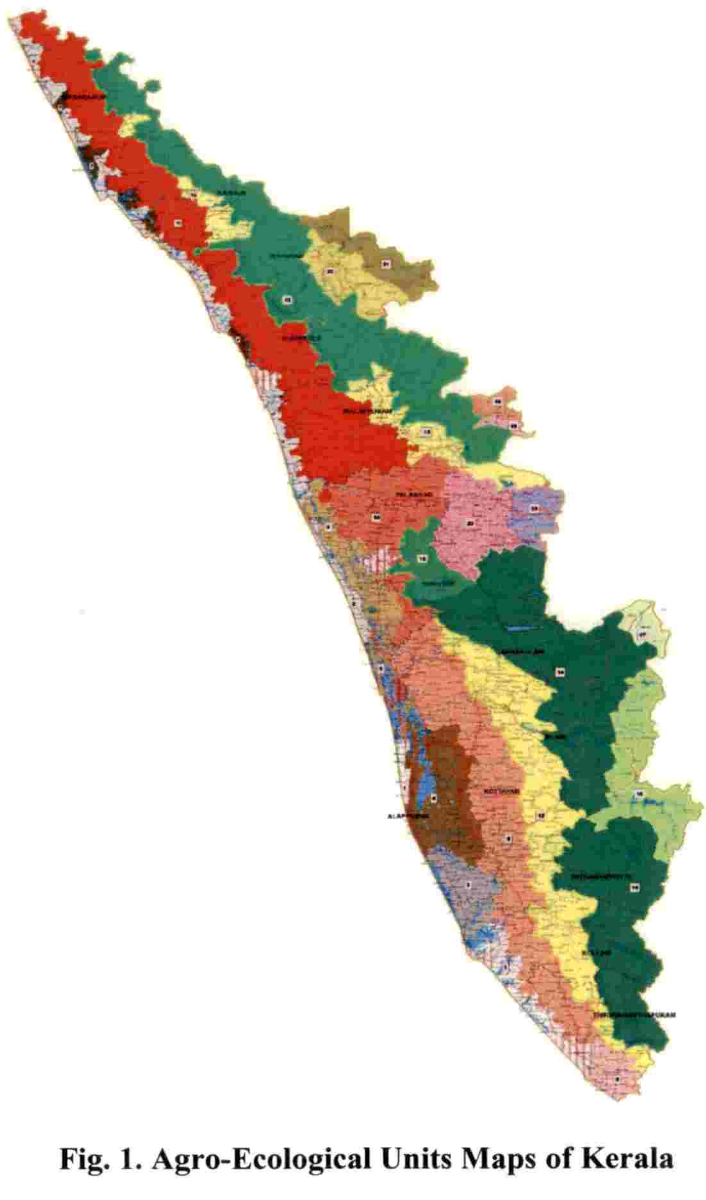

Fig. 1. Agro-Ecological Units Maps of Kerala

3.1 Collection of data

3.1.1 Meteorological data

Daily rainfall data for the period 1991-2014 were collected from 28 stations of Kerala state from the India Meteorological Department, Thiruvananthapuram Table 1 shows the name, latitude, longitude of the stations under study.

Table 1. Weather stations taken for the study

Sl.No	District	Station / Location	Latitude	Longitude
01	Ernakulam	NAS Kochi	09°57'N	76°16'E
02		Aluva	10°07'N	76°21'E
03		CIAL Kochi	10°09'N	76°24'E
04		Ernakulam (S)Rly	09°19'N	76°37'E
05		Perumbavur	10°05'N	76°25'E
06		Piravom	10°09'N	76°13'E
07	Malappuram	Karipur AP	11°08'N	75°57'E
08		Angadipuram	10°58'N	76°13'E
09		Manjeri	11°07'N	76°07'E
10		Nilambur	11°20'N	76°15'E
11		Perinthalmanna	10°58'N	76°13'E
12		Ponnani	10°47'N	75°54'E
13	Palakkad	Palakkad	10°46'N	76°39'E
14		Alathur	10°38'N	76°33'E
15		Chittur	10°42'N	76°45'E
16		Kollengode	10°37'N	76°43'E
17		Mannarkkad	10°09'N	76°34'E
18		Ottappalam	11°40'N	76°15'E
19		Parambikulam	10°20'N	76°45'E
20		Pattambi	10°48'N	77°12'E
21		Trithala	10°50'N	76°06'E
22	Thrissur	Enamackel	10°50'N	76°06'E
23		Irinjalakkuda	10°22'N	76°14'E
24		Kodungallur	10°03'N	76°22'E
25		Kunnamkulam	10°38'N	76°00'E
26		Thrissur	10°31'N	76°13'E
27		Vadakkancherry	10°35'N	76°10'E
28		Vellanikkara	10°31'N	76°13'E

3.1.2 Crops, cropping system and soil data

Agro Ecological Unit wise information on area and production of various crops and cropping system information were collected from Agro Ecology of Kerala, Published by NBSS & LUP and Kerala State Planning Board, 2012 and from the report of "Classification and Characterization of Farming Systems in District Wise Agroecological Units of Kerala" implemented in the Cropping Systems Research Centre, Karamana of Kerala Agricultural University.

3.2 Methodology

The daily weather data has been analysed on weekly, monthly, seasonal and annual basis. Mean values for the above periods have been computed for maximum temperature and minimum temperature, while totals were computed for rainfall for all the years. Seasons have been identified as per the following:

1. Winter: December to February
2. Summer: March to May
3. South West Monsoon: June to September
3. North East Monsoon: October to November

3.2.1 Rainfall

Mean weekly, monthly, seasonal and annual rainfall were worked from the totals obtained as above. Number of rainy days, length of growing period and high rainfall events were also woked out.

3.2.2. Reference crop Evapotranspiration (ET_0)

The reference crop evapotranspiration has been computed on a monthly basis for the all the stations where data on temperature, humidity, wind and sunshine duration are available. The method suggested by Doorenbos and Pruitt (1977) is used as it is widely accepted. The method is as follows:

$$ET_o = c\ [W.Rn + (1\text{-}w).\ f(u).\ (ea\text{-}ed)]$$

Where

ET_o = Reference crop evapotranspiration in mm/day

W = Temperature - related weighting factor

Rn = Net radiation in equivalent evaporation in mm/day

f(u) = Wind related function

(ea-ed) = Difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air both in millibar.

C = adjustment factor to compensate for the effect of day and night weather conditions.

ET_o for all the rain gauge stations has been interpolated based on Agro Ecological Units.

3.2.3. Water Balance Studies

Water balances have been computed following the book-keeping method of Thornthwaite and Mather (1955). The field capacity of the soil to hold moisture was assumed considering the type of soil and vegetation. Weekly water balances for all the stations have been computed by taking the dependable rainfall and the interpolated PET. The spatial variation of actual evapotranspiration, water surplus and water deficit over the state is presented.

3.2.3.1. Thornthwaite's Method of Water-Balance Computation

To facilitate the use of Thornthwaite's method of water – balance step by step description to estimate the various components and book – keeping procedures follows:

The requirements are the data of mean monthly temperature, the latitude of the station, the monthly precipitation and tables and charts prepared by the author (Thornthwaite and Mather, 1957).

Step 1. Unadjusted potential evapotranspiration (Unadj *PE*) to be ascertained from the monogram and the tables given by Thornthwaite (Thornthwaite and Mather, 1957).

Step 2. Adjusted potential evapotranspiration (*PE*). Correct the unadjusted *PE* values according to the latitude of the stations and to the month of the year (Thornthwaite and Mather, 1957).

Step 3. *P* is the rainfall and can be snowfall.

Step 4. $P - PE$.

This is the difference between precipitation and the adjusted potential evapotranspiration.

If P is less than PE, the value is negative.

If P is more than PE the value is positive.

Step 5. Accumulated Potential Water Loss (Acc Pot WL).

In wet climate

Where $P>PE$ (annual values)

Start with 0 in the month just before the one where negative value of $P-PE$ has started.

In dry climate where $P<PE$ (annual values)

Find the potential value of water deficiency with which to start accumulating negative value of PE.

The starting value can be found as follows:

a) Sum up all the negative $P-PE$ values
b) Sum up all the positive $P-PE$ values
c) Locate the value arrived in '*a*' (Thornthwaite and Mather, 1957) and locate corresponding value of actual retention
d) Locate the value arrived in step c on the vertical scale on the left side of the figure 1.2 (Thornthwaite and Mather, 1957).
e) Follow horizontally across on this line until it intersects the sloping line whose value equals the sum of the positive P – PE (step b). Read the value of the potential deficiency with which start accumulation.

Step 6. Storage (*St*)

For the negative values of $P-PE$, locate the storage figures using table 1.3 (Thornthwaite and Mather, 1957)

For the positive $P-PE$ values proceed as

a) Locate the last negative value in the column $P-PE$
b) Note the storage value of '*a*'

c) Add to the value of (b) the first positive integer (That is the positive value next to the negative value).

d) Complete the procedure for the rest of the months.

***Step** 7*. Change in soil moisture (ΔSt)

It is the difference in the storage value of two consecutive months. No difference is recorded when the values are above 300.

Step 8. Actual Evapotranspiration (*AE*)

When $P>PE$

Then $PE = AE$

When $P<PE$

Then $AE = P + St$* (Soil moisture storage)

*The negative sign of *S* is not considered.

It means teat *AE* is the sum of *P* and *St* without considering the sign of *St*.

Step 9. Moisture deficit (*D*)

It is the difference between *PE* and *AE* or $D = PE - AE$

Step 10. Moisture surplus (*S*)

1) Surplus exists when storage (*St*) is 300 and more and $P - PE$ is positive.
2) When the storage values are moving up towards 300, the first surplus will be $(P - PE) - St$.

Step 11. Water Run-off (*RO*)

RO is the one half of the surplus (*S*), the rest half goes to the next month. This should be added to the surplus of that month. Again, one-half of that month will be the run-off Add the remaining one-half to the S of the next month and the procedure continues.

Step 12. Snow-Melt Run Off (*SMRO*)

It is computed in areas of snow fall.

Step 13. Total Run-Off (*Tot. RO*)

It is the sum of the water surplus run-off and the snow-melt run-off.

Step 14. Total Moisture Detention (*DT*)

It is the sum of storage *St* and total run-off.

3.2.4. Length of growing period

The knowledge on the length of water availability periods will help to understand irrigational needs of crop at different phenological stages. Though, rainfall is the main source of water, the actual availability does not depend on rainfall alone as it should be balanced against the amounts due to evaporation. There are several methods for assessing the water availability periods based on monthly or weekly mean rainfall. However, mean rainfall data has limited utility and hence, Subramaniam and Kesava Rao (1983) have presented a method to determine water availability for optimization of crop growth. The method requires computation of water balances using dependable rainfall and comparison of AET with PET. The four water availability periods are defined as follows:

Humid period: $AET \geq PET/2$

Sub humid period: $PET/2 > AET > PET/4$

Semi dry period: $PET/4 > AET > PET/8$

Dry period: $PET/8 > AET$

Following the above, the number of days under different categories was worked out for all the stations. Moisture availability periods were estimated by combining the humid and sub humid periods. The number of days under humid period and sub humid period were added to get the total number of moist days.

3.3. Software

3.3.1. CROPWAT

CROPWAT for Windows is a decision support system developed by the Land and Water Development Division of FAO, Italy. The model does calculations for reference evapotranspiration, crop water requirements and irrigation requirements for the development of irrigation schedules under various management conditions and scheme water supply. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules and the assessment of production under rainfed conditions or deficit irrigation. The development of irrigation schedules and evaluation of rainfed and irrigation practices are based on a daily soil-moisture balance using various options for water supply and irrigation management conditions. Scheme water supply is calculated according to the cropping pattern provided in the program.

The potential evapotranspiration (ET_o) was computed by Penman-Monteith Model. In this model, most of the equation parameters are directly measured or can be readily calculated from weather data. The equation can be utilized for the direct calculation of any crop evapotranspiration (ET_c).The FAO Penman-Monteith method suggested by Verhoef and Feddes (1991) to estimate ETo is given as

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2\,(es - ea)}{\Delta + \gamma(1 + 0.34u_2)}$$

ET_o - Reference evapotranspiration [mm day-1]

Rn -Net radiation at the crop surface [MJ m-2 day-1]

G -Soil heat flux density [MJ m-2 day-1]

T -Mean daily air temperature at 2 m height [°C]

u2 -Wind speed at 2 m height [m s-1]

es -Saturation vapour pressure [kPa]

ea -Actual vapour pressure [kPa]

es-ea -Saturation vapour pressure deficit [kPa]

Δ -Slope vapour pressure curve [kPa°C-1]

A -Psychrometric constant [kPa°C-1].

3.3.2. WEATHER COCK v 1.5

Weather cock v.1.5 developed by Central Research Institute for Dryland Agriculture (CRIDA) has been used for converting the daily weather data into standard week, month and seasonal formats. It is also used to compute PET and Thornthwaite water balances.

3.4. Climate change Scenarios

Impacts of climate change will depend not only on the response of the Earth system but also on how humankind responds. These responses are uncertain, so future scenarios are used to explore the consequences of different options. The scenarios provide a range of options for the world's governments and other institutions for decision making. Policy decisions based on risk and values will help determine the pathway to be followed.

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) has introduced a new way of developing scenarios. These scenarios span the range of plausible radiative forcing scenarios, and are called representative concentration pathways (RCPs).

RCPs are concentration pathways used in the IPCC Assessment Report5 (AR5). They are prescribed pathways for greenhouse gas and aerosol concentrations, together with land use change, that are consistent with a set of broad climate outcomes used by the climate modelling community.

The pathways are characterized by the radiative forcing produced by the end of the 21st century. Radiative forcing is the extra heat the lower atmosphere will retain as a result of additional greenhouse gases, measured in Watts per square meter.

Table 2. Description of representative concentration pathway (RCP) scenarios

RCP	Description
RCP2.6	Its radiative forcing level first reaches a value around 3.1 Wm^{-2} mid- century, returning to 2.6 Wm^{-2} by 2100. Under this scenario greenhouse gas (GHG) emissions and emissions of air pollutants are reduced substantially over time.
RCP4.5	It is a stabilization scenario where total radiative forcing is stabilized before 2100 by employing a range of technologies and strategies for reducing GHG emissions.
RCP6.0	It is a stabilization scenario where total radiative forcing is stabilized after 2100 without overshoot by employing a range of technologies and strategies for reducing GHG emissions.

RCP8.5	It is characterized by increasing GHG emissions over time representative of scenarios in the literature leading to high GHG concentration levels.

Climate change data projected by GCM's on daily basis is used for the present study. Daily data of following variables has taken

1. Rainfall
2. Maximum Temperature
3. Minimum Temperature
4. Solar radiation

The regional climate scenarios including radiation, Maximum temperature (T_{max}), Minimum temperature (T_{min}) and precipitation as inputs of the Thornthwaite water balance to simulate the impacts of climate change on water balance of Kerala.

CHAPTER 4. RESULTS AND DISCUSSION

The results and discussion of the study entitled "Impact of Projected Climate Change on Cropping Patterns of Agro-Ecological Units of Central Kerala" are presented in this chapter. The changes in rainfall pattern and water balance due to changes in climate and its impact on irrigation water requirement and crop growing periods were studied.

4.1. Rainfall analysis

The data collected from India Meteorological Department, Thiruvananthapuram from 1991 to 2014 and the data from General Circulation Models based on RCP 4.5 and 8.5 were analyzed. The rainfall parameters or indices like seasonal and monthly rainfall, rainy days, high rainfall events, length of growing period etc. were calculated for the four districts viz. Ernakulam, Thrissur, Palakkad and Malappuram comprises central Kerala.

4.1.1. Rainfall analysis of various AEUs of Ernakulam district

The Ernakulam district has been divided into four agro-ecological units (Fig. 2) such as Pokkali lands(AEU5), South central laterites(AEU9), Southern and central foothills(AEU12), Southern high hills(AEU14) and these cover an area of 26,011 ha.(8.50%), 108,636 ha.(35.52%), 63,400 ha.(20.73%) and 83,804 ha.(27.40%) respectively.

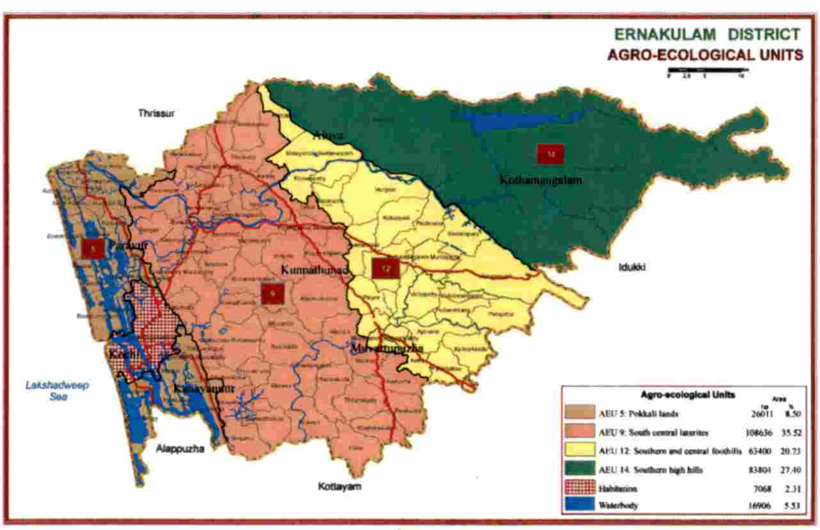

Fig.2 Agro-Ecological Units Map of Ernakulam District

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4.1.1.1. Rainfall analysis of Pokkali lands (AEU5) and impact of projected climate change in Ernakulam district

Pokkali Lands, a special agro-ecological unit, delineated for the lowlands, often below sea level, in coastal areas of Ernakulam district and extending to parts of Thrissur and Alappuzha districts and cover 34 panchayats. This unit covers 39,765 ha (1.02 %) in the state.

4.1.1.1.1. Rainfall and Rainy days of Pokkali lands (AEU5) in Ernakulam district

The monthly rainfall distribution of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 3.

Table 3. Monthly rainfall distribution under projected climate of Pokkali lands (AEU5) in Ernakulam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	14.6	7.1	20.9	21.8	14.6	20.9	22
February	50.4	13.4	3.5	5.9	50.4	2.8	0.9
March	180.5	10.4	26.8	27.6	180.5	30.3	29.5
April	401.9	69.3	78.6	80.8	401.9	54.3	60.2
May	530.3	490	548.1	539.9	530.3	658.4	476.2
June	776.8	1121.2	915.8	929.2	776.8	1122.6	883
July	702.9	1068.2	1138.1	1211.7	702.9	1060.6	1341.2
August	455.1	461.1	381.2	391.7	455.1	461.3	392.1
September	234.9	9.7	8.3	169.7	234.9	9.8	169
October	315.2	367.3	420.5	469.7	14.6	20.9	22
November	96.7	34.7	40.1	45.4	50.4	2.8	0.9
December	15.9	13.9	13.9	14.2	180.5	30.3	29.5
Total	**3775.2**	**3666.3**	**3595.8**	**3907.6**	**3592.9**	**3475**	**3426.5**

Presently, June and July are the wettest months, having a rainfall of 776.8mm and 702.9mm. January (14.6 mm) and December (15.9 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, March, April, September and November. As per the projections based on RCP 4.5, there is chance of reduction in the total annual rainfall during 2030s and 2050s but an increase during 2080s. Whereas, projections based on RCP 8.5 the total rainfall shows a continuous decline.

The monthly rainy days of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 4.

Table 4. Monthly rainy days under projected climate of Pokkali lands (AEU5) in Ernakulam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	1	1	1	1	2
February	2	1	1	2	0	0	1
March	5	1	2	2	2	2	3
April	11	5	8	8	7	7	1
May	16	16	16	16	18	16	19
June	22	26	27	27	26	27	26
July	22	28	28	27	28	28	28
August	18	12	12	12	12	12	13
September	9	1	1	6	1	6	5
October	11	11	11	13	11	13	13
November	5	4	4	4	4	4	4
December	1	1	1	2	1	3	5
Total	**123**	**108**	**112**	**120**	**111**	**119**	**120**

In the current condition, June and July months have the highest number of rainy days and it is around 22 days and the most reduced is in January and December. According to RCP 4.5 and 8.5, the highest number of rainy days will be happening in June and July and the lowest will be in January and February. The highest rainy days will be 28 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the yearly rainy days of Pokkali lands. In nut shell, the wet months will be wetter and dry periods will be drier.

The seasonal rainy days of Pokkali lands (AEU5) for the existing condition and projected climate were examined and given in table 5.

Table 5. Seasonal rainy days under projected climate of Pokkali lands (AEU5) in Ernakulam district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	65.1	32	1112.7	71	2169.6	16	427.8
4.5	2030	3	20.5	22	569.7	67	2660.2	16	415.9
	2050	2	24.4	26	653.5	68	2443.4	16	474.5
	2080	3	27.7	26	648.3	72	2702.3	19	529.3
8.5	2030	1	23.7	27	743	67	2654.3	16	425.7
	2050	1	22.9	25	565.9	73	2785.3	20	588.2
	2080	3	34.1	23	416.1	72	2572.7	22	601.3

At present, the greatest number of rainy days happens in south west monsoon period (71 days) followed by North East (16 days), summer season (32 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in South West monsoon period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be an extreme abatement in precipitation in summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West and North East.

4.1.1.1.2. High rainfall events of Pokkali lands (AEU5) in Ernakulam district

The high rainfall events of Pokkali lands (AEU5) were studied for the present and projected climate and given in table 6.

Table 6. High rainfall events under projected climate of Pokkali lands (AEU5) in Ernakulam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	22	17	6	1	0	22	17	6	1	0
	SW monsoon	20	15	7	1	2	20	15	7	1	2
	NE monsoon	2	1	0	0	0	2	1	0	0	0
	Total	**46**	**33**	**13**	**2**	**2**	**46**	**33**	**13**	**2**	**2**
2030	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	10	4	2	0	1	12	2	1	0	3
	SW monsoon	15	22	12	4	4	20	20	12	4	4
	NE monsoon	5	2	1	0	1	5	1	2	0	1
	Total	**31**	**28**	**15**	**4**	**6**	**38**	**23**	**15**	**4**	**8**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	11	2	1	1	2	11	2	1	1	1
	SW monsoon	23	18	14	3	2	23	17	13	8	3
	NE monsoon	6	1	2	0	1	7	5	1	1	1
	Total	**41**	**21**	**17**	**4**	**5**	**42**	**24**	**15**	**10**	**5**
2080	Winter	1	0	0	0	0	2	0	0	0	0
	Summer	11	2	1	3	0	13	2	0	1	0
	SW monsoon	25	15	14	6	3	26	18	13	3	3
	NE monsoon	4	4	1	1	1	5	3	1	2	1
	Total	**41**	**21**	**16**	**10**	**4**	**46**	**23**	**14**	**6**	**4**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (46) and 25 to 50 mm (33) and heavy rainfall which is in the range 50 to more than 100 mm (17) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.1.2. Rainfall analysis of south central laterites (AEU9) and impact of projected climate change in Ernakulam district

The South Central Laterites agro-ecological unit, delineated to represent midland laterite terrain with typical laterite soils and short dry period. The unit covering 161 panchayats of midlands extends from Thiruvananthapuram to Ernakulam district. This unit covers around 3, 65,932 ha (9.42 %) in the state.

4.1.1.2.1. Rainfall and Rainy days of south central laterites (AEU9) in Ernakulam district

The monthly rainfall distribution of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and presented in table 7.

Table 7. Monthly rainfall distribution under projected climate of south central laterites (AEU9) in Ernakulam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	33.3	21.5	24.5	25.6	24	18.2
February	2	0.9	9.8	11.8	10.1	11.5	7.6
March	1	34.2	23.8	24.2	24.3	23.7	30.4
April	103	46.2	62	38.7	60.9	33.1	18.9
May	191	560.6	513	414.3	504.4	424.1	440.2
June	518.5	996.9	1088.5	817	983.2	733.1	871.6
July	641.5	1148.2	1172.7	1133.5	1101.2	1156.1	1080.8
August	891	518	390.7	416.5	481.7	474.4	477
September	381	71.4	9.5	96.6	10.1	98.1	199.4
October	357	326.8	423.3	308.7	335.6	478.8	526.6
November	72	14.9	36.3	19	15.1	69.4	39.6
December	144	49.1	9	57.9	51.8	56.3	66.3
Total	**3302**	**3800.5**	**3760.1**	**3362.7**	**3604**	**3582.6**	**3776.6**

In the existing condition July and August are the wettest months, having a rainfall of 641.5 mm and 891 mm and there is little rainfall during January. Based on RCP 4.5 and 8.5 in projected climate there will be a probability of getting maximum rainfall during June and July and the lowest in February. Compared to the present condition the rainfall of projected climate will be decreasing during April, August, September, November and December whereas in January, March and May there will be a drastic increase in the rainfall. As per RCP 4.5 and 8.5 the total rainfall shows an increasing trend from the current condition.

The monthly rainy days of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 8.

Table 8. Monthly rainy days under projected climate of south central laterites (AEU9) in Ernakulam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	2	3	3	3	3	3
February	1	0	1	1	1	1	2
March	1	2	3	3	3	3	3
April	8	6	5	4	5	3	1
May	10	18	19	15	19	16	20
June	22	26	26	27	26	26	25
July	24	29	28	25	28	25	28
August	21	16	14	13	14	14	15
September	16	3	1	5	1	5	7
October	20	12	11	14	12	12	14
November	4	3	3	3	3	4	3
December	4	4	1	4	4	3	6
Total	**131**	**121**	**115**	**117**	**119**	**115**	**127**

Currently, July has the maximum number of rainy days and it is 24 days. And no rainy days are occurring in January. According to RCP 4.5 and 8.5, the maximum rainy days also will be in July and the minimum in February. As per RCP 4.5 and 8.5 the projected climate shows a decreasing trend in the annual rainy days of south central laterites from present condition.

For the current condition and projected climate, the seasonal rainy days of south central laterites (AEU9) were examined and given in table 9.

Table 9. Seasonal rainy days under projected climate of south central laterites (AEU9) in Ernakulam district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	2	37.8	19	399.4	81	2249.3	25	565.4
4.5	2030	2	34.2	26	641	74	2734.5	19	390.8
	2050	4	31.3	27	598.8	69	2661.4	15	468.6
	2080	4	36.3	22	477.2	70	2463.6	21	385.6
8.5	2030	4	35.7	27	589.6	69	2576.2	19	402.5
	2050	4	35.5	22	480.9	70	2461.7	19	604.5
	2080	5	25.8	24	489.5	75	2628.8	23	632.5

Presently, the maximum number of rainy days occurs during south west monsoon period (81 days) followed by North East (25 days), summer season (19 days) and winter season (2 days). According to projected climate the highest number of rainy days will get in South West monsoon followed by summer season. There will be an increasing trend in seasonal rainfall during south west monsoon period and summer season. Whereas during north east monsoon period and winter season, the rainfall will be decreasing. As per RCP 8.5 in 2080 there will be an increase in rainfall during northeast monsoon period from the current condition.

4.1.1.2.2. High rainfall events of south central laterites (AEU9) in Ernakulam district

High rainfall events for the present condition and projected climate of south central laterites (AEU9) were analyzed and represented in table 10.

Table 10. High rainfall events under projected climate of south central laterites (AEU 9) in Ernakulam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	2	2	0	0	4	2	2	0	0
	SW monsoon	28	25	7	4	2	28	25	7	4	2
	NE monsoon	11	7	2	0	0	11	7	2	0	0
	Total	**43**	**34**	**11**	**4**	**2**	**43**	**34**	**11**	**4**	**2**
2030	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	13	2	1	0	2	14	2	2	0	1
	SW monsoon	20	21	12	5	4	16	25	11	5	2
	NE monsoon	6	4	1	1	0	6	4	1	1	0
	Total	**41**	**27**	**14**	**6**	**6**	**37**	**31**	**14**	**6**	**3**
2050	Winter	1	0	0	0	0	3	0	0	0	0
	Summer	14	2	2	0	1	11	2	1	0	1
	SW monsoon	21	20	13	3	4	20	20	11	5	2
	NE monsoon	6	1	2	0	1	7	4	2	0	2
	Total	**42**	**23**	**17**	**3**	**6**	**41**	**26**	**14**	**5**	**5**
2080	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	11	2	1	0	1	13	3	0	0	1
	SW monsoon	20	19	12	5	2	24	18	15	3	3
	NE monsoon	6	6	1	0	0	5	3	1	2	1
	Total	**39**	**27**	**14**	**5**	**3**	**43**	**24**	**16**	**5**	**5**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm (43) and 25 to 50 mm (34) and heavy rainfall which is in the range 50 to more than 100 mm (17) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.1.3. Rainfall analysis of Southern and central foothills (AEU12) and impact of projected climate change in Ernakulam district

The Southern and Central Foothills agro-ecological unit, delineated to represent the undulating lands with low hills, between midland laterites and the high hills of

Western Ghats. It covers 90 panchayats from Thiruvananthapuram to Thrissur districts. This unit covers around 3, 15,893 ha (8.13 %) in the state.

4.1.1.3.1. Rainfall and Rainy days of Southern and central foothills (AEU12) in Ernakulam district

The monthly rainfall distribution of Southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 11.

Table 11. Monthly rainfall distribution under projected climate of Southern and central foothills (AEU12) in Ernakulam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	16.7	26.1	25.6	24.9	26.6	24.6	24.2
February	51.9	0.6	0.7	0.6	0.6	0.6	1.3
March	84.3	25.7	25	29.2	26.2	28.8	25.9
April	227.1	53.1	54.3	57.9	53.8	56.7	56.6
May	253.2	435.9	445.8	421.7	440.9	410.4	343.5
June	435.4	809.1	902	667.3	838.4	637.8	847.6
July	409.4	1206	1302	1236.8	1213.2	1197.6	1155.6
August	297.8	727.7	573.8	648	731.6	743.2	704.4
September	250.2	55.1	46.3	132.2	55.8	92	139.5
October	454.8	436.7	494.7	437.7	449.3	438.9	369.7
November	249.1	38.1	39.9	128.7	39	129.4	202.6
December	47.5	60.4	64.6	72.9	63.1	69	88.4
Total	**2777.4**	**3874.5**	**3974.7**	**3857.9**	**3938.5**	**3829**	**3959.3**

Presently, June and July are the wettest months; having a rainfall of 435.4mm and 409.4mm. January (16.7 mm.) is the months having lowest rainfall. As per RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during July and the lowest in February. Comparing the projected climate and present condition, the amount of rainfall shows a drastic decrease in the month February, April, September and November where as in July there will be a high increase. In projected climate the amount of annual rainfall will be higher than that of the present condition.

The monthly rainy days of Southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 12.

Table 12. Monthly rainy days under projected climate of Southern and central foothills (AEU12) in Ernakulam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	3	3	3	2	3	2
February	3	0	0	0	0	0	0
March	2	3	3	3	3	3	3
April	14	4	4	7	4	7	6
May	15	19	19	16	19	15	19
June	22	24	24	25	24	25	24
July	24	28	27	25	28	25	28
August	24	18	17	18	18	19	19
September	17	4	3	6	4	4	8
October	21	11	11	13	11	13	11
November	11	3	3	4	3	4	5
December	6	4	6	6	4	6	7
Total	**160**	**121**	**120**	**126**	**120**	**124**	**132**

In the current condition, July has the maximum number of rainy days and it is 24 days and the lowest is in January (1 day).According to RCP 4.5 and 8.5, the maximum rainy days will be in July and there will be no rainy days in February. As per RCP 4.5 and 8.5 the projected climate shows a decreasing trend in the annual rainy days of southern and central foothills from the present condition.

For the current condition and projected climate, the seasonal rainy days of southern and central foothills (AEU12) were examined and presented in table 13.

Table 13. Seasonal rainy days under projected climate of Southern and central foothills (AEU 12) in Ernakulam district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	6	108.3	27	582.2	77	1817.2	40	997.1
4.5	2030	3	26.7	26	514.7	74	2797.9	18	535.2
	2050	3	26.3	26	525.1	71	2824.1	20	599.2
	2080	3	25.5	26	508.8	74	2684.3	23	639.3
8.5	2030	2	27.2	26	520.9	74	2839	18	551.4
	2050	3	25.2	25	495.9	73	2670.6	23	637.3
	2080	2	25.5	28	426	79	2847.1	23	660.7

Presently, the maximum number of rainy days occurs during south west monsoon period (77 days) followed by North East (40 days), summer season (27 days) and winter season (6 days). According to projected climate, the highest number of rainy days will be in South West monsoon followed by summer season and the lowest in winter. There will be an increasing trend in seasonal rainfall during south west monsoon time. The intensity of rain during north east monsoon period will be higher than the summer season. In projected climate there will be a drastic decrease in rainfall during winter and north east monsoon period compared to the present condition.

4.1.1.3.2. Heavy rainfall events of southern and central foothills (AEU12) in Ernakulam district

The heavy rainfall events of southern and central foothills for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 14.

Table 14. Heavy rainfall events under projected climate of Southern and central foothills (AEU 12) in Ernakulam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	12	5	1	0	0	12	5	1	0	0
	SW monsoon	31	9	5	0	1	31	9	5	0	1
	NE monsoon	18	8	3	1	1	18	8	3	1	1
	Total	**63**	**22**	**9**	**1**	**2**	**63**	**22**	**9**	**1**	**2**
2030	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	13	3	0	0	1	13	3	0	0	1
	SW monsoon	16	23	16	3	4	16	22	17	3	4
	NE monsoon	7	4	0	0	2	7	4	0	0	2
	Total	**37**	**30**	**16**	**3**	**7**	**37**	**29**	**17**	**3**	**7**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	13	3	0	0	1	10	3	0	0	1
	SW monsoon	20	19	16	4	3	15	24	11	6	3
	NE monsoon	8	4	0	0	2	6	3	1	2	1
	Total	**42**	**26**	**16**	**4**	**6**	**32**	**30**	**12**	**8**	**5**
2080	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	11	3	0	0	1	11	5	0	0	0
	SW monsoon	17	23	11	6	3	20	21	13	5	5
	NE monsoon	6	3	1	2	1	7	3	0	3	1
	Total	**35**	**29**	**12**	**8**	**5**	**39**	**29**	**13**	**8**	**6**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (62) and heavy rainfall which is in the range 25 to more than 100 mm (34) the number of rainfall events is less. Comparing the present to the projected climate, there will be a decreasing trend in the number of rainfall events below 25 mm per day whereas the heavy rainfall events show an increasing trend.

4.1.1.4. Rainfall analysis of southern high hills (AEU14) and impact of projected climate change in Ernakulam district

The Southern High Hills agro-ecological unit extending from Thiruvananthapuram to Nelliyampathy in Palakkad district has elevation more than 600 meters. Besides elevation, the steep slopes of the terrain and lower temperatures distinguish the high hills from the foothills and midlands. Thirty panchayats in Thiruvananthapuram to Palakkad district constitute this unit. This unit covers around 6, 72,675 ha (17.31 %) in the state.

4.1.1.4.1. Rainfall and Rainy days of southern high hills (AEU14) in Ernakulam district

The monthly rainfall distribution of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 15.

Table15. Monthly rainfall distribution under projected climate of southern high hills (AEU 14) in Ernakulam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	25.1	27	25.8	24.7	25.8	21.8
February	22	1	1.1	1.1	1.1	1.1	3.7
March	58.6	32.3	32.4	35.3	33	35.3	35.1
April	64.4	39.7	33.4	38.5	32.8	37.3	30.7
May	262.2	387.7	317.7	267.7	312.5	257.8	254
June	308.8	856.4	991.2	785.7	941.2	728.1	817.1
July	350.2	1096.5	1120.7	1143	1108.6	1194.3	1083.4
August	536	807.8	700.5	773.2	835.9	806.3	730.9
September	243	51.9	125.4	88.2	52.6	90.1	133.7
October	335.4	434.5	352.6	364	446.7	343.8	351.1
November	205.2	41.5	38.5	37	24.2	58.6	192.5
December	36.4	55.2	89.5	98	75.3	94.1	87.2
Total	**2423.2**	**3829.6**	**3830**	**3657.5**	**3888.6**	**3672.6**	**3741.2**

Presently, August is the wettest month having a rainfall of 536mm. and the driest month is January. As per RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during July and the minimum in February. According to RCP 4.5 and 8.5 the total rainfall shows an increasing trend. In projected climate there will be a drastic decrease in the amount of rainfall during February, September and November from the present state.

The monthly rainy days of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and given in table 16.

Table 16. Monthly rainy days under projected climate of southern high hills (AEU 14) in Ernakulam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	1	1	1	1	2
February	2	1	1	2	0	0	1
March	5	1	2	2	2	2	3
April	11	5	8	8	7	7	1
May	16	16	16	16	18	16	19
June	22	26	27	27	26	27	26
July	22	28	28	27	28	28	28
August	18	12	12	12	12	12	13
September	9	1	1	6	1	6	5
October	11	11	11	13	11	13	13
November	5	4	4	4	4	4	4
December	1	1	1	2	1	3	5
Total	**123**	**108**	**112**	**120**	**111**	**119**	**120**

Presently, June and July have the maximum number of rainy days and it is about 22 days and the lowest is in January and December. As per RCP 4.5 and 8.5, the maximum number of rainy days will be occurring during July and the minimum will be in January and February. The annual rainy days of projected climate will be less as compared to the present condition. In nut shell, the wet months will be wetter and dry periods will be drier.

The seasonal rainy days of southern high hills (AEU14) for the existing condition and projected climate were examined and represented in table 17.

Table 17. Seasonal rainy days under projected climate of southern high hills (AEU 14) in Ernakulam district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	62.1	19	370.4	66	1286.2	33	760.8
4.5	2030	3	26.1	26	459.7	73	2812.6	18	531.2
	2050	2	28.1	25	383.5	73	2937.8	20	480.6
	2080	2	26.9	23	341.5	72	2790.1	20	499
8.5	2030	3	25.8	25	378.3	74	2938.3	18	546.2
	2050	2	26.9	22	330.4	73	2818.8	20	496.5
	2080	2	25.5	22	319.8	79	2765.1	23	630.8

Currently, the maximum number of rainy days occurs during south west monsoon time (66 days) followed by North East (33 days), summer season (19 days) and winter season (3 days). According to projected climate the maximum number of rainy days will be occurs in south west monsoon followed by summer season. The minimum number of rainy days will be getting in winter. The projected climate shows an intensified rainfall in north east monsoon period. The winter and north east monsoon period shows a decreasing trend in rainfall compared to the current condition.

4.1.1.4.2. High rainfall events of southern high hills (AEU14) in Ernakulam district

For the present and projected climate based on RCP 4.5 and 8.5, the high rainfall events of southern high hills were studied and presented in table 18.

Table 18. High rainfall events under projected climate of southern high hills (AEU14) in Ernakulam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	4	0	1	0	6	4	0	1	0
	SW monsoon	31	14	3	0	1	31	14	3	0	1
	NE monsoon	10	6	1	0	0	10	6	1	0	0
	Total	**48**	**24**	**4**	**1**	**1**	**48**	**24**	**4**	**1**	**1**
2030	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	14	3	0	1	0	14	3	0	0	0
	SW monsoon	15	23	11	7	4	15	23	11	8	4
	NE monsoon	9	3	0	0	2	9	3	0	0	2
	Total	**39**	**29**	**11**	**8**	**6**	**39**	**29**	**11**	**8**	**6**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	14	3	0	0	0	10	2	0	0	0
	SW monsoon	21	19	10	9	4	16	22	8	10	3
	NE monsoon	9	2	0	1	1	9	3	0	1	1
	Total	**45**	**24**	**10**	**10**	**5**	**36**	**27**	**8**	**11**	**4**
2080	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	12	1	0	0	0	13	1	0	0	0
	SW monsoon	15	22	9	8	4	23	19	14	6	3
	NE monsoon	10	3	0	1	1	6	3	1	2	1
	Total	**38**	**26**	**9**	**9**	**5**	**43**	**23**	**15**	**8**	**4**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (48) and 25 to 50 mm (24) and heavy rainfall which is in the range 50 to more than 100 mm (6) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 25 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.2. Rainfall analysis of various AEUs of Thrissur district

The Thrissur district has been divided in to six agro-ecological units (Fig. 3) such as Northern coastal plain (AEU2), Pokkali lands (AEU5), Kole lands (AEU6), North central laterites (AEU10), Southern high hills (AEU14), Northern high hills (AEU15) and these units covers an area of 22,228 ha.(7.34%), 11,704 ha.(3.86%), 56,580 ha.(18.67%), 85,335 ha.(28.17%), 51,022 ha.(16.84%) and 59,486 ha.(19.64%) respectively.

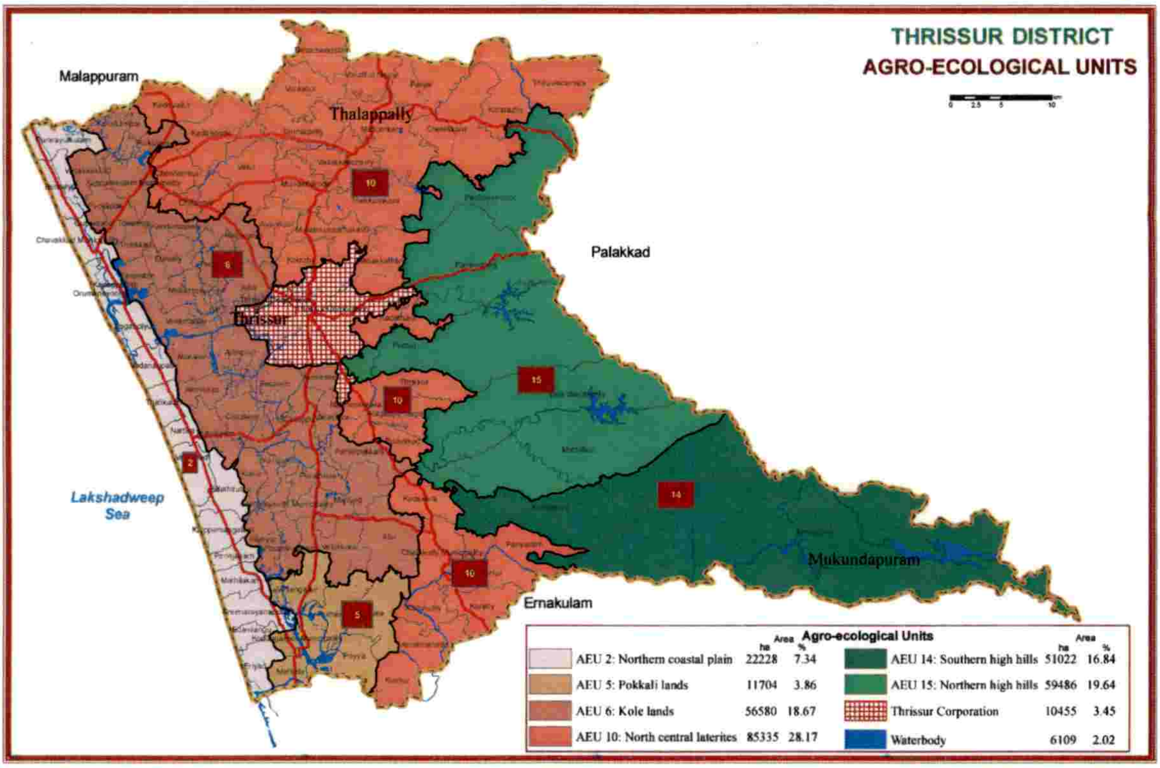

Fig.3 Agro-Ecological Units Map of Thrissur District

4.1.2.1. Rainfall analysis of Northern coastal plain (AEU2) and impact of projected climate change in Thrissur districts

The Northern Coastal Plain agro-ecological unit represents the coastal plain north of Ernakulam district and comprises 77 panchayats along the coast from Thrissur till the northern end of the state. This unit covers around 1, 22,970 ha (3.16 %) in the state.

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4.1.2.1.1. Rainfall and Rainy days of Northern coastal plain (AEU2) in Thrissur district

The monthly rainfall distribution of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 19.

Table 19. Monthly rainfall distribution under projected climate of Northern coastal plain (AEU2) in Thrissur district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	2.1	7.9	9.1	0.6	7.9	7.9	0
February	5.9	7.7	0.7	4.2	0	0	2
March	23.1	6	18.8	25.5	14.7	14	12.2
April	82.8	42.1	15.4	22.4	45.9	69.3	27.4
May	232.2	289.8	437.2	424.7	283.4	380.7	371.3
June	841.5	1192	1018	1046	1388.1	881.7	790.9
July	788.7	1378.2	1123.6	1244.5	1200.9	1373.8	1211.8
August	408.8	400.6	462.6	495.3	394.4	517.1	476.7
September	271.4	7.3	10	59.5	7.4	77.5	184.6
October	323.1	381.1	434.8	285.7	390.8	284.1	321.1
November	130.1	39.1	64.8	64.2	40.1	64.4	41.6
December	19	42.5	48.1	51.1	45	48.2	59.8
Total	**3128.7**	**3794.3**	**3643.1**	**3723.7**	**3818.6**	**3718.7**	**3499.4**

In the existing condition June is the wettest month having a rainfall of 841.5 mm and the lowest is in January (2.1 mm.). Based on RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during July in the projected climate and the lowest in February. Compared to the present condition the rainfall of projected climate during September and November shows a drastic decrease. As per RCP 4.5 and 8.5 the total rainfall shows an increasing trend compared with the current condition.

The monthly rainy days of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 20.

Table 20. Monthly rainy days under projected climate of Northern coastal plain (AEU2) in Thrissur district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	1	0	1	1	0
February	1	1	0	1	0	0	0
March	1	0	3	4	2	2	2
April	4	3	3	2	3	1	2
May	9	11	14	17	14	13	15
June	23	26	27	26	26	26	26
July	25	28	24	24	27	24	29
August	19	14	14	14	13	14	14
September	12	1	1	3	1	4	7
October	12	11	12	10	11	10	10
November	6	3	4	4	3	4	3
December	1	3	3	3	3	3	5
Total	**114**	**102**	**106**	**108**	**104**	**102**	**113**

In the current condition, July (25) have the maximum number of rainy days and the lowest is in January, February, March and December. According to RCP 4.5 and 8.5, the maximum rainy days will be in July and the minimum will be in February. The annual rainy days of projected climate will be lesser than the present condition.

For the current condition and projected climate, the seasonal rainy days of northern coastal plain (AEU2) were examined and given in table 21.

Table 21. Seasonal rainy days under projected climate of northern coastal plain (AEU2) in Thrissur district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	1	7.9	14	338.2	79	2310.4	20	472.2
4.5	2030	2	15.6	14	337.9	69	2978.1	17	462.7
	2050	1	9.8	20	471.4	66	2614.2	19	547.7
	2080	1	4.8	23	472.6	67	2845.3	17	401
8.5	2030	1	7.9	19	344	67	2990.8	17	475.9
	2050	1	7.9	16	464	68	2850.1	17	396.7
	2080	0	2	19	410.9	76	2664	18	422.5

Presently, the maximum number of rainy days occurs during south west monsoon time (79) followed by North East (20), summer season (14) and winter season (1). According to projected climate the highest number of rainy days will occur in South West monsoon period followed by summer season. In the case of summer season the rainfall shows an increasing trend where as in winter season the amount of rainfall shows a decreasing trend compared to the present state.

4.1.2.1.2. High rainfall events of Northern coastal plain (AEU2) in Thrissur district

For the present condition and projected climate, the high rainfall events of northern coastal plain (AEU2) were studied and given in table 22.

Table 22. High rainfall events under projected climate of northern coastal plain (AEU2) in Thrissur district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	2	1	2	0	2	2	1	2	0
	SW monsoon	28	23	7	4	2	28	23	7	4	2
	NW monsoon	11	3	1	0	1	11	3	1	0	1
	Total	**41**	**28**	**9**	**6**	**3**	**41**	**28**	**9**	**6**	**3**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	5	1	0	0	3	3	2	0	0
	SW monsoon	19	22	12	4	5	19	22	11	3	6
	NW monsoon	8	2	1	0	1	8	1	2	0	1
	Total	**30**	**29**	**14**	**4**	**6**	**30**	**26**	**15**	**3**	**7**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	5	3	0	0	2	4	2	0	1
	SW monsoon	17	24	9	3	5	21	21	9	6	5
	NW monsoon	7	5	0	1	1	7	4	0	1	0
	Total	**26**	**34**	**12**	**4**	**6**	**30**	**29**	**11**	**7**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	2	3	0	0	4	5	2	0	0
	SW monsoon	19	21	9	8	4	22	23	14	3	2
	NW monsoon	8	4	0	1	0	7	2	0	1	1
	Total	**34**	**27**	**12**	**9**	**4**	**33**	**30**	**16**	**4**	**3**

In present state, the number of rainfall events occurring is more in the range of 10 to 50 mm and heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present and projected climate based on RCP 4.5 and 8.5 the number of rainfall events shows an increasing trend in the range above 25 mm whereas it shows a decreasing trend below 25 mm.

4.1.2.2. Rainfall analysis of Pokkali lands (AEU5) and impact of projected climate change in Thrissur districts

Pokkali lands, a special agro-ecological unit, depicted for the swamps, regularly beneath sea level, in waterfront regions of Ernakulam locale and stretching out to parts of Thrissur and Alappuzha areas and cover 34 panchayats. This unit covers 39,765 ha (1.02 %) in the state.

4.1.2.2.1. Rainfall and Rainy days of Pokkali lands (AEU5) in Thrissur district

The monthly rainfall distribution of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and presented in table 23.

Table 23. Monthly rainfall distribution under projected climate of Pokkali lands (AEU5) in Thrissur district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	14.6	1	3.2	21.8	2.8	1	0
February	50.4	2.6	7.5	12.8	9.6	2.7	19
March	180.5	15.5	16	18.2	14.8	18.6	14.9
April	401.9	46.1	27.6	11.8	40.5	25	3
May	530.3	477.3	318	228.2	434.9	230.6	347.5
June	776.8	1558.2	1406.6	1328.7	1748.8	1161.2	1090.8
July	702.9	1220.4	1124.2	1243.1	1158.9	1194.9	1117.6
August	455.1	495.5	399.5	420.9	388.5	485.2	474.2
September	234.9	69	8.5	93.7	7.8	94.8	190.1
October	315.2	376.1	442.4	334.9	399.3	319	327.7
November	96.7	35.8	34.8	51.1	40.6	65	42.7
December	15.9	44.1	49.4	42.2	47.5	40.5	65
Total	**3775.2**	**4341.6**	**3837.7**	**3807.4**	**4294**	**3638.5**	**3692.5**

In the present situation, June (776.8 mm) and July (703.9 mm) are the months having maximum amount of rainfall and the lowest in January and December. Based on RCP 4.5 and 8.5 in projected climate there will be a chance of getting high amount of rainfall in June and July as compared to the present climate. But there will be a drastic decrease in rainfall during March, April and September. In projected climate the yearly rainfall will be higher than the present condition.

The month to month rainy days of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were investigated and given in table 24.

Table 24. Monthly rainy days under projected climate of Pokkali lands (AEU5) in Thrissur district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	1	1	1	0	0
February	2	1	1	2	1	0	2
March	5	1	4	2	4	2	3
April	11	3	2	2	2	2	0
May	16	15	15	12	16	13	14
June	22	25	27	26	25	28	25
July	22	29	25	25	27	25	29
August	18	14	13	13	13	14	14
September	9	3	1	5	1	5	7
October	11	11	15	11	11	10	10
November	5	3	4	3	3	4	3
December	1	3	4	4	3	4	6
Total	**123**	**108**	**112**	**106**	**107**	**107**	**113**

In the current condition, June and July have more number of rainy days and it is about 22 days and the lowest is in January and December. According to RCP 4.5 and 8.5, the highest number of rainy days will be happening in June and July and the base will be in January. The projected climate demonstrates a decreasing pattern in the yearly rainy days of Pokkali lands compared with the current condition.

The seasonal rainy days of Pokkali lands (AEU5) for the existing condition and projected climate were examined and given in table 25.

Table 25. Seasonal rainy days under projected climate of Pokkali lands (AEU5) in Thrissur district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	65.1	32	1112.7	71	2169.7	16	427.8
4.5	2030	1	3.6	19	538.9	71	3343.1	17	456
	2050	2	10.7	21	361.6	66	2938.8	23	526.6
	2080	3	34.6	16	258.2	69	3086.4	18	428.2
8.5	2030	2	12.4	22	490.2	66	3304	17	487.4
	2050	0	3.7	17	274.2	72	2936.1	18	424.5
	2080	2	19	17	365.4	75	2872.7	19	435.4

Currently, the maximum number of rainy days occurs during south west monsoon period (71) followed by summer season (32), North East (16) and winter season (3). According to projected climate the highest number of rainy days and high amount of rainfall will get in South west monsoon period and the minimum will be in winter season. Rainfall during summer and winter season shows a drastic decrease in projected climate as compared to the current condition and northeast monsoon rainfall doesn't show much variation.

4.1.2.2.2. High rainfall events of Pokkali lands (AEU5) in Thrissur district

For the present condition and projected climate, the high rainfall events of Pokkali lands (AEU5) were studied and given in table 26.

Table 26. High rainfall events under projected climate of Pokkali lands (AEU5) in Thrissur district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	22	17	6	1	0	22	17	6	1	0
	SW monsoon	20	15	7	1	2	20	15	7	1	2
	NW monsoon	2	1	0	0	0	2	1	0	0	0
	Total	**46**	**33**	**13**	**2**	**2**	**46**	**33**	**13**	**2**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	1	1	1	7	3	2	0	1
	SW monsoon	16	22	11	5	7	15	18	11	4	9
	NW monsoon	8	1	2	0	1	7	2	2	0	1
	Total	**28**	**27**	**14**	**6**	**9**	**29**	**23**	**15**	**4**	**11**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	2	0	1	0	8	0	0	1	0
	SW monsoon	18	17	10	7	5	20	25	7	8	4
	NW monsoon	8	2	2	0	1	6	3	0	1	1
	Total	**32**	**21**	**12**	**8**	**6**	**34**	**28**	**7**	**10**	**5**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	6	1	1	0	0	4	3	2	0	0
	SW monsoon	16	23	10	7	5	23	24	12	4	3
	NW monsoon	6	3	0	1	1	7	2	0	1	1
	Total	**29**	**27**	**11**	**8**	**6**	**34**	**29**	**14**	**5**	**4**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (46) and 25 to 50 mm (33) and heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present and the projected climate there will be a decreasing trend in the number of rainfall events in the range below 50 mm. whereas it shows an increasing trend in the range above 75 mm.

4.1.2.3. Rainfall analysis of Kole lands (AEU6) and impact of projected climate change in Thrissur districts

The Kole Lands agro-ecological unit, spread over the coastal part of Thrissur district and extending to southern coastal parts of Malappuram district covers 40 panchayats. This land is, for most part, below sea level. Seawater ingress into these lands is controlled through barrages and weirs to facilitate rice cultivation. This unit covers 71,142 ha (1.83 %) in the state.

4.1.2.3.1. Rainfall and Rainy days of Kole lands (AEU6) in Thrissur district

The monthly rainfall distribution of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and presented in table 27.

Table 27. Monthly rainfall distribution under projected climate of Kole lands (AEU6) in Thrissur district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3.1	7.8	9.8	0.6	7.7	7.9	0
February	11.9	7.6	0.7	4	0	0	0
March	21.1	6.4	15.9	18.7	15.4	12	13.1
April	98	42.2	15.8	9	44.1	58.9	27.1
May	244.6	283.7	317.5	383.1	276.5	387.4	347.3
June	768.5	1144.5	1472.2	1119.4	1286.9	849.5	779.2
July	630.8	1388.4	1182.9	1113	1200.7	1156.7	1180
August	398.2	406.4	447.7	454.7	451.7	460.1	541.6
September	294.8	7.2	10.7	86.6	9.1	109	185.4
October	351.7	384.8	435.8	267	375.1	241.1	321.7
November	110.1	38.5	63.7	38.5	58.4	60	41.3
December	12.3	42	48.2	55	45.6	47.3	57.9
Total	**2945.1**	**3759.5**	**4020.9**	**3549.6**	**3771.2**	**3389.9**	**3494.6**

In the existing condition June is the wettest month having a rainfall of 768.5 mm and the minimum in January (3.1 mm.). Based on RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during June and July in the projected climate whereas the driest month will be February. Compared to the present condition the rainfall of projected climate will be decreasing during April, September and November. According to RCP 4.5 and 8.5 the yearly rainfall amount shows an increase from the present condition.

The monthly rainy days of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 28.

Table 28. Monthly rainy days under projected climate of Kole lands (AEU6) in Thrissur district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	1	0	1	1	0
February	1	1	0	1	0	0	0
March	1	2	3	4	3	2	2
April	5	3	2	2	3	1	2
May	10	11	14	13	13	14	14
June	24	26	26	27	25	26	26
July	24	28	24	29	27	29	29
August	18	14	14	14	15	13	15
September	13	1	1	5	1	6	7
October	14	11	12	12	10	11	10
November	5	3	4	4	4	4	3
December	1	3	3	5	3	3	5
Total	**117**	**104**	**104**	**116**	**105**	**110**	**113**

In the current condition, June and July have more number of rainy days and it is about 24 days and the lowest is during January, February, March and December. As indicated by RCP 4.5 and 8.5, the maximum rainy days will be in July whereas the minimum will be in January and February. As per RCP 4.5 and 8.5 the projected climate shows a decreasing trend in the annual rainy days from the present condition.

For the current condition and projected climate, the seasonal rainy days of Kole lands (AEU6) were examined and given in table 29.

Table 29. Seasonal rainy days under projected climate of Kole lands (AEU6) in Thrissur district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	1	14.9	16	363.6	80	2092.3	21	474.1
4.5	2030	2	15.4	16	332.3	69	2946.5	17	465.3
	2050	1	10.5	19	349.2	65	3113.5	19	547.7
	2080	1	4.6	19	410.8	75	2773.7	21	360.5
8.5	2030	1	7.7	19	336	68	2948.4	17	479.1
	2050	1	7.9	17	458.3	74	2575.3	18	348.4
	2080	0	0	18	387.5	77	2686.2	18	420.9

Presently, the maximum number of rainy days occurs during south west monsoon season (80) followed by North East (21), summer season (16) and winter season (1). According to projected climate the highest number of rainy days will get in South West monsoon period followed by North east. In the case of summer, winter and north east monsoon period there will be a decreasing trend in the amount of rainfall whereas in southwest monsoon period the rain will get intensified.

4.1.2.3.2. Heavy rainfall events of Kole lands (AEU6) in Thrissur district

The heavy rainfall events of Kole lands for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 30.

Table 30. Heavy rainfall events under projected climate of Kole lands (AEU 6) in Thrissur district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	0	2	1	0	1	0	2	1	0	1
	SW monsoon	32	20	5	3	1	32	20	5	3	1
	NW monsoon	10	5	1	0	0	10	5	1	0	0
	Total	**42**	**27**	**7**	**3**	**2**	**42**	**27**	**7**	**3**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	5	1	0	0	3	3	2	0	0
	SW monsoon	20	21	12	4	5	17	23	12	2	6
	NW monsoon	8	2	1	0	1	8	1	2	0	1
	Total	**31**	**28**	**14**	**4**	**6**	**28**	**27**	**16**	**2**	**7**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	3	1	1	0	4	4	2	0	1
	SW monsoon	18	24	8	2	7	23	25	12	2	3
	NW monsoon	7	5	0	2	0	7	3	1	0	0
	Total	**29**	**32**	**9**	**5**	**7**	**34**	**32**	**15**	**2**	**4**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	4	0	2	0	3	5	2	0	0
	SW monsoon	23	25	12	2	4	23	23	14	3	2
	NW monsoon	7	2	0	0	1	7	2	0	1	1
	Total	**32**	**31**	**12**	**4**	**5**	**33**	**30**	**16**	**4**	**3**

Currently, the number of rainfall events occurring is more in the range of 10 to 50 mm and the heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present with the projected climate there will be a decreasing trend in the number of rainfall events in the range 10 to 25 mm whereas it will show an increasing trend above 25mm.

4.1.2.4. Rainfall analysis of North central laterites (AEU10) and impact of projected climate change in Thrissur districts

The North Central Laterites, agro-ecological unit is delineated to represent midland laterite terrain with longer dry period than its southern counterpart, but less than the one in the north. The unit is spread over 62 panchayats, 3 municipalities and a corporation in Thrissur and Palakkad districts. This unit covers 1, 71, 469 ha (4.41 %) in the state.

4.1.2.4.1. Rainfall and Rainy days of North central laterites (AEU10) in Thrissur district

The monthly rainfall distribution of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 31.

Table 31. Monthly rainfall distribution under projected climate of North central laterites (AEU10) in Thrissur district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0.5	0.5
February	0	3.7	0	8.2	0	0	0
March	0	17	9.4	7.3	12.3	10.6	9.5
April	23.6	5.1	19.3	80.1	20	13.5	6.6
May	236.1	286.9	416.2	290.4	253	340.3	293.9
June	522.9	985.7	1135.2	1058.9	1202.6	1007.3	930.5
July	671.9	985.1	1066.4	978.4	1148.5	1069.6	1152.7
August	705.1	466.9	489.7	478.7	482.4	497.3	573.6
September	195.9	0.3	3.8	3.8	3.7	13.3	19.7
October	303.4	264.3	252.6	254.7	247.9	252.5	240
November	72.1	22.5	45	61.2	44.4	46	19.3
December	21.5	37.2	20.1	49.5	19.2	18.5	17.4
Total	**2752.5**	**3074.7**	**3457.7**	**3271.2**	**3434**	**3269.4**	**3263.7**

Presently, January, February and March are the driest months, having no rainfall and the wettest months are July (671.9 mm.) and August (705.1 mm.). As per RCP 4.5

and 8.5, there will be a probability of getting maximum rainfall during June and July and the lowest rainfall in January and February. Comparing the projected climate and present condition, the amount of rainfall shows a drastic decrease in the month September. In projected climate the amount of yearly rainfall will be higher than that of the present condition.

The monthly rainy days of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 32.

Table 32. Monthly rainy days under projected climate of North central laterites (AEU10) in Thrissur district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	0	0	0	0	0
February	1	1	0	1	0	0	0
March	1	2	2	1	2	1	2
April	5	0	2	3	2	1	1
May	7	11	14	16	12	13	12
June	22	27	25	26	24	26	24
July	23	28	25	28	25	26	26
August	18	15	17	17	17	17	18
September	12	0	1	1	1	2	3
October	12	13	10	10	10	10	10
November	6	4	3	4	3	3	2
December	1	5	3	3	3	3	2
Total	**109**	**106**	**102**	**110**	**99**	**102**	**100**

In the current condition, June (22) and July (23) have the maximum number of rainy days and the lowest is in January, February, March and December. According to RCP 4.5 and 8.5, the maximum rainy days will be in June and July whereas January becomes drier. The annual rainy days of projected climate will be less as compared to the present condition.

For the current condition and projected climate, the seasonal rainy days of North central laterites (AEU10) were examined and presented in table 33.

Table 33. Seasonal rainy days under projected climate of North central laterites (AEU 10) in Thrissur district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	1	15	13	263.7	75	1889.6	18	409.9
4.5	2030	1	3.7	13	309	70	2438	22	324
	2050	0	0	18	444.9	68	2695.1	16	317.7
	2080	1	8.2	20	377.8	72	2519.8	17	365.4
8.5	2030	0	0	16	285.3	67	2837.2	16	311.5
	2050	0	0.5	15	364.4	71	2587.5	16	317
	2080	0	0.5	15	310	71	2676.5	14	276.7

Currently, the maximum number of rainy days occurs during south west monsoon period (75) followed by North East (18), summer season (13) and winter season (1). According to projected climate the highest number of rainy days will get in South West monsoon period and the minimum will be in winter season. As per RCP 4.5 and 8.5, there will be an increase in southwest monsoon and summer rainfall from the present condition whereas in northeast and winter season the rain shows a deceasing trend.

4.1.2.4.2. Heavy rainfall events of North central laterites (AEU10) in Thrissur district

The heavy rainfall events of North central laterites for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 34.

Table 34. Heavy rainfall events under projected climate of North central laterites (AEU 10) in Thrissur district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	1	1	0	1	1	1	1	0	1	1
	SW monsoon	25	18	7	2	2	25	18	7	2	2
	NW monsoon	6	3	2	0	0	6	3	2	0	0
	Total	**32**	**22**	**9**	**3**	**3**	**32**	**22**	**9**	**3**	**3**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	0	3	0	0	5	3	1	0	0
	SW monsoon	23	22	10	4	2	14	22	10	4	4
	NW monsoon	7	1	0	0	1	6	2	0	1	0
	Total	**35**	**23**	**13**	**4**	**3**	**25**	**27**	**11**	**5**	**4**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	3	0	0	6	3	1	1	0
	SW monsoon	11	26	9	6	3	12	25	12	1	4
	NW monsoon	6	2	0	1	0	6	2	0	1	0
	Total	**21**	**32**	**12**	**7**	**3**	**24**	**30**	**13**	**3**	**4**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	5	1	0	0	4	1	3	0	0
	SW monsoon	14	27	11	3	2	18	23	11	4	3
	NW monsoon	9	2	0	1	0	6	2	1	0	0
	Total	**30**	**34**	**12**	**4**	**2**	**28**	**26**	**15**	**4**	**3**

At present the number of rainfall events happening is more in the range of 10 to 50 mm and above 50 mm. the rainfall events is less. In projected climate the number of rainfall events above 25mm shows an increasing trend whereas a decrease will occur below 25 mm based on RCP 4.5 and 8.5.

4.1.2.5. Rainfall analysis of southern high hills (AEU14) and impact of projected climate change in Thrissur districts

The Southern High hills, agro-ecological unit reaching out from Thiruvananthapuram to Nelliyampathy in Palakkad locale has height more than 600 meters. Other than rise, the steep slopes of the terrain and lower temperatures recognize the high hills from the foothills and midlands. Thirty panchayats in Thiruvananthapuram to Palakkad area constitute this unit. This unit covers around 6, 72,675 ha (17.31 %) in the state.

4.1.2.5.1. Rainfall and Rainy days of southern high hills (AEU14) in Thrissur district

The monthly rainfall distribution of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 35.

Table 35. Monthly rainfall distribution under projected climate of southern high hills (AEU 14) in Thrissur district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0.2	20.5	2.7	1.8	1.4	0
February	22	2.8	6.3	13.1	13.1	2.7	1.8
March	58.6	30.4	14	24.7	23.2	33.1	29.8
April	64.4	24.9	22	20.1	17.4	41	13.4
May	262.2	464.7	482.2	437.4	474.4	320.7	232.7
June	308.8	848.4	892.2	1026.7	1208	853.4	1081.1
July	350.2	1086.2	1194.2	1052.4	1019.7	1182.4	1166.7
August	536	631.6	500.9	541.8	633.3	624	610.3
September	243	9	112.1	79.3	9.1	80.4	192
October	335.4	331.5	314.4	326.6	366.3	326.6	338.4
November	205.2	40.6	34.8	35.5	23	35.4	18.6
December	36.4	13.5	61.6	67.1	10.9	63.3	75
Total	**2423.2**	**3483.8**	**3655.2**	**3627.4**	**3800.2**	**3564.4**	**3759.8**

Presently, August is the wettest month having a rainfall of 536 mm and January is the driest month. As per projected climate based on RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during July and the lowest rainfall gets during January. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, April, September and November. As in the case of annual rainfall, the projected climate shows an increasing trend from the present condition.

The monthly rainy days of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 36.

Table 36. Monthly rainy days under projected climate of Southern high hills (AEU14) in Thrissur district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	0	3	1	0	0	0
February	1	0	1	1	1	0	0
March	4	4	3	3	2	5	4
April	7	2	2	2	2	2	2
May	10	18	19	16	19	16	13
June	20	25	25	25	23	25	26
July	22	26	26	24	26	23	28
August	18	16	14	14	15	15	18
September	15	1	6	4	1	4	7
October	20	12	11	11	11	11	11
November	13	3	3	3	3	3	2
December	6	1	6	6	1	6	6
Total	**136**	**108**	**119**	**110**	**104**	**110**	**117**

In the current condition July has the highest number of rainy days and it is about 22 days and the most reduced is in January. According to RCP 4.5 and 8.5, the more number of rainy days will be happening in June and July and the minimum will be in

January and February. The projected climate demonstrates a decreasing pattern in the yearly rainy days contrasted with the current condition.

The seasonal rainy days of Southern high hills (AEU14) for the existing condition and projected climate were examined and given in table 37.

Table 37. Seasonal rainy days under projected climate of Southern high hills (AEU14) in Thrissur district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	62.1	19	370.4	66	1286.2	33	760.8
4.5	2030	0	3	24	520	68	2575.2	16	385.6
	2050	4	26.8	24	518.2	71	2699.4	20	410.8
	2080	2	15.8	21	482.2	67	2700.2	20	429.2
8.5	2030	1	14.9	23	515	65	2870.1	15	400.2
	2050	0	4.1	23	394.8	67	2740.2	20	425.3
	2080	0	1.8	19	275.9	79	3050.1	19	432

At present, the more number of rainy days happens in south west monsoon period (66) followed by North East (33), summer season (19) and winter season (3). As indicated by projected climate the highest number of rainy days and high measure of rainfall will get in South West monsoon period followed by summer season. There will be an extreme abatement in precipitation during winter season and northeast contrasted with the current condition.

4.1.2.5.2. High rainfall events of Southern high hills (AEU14) in Thrissur district

For the present condition and projected climate, the high rainfall events of Southern high hills (AEU14) were studied and given in table 38.

Table 38. High rainfall events under projected climate of Southern high hills (AEU14) in Thrissur district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	4	0	1	0	6	4	0	1	0
	SW monsoon	31	14	3	0	1	31	14	3	0	1
	NW monsoon	10	6	1	0	0	10	6	1	0	0
	Total	**48**	**24**	**4**	**1**	**1**	**48**	**24**	**4**	**1**	**1**
2030	Winter	0	0	0	0	0	1	0	0	0	0
	Summer	6	4	2	1	0	9	1	2	2	0
	SW monsoon	17	23	10	6	2	10	22	11	5	6
	NW monsoon	6	3	1	1	0	3	3	1	0	1
	Total	**29**	**30**	**13**	**8**	**2**	**23**	**26**	**14**	**7**	**7**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	3	3	1	0	9	4	1	0	0
	SW monsoon	21	17	15	3	4	14	22	9	7	4
	NW monsoon	5	3	0	2	0	5	3	0	1	1
	Total	**31**	**23**	**18**	**6**	**4**	**28**	**29**	**10**	**8**	**5**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	10	3	3	0	0	6	2	1	0	0
	SW monsoon	12	22	8	10	3	25	21	13	4	5
	NW monsoon	5	3	0	1	1	7	2	0	1	1
	Total	**28**	**28**	**11**	**11**	**4**	**38**	**25**	**14**	**5**	**6**

At present the number of rainfall events happening is more in the range of 10 to 25 mm. (48) and 25 to 50 mm. (24) and the heavy precipitation which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present with the projected climate based on RCP 4.5 and 8.5, there will be a decreasing pattern in the number of rainfall events below 25 mm. whereas it shows an increasing pattern above 25 mm.

4.1.2.6. Rainfall analysis of Northern high hills (AEU15) and impact of projected climate change in Thrissur districts

The Northern High Hills agro-ecological unit extending from Thrissur to Kannur is similar to its southern counterpart except for the longer dry period. The unit comprises 61 panchayats spread over the northern districts. This unit covers around 5, 28,434 ha (13.60 %) in the state.

4.1.2.6.1. Rainfall and Rainy days of Northern high hills (AEU15) in Thrissur district

The monthly rainfall distribution of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 39.

Table 39. Monthly rainfall distribution under projected climate of Northern high hills (AEU15) in Thrissur district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	8.6	3.8	8.8	1.5	7.6	8	0
February	12.8	7.2	10.9	8.9	0	10.5	7.3
March	18.2	12.6	12.2	17.4	17.6	28.8	18
April	113.5	35.7	15.1	24.2	43.8	37.3	11.2
May	156.7	416.4	325.8	448.1	278.9	207.5	269.5
June	495.5	931.9	1272.5	1035	1149.3	961.9	1089.4
July	579.6	1096.2	1088.7	1106.5	1112.7	1158.5	1087.2
August	370.6	448	459.7	502.6	444.9	535.7	541.5
September	206.8	9	77.5	25.8	34.5	25.8	114.4
October	270	326.1	235	247.6	335.3	246.7	327.6
November	135.4	24.2	19.4	18.9	21.7	18	43.2
December	30.1	42.5	12.9	14.2	11.5	14.6	66.6
Total	**2397.8**	**3353.6**	**3538.5**	**3450.7**	**3457.8**	**3253.3**	**3575.9**

Presently, July is the wettest month having a rainfall of 579.6 mm. and the driest month is January. As per RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during June and July whereas the lowest rainfall gets during January. Comparing the projected climate and present condition, the amount of rainfall shows a drastic decrease in the months April, September and November. In projected climate the amount of yearly rainfall will be higher than the present condition.

The monthly rainy days of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 40.

Table 40. Monthly rainy days under projected climate of Northern high hills (AEU15) in Thrissur district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	1	0	1	1	0
February	1	1	1	2	0	1	1
March	2	2	2	2	2	3	3
April	10	3	2	4	2	2	1
May	11	14	16	16	16	14	15
June	20	24	24	26	24	25	25
July	24	28	25	24	28	25	28
August	20	14	13	14	14	15	15
September	13	1	4	2	2	2	6
October	16	11	10	10	11	10	10
November	9	3	2	2	2	2	2
December	2	4	1	1	1	1	6
Total	**129**	**106**	**101**	**103**	**103**	**101**	**112**

In the current condition July has the maximum number of rainy days and it is about 24 days and the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be in June and July and the minimum will be in January and February. As per RCP 4.5 and 8.5 the projected climate shows a decreasing trend in the annual rainy days compared to the present condition. In nut shell the wet months will be wetter and dry periods will be drier.

For the current condition and projected climate, the seasonal rainy days of Northern high hills (AEU15) were examined and presented in table 41.

Table 41. Seasonal rainy days under projected climate of Northern high hills (AEU 15) in Thrissur district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	2	21.4	22	288.4	77	1652.6	28	435.4
4.5	2030	2	11	19	464.7	67	2485.1	18	392.8
	2050	2	19.7	20	353.1	66	2898.4	13	267.3
	2080	2	10.4	22	489.7	66	2669.9	13	280.7
8.5	2030	1	7.6	20	340.3	68	2741.4	14	368.5
	2050	2	18.5	19	273.6	67	2681.9	13	279.3
	2080	1	7.3	19	298.7	74	2832.5	18	437.4

Presently, the maximum number of rainy days occurs during south west monsoon time (77) followed by North East (28), summer season (22) and winter season (2). According to projected climate the highest number of rainy days will get in South West monsoon followed by summer season. There will be an increasing trend in the amount of rainfall during south west monsoon time and summer season whereas in winter and northeast monsoon period the rainfall shows a decreasing trend.

4.1.2.6.2. Heavy rainfall events of Northern high hills (AEU15) in Thrissur district

The heavy rainfall events of Northern high hills for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 42.

Table 42. Heavy rainfall events under projected climate of Northern high hills (AEU 15) in Thrissur district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	2	0	0	0	7	2	0	0	0
	SW monsoon	24	18	4	2	0	24	18	4	2	0
	NW monsoon	7	0	0	0	0	7	0	0	0	0
	Total	**38**	**20**	**4**	**2**	**0**	**38**	**20**	**4**	**2**	**0**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	6	1	1	0	6	4	1	0	0
	SW monsoon	22	21	12	3	2	19	22	11	4	3
	NW monsoon	6	3	1	1	0	5	3	1	1	0
	Total	**33**	**30**	**14**	**5**	**2**	**30**	**29**	**13**	**5**	**3**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	0	1	0	6	4	0	0	0
	SW monsoon	19	25	11	3	3	19	23	6	7	3
	NW monsoon	4	3	1	0	0	5	3	1	0	0
	Total	**28**	**32**	**12**	**4**	**3**	**30**	**30**	**7**	**7**	**3**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	3	4	0	0	5	1	2	0	0
	SW monsoon	20	23	10	6	2	25	18	13	4	3
	NW monsoon	5	3	1	0	0	6	3	0	1	1
	Total	**31**	**29**	**15**	**6**	**2**	**36**	**22**	**15**	**5**	**4**

Currently, the number of rainfall events happening is more in the range of 10 to 25 mm (38) and 25 to 50 mm (20) and the heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present to the projected climate there will be an increasing trend in the number of rainfall events above 25 mm. whereas a decreasing trend will occur below 25mm.

4.1.3. Rainfall analysis of various AEUs of Palakkad district

The Palakkad district has been divided in to eight agro-ecological units (Fig. 4) such as North central laterites (AEU10), Northern foothills (AEU13), Southern high hills (AEU14), Northern high hills (AEU15), Attappady hills (AEU18), Attappady dry hills (AEU19), Palakkad central plains (AEU22), Palakkad eastern plains (AEU23) and these agro-ecological units covers an area of 86,134 ha.(19.24%), 54,961 ha.(12.28%), 55,452 ha.(12.39%), 54,828 ha.(12.25%), 8872 ha.(1.98%), 18495 ha.(4.13%), 112,957 ha.(25.23%) and 47,049 ha.(10.51%) respectively.

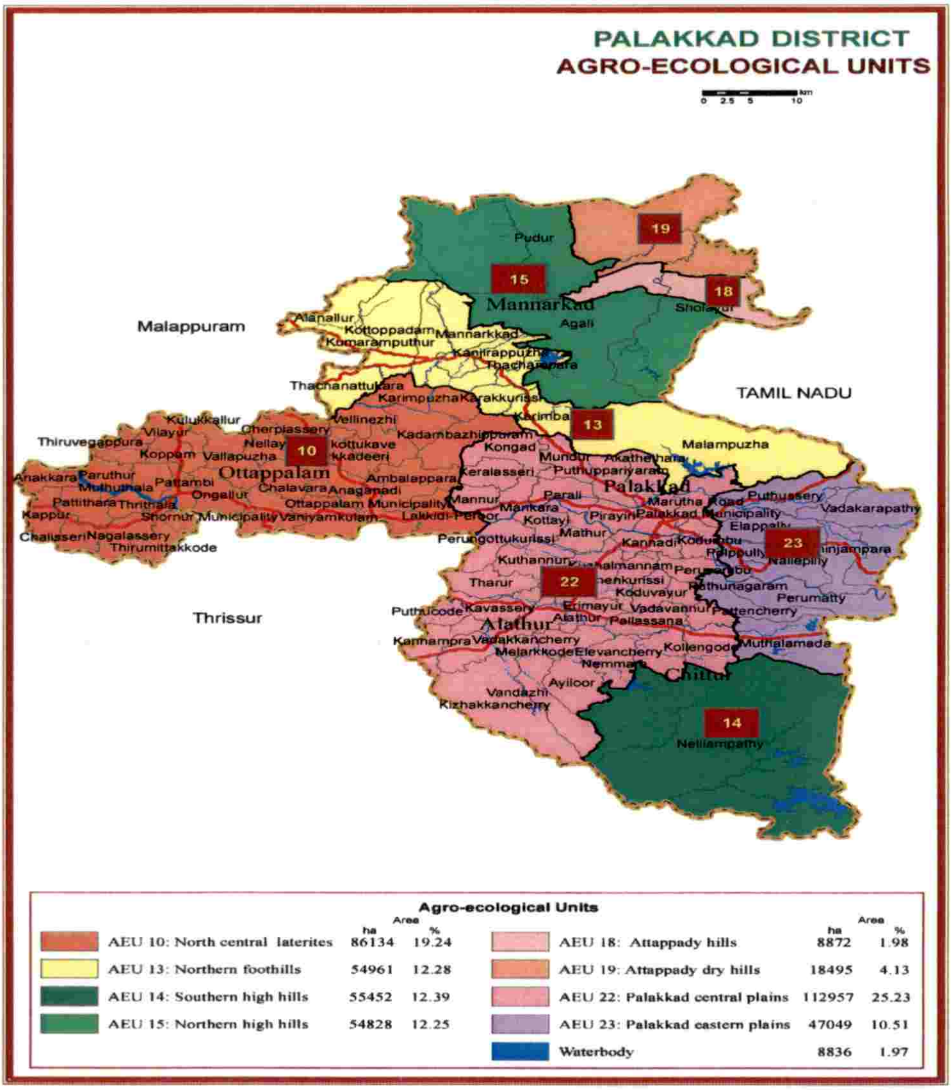

Fig.4 Agro-Ecological Units Map of Palakkad District

4.1.3.1. Rainfall analysis of North central laterites (AEU10) and impact of projected climate change in Palakkad districts

The North Central Laterites agro-ecological unit is delineated to represent midland laterite terrain with longer dry period than its southern counterpart, but less than the one in the north. The unit is spread over 62 panchayats, 3 municipalities and a corporation in Thrissur and Palakkad districts. This unit covers 1, 71, 469 ha (4.41 %) in the state.

4.1.3.1.1. Rainfall and Rainy days of North central laterites (AEU10) in Palakkad district

The monthly rainfall distribution of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 43.

Table 43. Monthly rainfall distribution under projected climate of North central laterites (AEU10) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	5	12.1	0	5.9	0
March	0	6.6	8.6	12.4	10.3	7.2	10.9
April	23.6	44.8	8.7	28	9.2	3.9	9.3
May	236.1	296.2	282.1	228.9	256.5	325.1	258
June	522.9	1060.3	996.5	1050.1	1098.2	864.5	867.9
July	671.9	1121.7	1343.4	1000.5	1144.7	1048.4	1084.7
August	705.1	379.9	441.3	453.4	462.9	473.8	475
September	195.9	3.9	5.1	3.1	2.9	10.3	72.8
October	303.4	236.3	231.8	258.4	253.3	256.2	249.2
November	72.1	16.2	23.3	61.4	44.7	46.1	19
December	21.5	36.8	45.1	50.9	21.3	20.6	18.9
Total	**2752.5**	**3202.7**	**3390.9**	**3159.2**	**3304**	**3062**	**3065.7**

In the current situation July and August are the wettest months, having a rainfall of 671.9 mm and 705.1 mm. and there is no rainfall during the months January, February and March. Based on RCP 4.5 and 8.5, in projected climate the maximum rainfall will get during June and July and the driest months are January and February. Compared to the present condition the rainfall of projected climate will shows a drastic decrease during August and September. In projected climate there will be an increase in yearly rainfall with compared to the present condition.

The monthly rainy days of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 44.

Table 44. Monthly rainy days under projected climate of North central laterites (AEU10) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	0	0	0	0	0
February	1	0	1	2	0	1	0
March	1	1	2	2	2	1	2
April	5	4	1	3	1	1	1
May	7	11	12	13	12	12	12
June	22	25	25	27	25	26	26
July	23	25	25	26	25	26	27
August	18	12	13	15	15	15	15
September	12	1	1	0	0	1	4
October	12	11	10	10	10	10	10
November	6	3	3	4	3	3	2
December	1	4	5	3	3	3	3
Total	**109**	**97**	**98**	**105**	**96**	**99**	**102**

Presently,, June (22) and July (23) have the maximum number of rainy days and the lowest in January, February, March and December. According to RCP 4.5 and 8.5, the maximum rainy days will be in July and there will be no rainy days in January. As per

RCP 4.5 and 8.5 the projected climate shows a decreasing trend in the yearly rainy days from the present condition.

For the current condition and projected climate, the seasonal rainy days of north central laterites (AEU10) were examined and given in table 45.

Table 45. Seasonal rainy days under projected climate of North central laterites (AEU10) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	1	15	13	263.7	75	1889.6	18	409.9
	2030	0	0	16	347.6	63	2565.8	18	289.3
4.5	2050	1	5	15	299.4	64	2786.3	18	300.2
	2080	2	12.1	18	269.3	68	2507.1	17	370.7
	2030	0	0	15	276	65	2708.7	16	319.3
8.5	2050	1	5.9	14	336.2	68	2397	16	322.9
	2080	0	0	15	278.2	72	2500.4	15	287.1

Presently, the maximum number of rainy days occurs during south west monsoon (75) followed by north east (18), summer (13) and winter season (1). According to projected climate the highest number of rainy days will get in south west monsoon followed by north east monsoon period. North east monsoon and winter season shows a decreasing trend in rainfall during projected climate where as in summer season it is increasing.

4.1.3.1.2. High rainfall events of North central laterites (AEU10) in Palakkad district

For the present condition and projected climate, the high rainfall events of north central laterites (AEU10) were studied and given in table 46.

Table 46. High rainfall events under projected climate of north central laterites (AEU10) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	1	1	0	1	1	1	1	0	1	1
	SW monsoon	25	18	7	2	2	25	18	7	2	2
	NE monsoon	6	3	2	0	0	6	3	2	0	0
	Total	**32**	**22**	**9**	**3**	**3**	**32**	**22**	**9**	**3**	**3**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	1	2	1	0	3	3	1	0	0
	SW monsoon	19	23	8	4	4	20	16	9	7	4
	NE monsoon	6	3	1	0	0	6	2	0	1	0
	Total	**28**	**27**	**11**	**5**	**4**	**29**	**21**	**10**	**8**	**4**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	4	1	0	0	4	2	3	0	0
	SW monsoon	19	21	7	7	5	22	17	11	4	2
	NE monsoon	6	3	1	0	0	6	2	0	1	0
	Total	**28**	**28**	**9**	**7**	**5**	**32**	**21**	**14**	**5**	**2**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	2	1	0	0	2	2	2	0	0
	SW monsoon	19	19	11	5	2	29	17	11	3	3
	NE monsoon	7	4	0	1	0	5	3	1	0	0
	Total	**32**	**25**	**12**	**6**	**2**	**36**	**22**	**14**	**3**	**3**

Presently, the number of rainfall events occurring is more in the range of 10 to 25 mm (32) and rainfall which is in the range 25 to 100 mm the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 25 mm per day whereas the heavy rainfall events in the range of 25 to 100 mm. shows an increasing trend. In projected climate there will be slight variations in rainfall events in the range of more than 100 mm

4.1.3.2. Rainfall analysis of Northern foothills (AEU13) and impact of projected climate change in Palakkad districts

The Northern Foothills agro-ecological unit represents foothills from Thrissur to Kasaragod and differs from its southern counterpart for longer dry period. It covers 27 panchayats of Palakkad, Malappuram, Kannur and Kasaragod districts. This unit covers 1,44,181 ha (3.71 %) in the state.

4.1.3.2.1. Rainfall and Rainy days of Northern foothills (AEU13) in Palakkad district

The monthly rainfall distribution of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and presented in table 47.

Table 47. Monthly rainfall distribution under projected climate of Northern foothills (AEU13) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1.7	0	0	0	0	0	0
February	11.3	0	0	0	0	0	0
March	33.4	35.5	10.3	15	20.3	40.6	28.6
April	114.8	20.6	10.2	34.3	24	35.6	8.1
May	165.1	189.1	256.3	346.1	280.8	265.8	272.6
June	515.2	722.5	824.4	883.3	769.9	621.3	695
July	571.9	1083.3	1093.4	1097.7	1005.1	1035.5	913.2
August	332	451	477	510.1	468.5	540	568.9
September	266.8	2.7	8.8	7.3	8.7	7.2	61
October	371	245.5	254.8	265.1	249.5	264.2	280.8
November	158.5	42.2	57.9	61	57.3	44.3	45.2
December	18.3	22.1	40.3	50.3	40.6	56.7	64.4
Total	**2560**	**2814.5**	**3033.4**	**3270.2**	**2924.7**	**2911.2**	**2937.8**

In present situation, June and July are the months having maximum amount of rainfall and the lowest in January. April, September and November is getting sufficient amount of rainfall where as in projected climate there will be a drastic decrease during these months. Based on RCP 4.5 and 8.5 in projected climate there will be a chance of getting high amount of rainfall in July and the driest months are January and February. The amount of yearly rainfall going to occur will be higher than the present condition.

The month to month rainy days of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were investigated and given in table 48.

Table 48. Monthly rainy days under projected climate of Northern foothills (AEU13) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	0	0	0	0	0
February	1	0	0	0	0	0	0
March	2	3	2	3	2	3	5
April	6	2	2	4	2	2	2
May	8	13	11	14	14	14	9
June	20	23	23	24	23	23	23
July	23	27	25	24	26	24	26
August	17	15	14	14	15	15	16
September	12	0	1	1	1	1	3
October	16	10	10	10	10	10	10
November	7	3	4	4	4	3	3
December	1	3	3	3	3	4	5
Total	**114**	**99**	**95**	**101**	**100**	**99**	**102**

In the current condition, July has more number of rainy days and it is around 23 days and the lowest is in January, February and December. According to RCP 4.5 and 8.5, the highest number of rainy days will be happening in July and the base will be in

January and February. September also shows a decline in the number of rainy days. The projected climate demonstrates a decreasing pattern in the yearly rainy days of Northern foothills compared with the current condition.

The seasonal rainy days of Northern foothills (AEU13) for the existing condition and projected climate were examined and given in table 49.

Table 49. Seasonal rainy days under projected climate of Northern foothills (AEU13) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	1	13	16	313.3	72	1685.8	24	547.8
4.5	2030	0	0	18	245.2	65	2259.5	16	309.8
	2050	0	0	15	276.8	63	2403.6	17	353
	2080	0	0	21	395.4	63	2498.4	17	376.4
8.5	2030	0	0	18	325.1	65	2252.2	17	347.4
	2050	0	0	19	342	63	2204	17	365.2
	2080	0	0	16	309.3	68	2238.1	18	390.4

Currently, the maximum number of rainy days occurs during south west monsoon period (72days) followed by North East (24 days), summer season (16 days) and winter season (1 day). According to projected climate the highest number of rainy days and high amount of rainfall will get in South west monsoon. There will be no rainy days occurring in winter season. In projected climate there will be a decreasing trend in rainfall during northeast monsoon period and summer season.

4.1.3.2.2. High rainfall events of Northern foothills (AEU13) in Palakkad district

For the present condition and projected climate, the high rainfall events of Northern foothills (AEU13) were studied and given in table 50.

Table 50. High rainfall events under projected climate of Northern foothills (AEU13) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	3	0	0	0	3	3	0	0	0
	SW monsoon	25	24	9	1	1	25	24	9	1	1
	NW monsoon	7	2	0	0	1	7	2	0	0	1
	Total	**35**	**29**	**9**	**1**	**2**	**35**	**29**	**9**	**1**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	3	0	0	0	8	3	1	0	0
	SW monsoon	22	15	13	3	1	23	16	11	3	2
	NW monsoon	6	2	0	1	0	8	2	0	1	0
	Total	**35**	**20**	**13**	**4**	**1**	**39**	**21**	**12**	**4**	**2**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	3	1	0	0	8	4	1	0	0
	SW monsoon	20	16	10	4	4	20	17	5	9	1
	NW monsoon	8	2	0	1	0	7	3	0	1	0
	Total	**30**	**21**	**11**	**5**	**4**	**35**	**24**	**6**	**10**	**1**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	3	2	0	0	2	2	1	1	0
	SW monsoon	17	19	8	6	4	20	21	6	3	3
	NW monsoon	6	5	0	1	0	7	3	0	1	0
	Total	**28**	**27**	**10**	**7**	**4**	**29**	**26**	**7**	**5**	**3**

Currently the number of rainfall events occurring is more in the range of 10 to 50 mm (64). But in the case of heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present to the projected climate based on RCP 4.5 and 8.5 there will be a decreasing trend in the number of rainfall events in the range of 10 to 50 mm whereas heavy rainfall events shows an increasing trend.

4.1.3.3. Rainfall analysis of Southern high hills (AEU14) and impact of projected climate change in Palakkad districts

The Southern High Hills agro-ecological unit extending from Thiruvananthapuram to Nelliyampathy in Palakkad district has elevation more than 600 meters. Besides elevation, the steep slopes of the terrain and lower temperatures distinguish the high hills from the foothills and midlands. Thirty panchayats in Thiruvananthapuram to Palakkad district constitute this unit. This unit covers 6, 72, 675 ha (17.31 %) in the state.

4.1.3.3.1. Rainfall and Rainy days of Southern high hills (AEU14) in Palakkad district

The monthly rainfall distribution of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and presented in table 51.

Table 51. Monthly rainfall distribution under projected climate of Southern high hills (AEU14) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	31	19.6	20.6	15.8	18.3	18
February	22	4.8	17.3	15.8	5.3	5.4	30
March	58.6	26.5	37.3	29.2	17.4	17.3	42.3
April	64.4	28.5	31.1	31.3	36.3	37.9	66.5
May	262.2	147.5	154.5	181.1	155.3	150.8	110.6
June	308.8	653.6	688.1	579.7	516.5	561.1	447.9
July	350.2	663.2	586.5	643.1	623.3	546.4	750.6
August	536	487.8	549.7	552.4	448.3	482.8	495.8
September	243	1.1	9.9	10.4	36.6	72.7	28.8
October	335.4	235.8	253.8	269	248.2	274.8	267.6
November	205.2	41.1	44.3	47.1	109.1	121.3	38.7
December	36.4	85.6	86.5	94.5	108	107.6	87.4
Total	**2423.2**	**2406.5**	**2478.6**	**2474.2**	**2320.1**	**2396.4**	**2384.2**

In the existing condition August is the wettest month having a rainfall of 536 mm and driest month is January. Based on RCP 4.5 and 8.5 in the projected climate, there will be a probability of getting maximum rainfall during June and July and the lowest in February. Compared to the present condition the rainfall of projected climate will shows a decline during September and November whereas in January there will be a drastic increase. Annual rainfall in projected climate will be less compared to the current condition. According to RCP 4.5 the total rainfall shows slight increase in 2050 and 2080.

The monthly rainy days of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 52.

Table 52. Monthly rainy days under projected climate of Southern high hills (AEU14) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	2	1	1	1	1	1
February	1	1	2	2	1	1	1
March	4	3	4	3	3	3	3
April	7	1	1	3	3	5	6
May	10	11	10	10	11	10	9
June	20	22	23	22	22	23	23
July	22	25	24	25	26	25	25
August	18	17	17	16	18	15	20
September	15	0	1	1	1	3	2
October	20	10	11	11	9	9	10
November	13	4	4	4	5	5	4
December	6	7	7	7	6	6	5
Total	**136**	**103**	**105**	**105**	**106**	**106**	**109**

In the current condition, July has the highest number of rainy days and it is about 22 days and the lowest is in January. As indicated by RCP 4.5 and 8.5, the maximum rainy days will be in July and the minimum will be in January. As per RCP 4.5 and 8.5, the annual rainy days of projected climate shows a decreasing pattern from the present condition.

For the current condition and projected climate, the seasonal rainy days of Southern high hills (AEU14) were examined and given in table 53.

Table 53. Seasonal rainy days under projected climate of Southern high hills (AEU14) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	3	62.1	19	370.4	66	1286.2	33	760.8
4.5	2030	3	35.8	15	202.5	64	1805.7	21	362.5
	2050	3	36.9	15	222.9	65	1834.2	22	384.6
	2080	3	36.4	16	241.6	64	1785.6	22	410.6
8.5	2030	2	21.1	17	209	67	1624.7	20	465.3
	2050	2	23.7	18	206	66	1663	20	503.7
	2080	2	48	18	219.4	70	1723.1	19	393.7

Presently, the maximum number of rainy days occurs during south west monsoon season (66 days) followed by North East (33 days), summer season (19 days) and winter season (3 days). According to projected climate the highest number of rainy days will get in South West monsoon followed by North east. Based on RCP 4.5 and 8.5 in projected climate, the amount of rainfall during northeast monsoon period, summer season and winter season shows a decreasing trend.

4.1.3.3.2. Heavy rainfall events of Southern high hills (AEU14) in Palakkad district

The heavy rainfall events of Southern high hills for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 54.

Table 54. Heavy rainfall events under projected climate of Southern high hills (AEU 14) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	4	0	1	0	6	4	0	1	0
	SW monsoon	31	14	3	0	1	31	14	3	0	1
	NE monsoon	10	6	1	0	0	10	6	1	0	0
	Total	**48**	**24**	**4**	**1**	**1**	**48**	**24**	**4**	**1**	**1**
2030	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	6	2	0	0	0	7	1	0	0	0
	SW monsoon	18	18	6	2	1	24	16	6	2	0
	NE monsoon	6	3	0	1	0	9	3	0	2	0
	Total	**32**	**23**	**6**	**3**	**1**	**41**	**20**	**6**	**4**	**0**
2050	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	6	3	0	0	0	7	1	0	0	0
	SW monsoon	17	19	5	3	1	24	16	5	3	0
	NE monsoon	6	3	0	0	1	8	4	0	2	0
	Total	**31**	**25**	**5**	**3**	**2**	**40**	**21**	**5**	**5**	**0**
2080	Winter	2	0	0	0	0	1	1	0	0	0
	Summer	9	1	0	0	0	9	1	0	0	0
	SW monsoon	22	16	7	3	0	19	20	8	1	0
	NE monsoon	7	3	0	0	1	9	3	0	0	1
	Total	**40**	**20**	**7**	**3**	**1**	**38**	**25**	**8**	**1**	**1**

At present, the number of rainfall events which is in the range 25 to more than 100 mm (32) is less whereas it is high in the range of 10 to25 mm (48). Comparing the present with the projected climate there will be a decreasing trend in the number of rainfall events in the range of 10 to25 mm. In the case of heavy rainfall the number of rainfall events shows an increasing trend.

4.1.3.4. Rainfall analysis of Northern high hills (AEU15) and impact of projected climate change in Palakkad districts

The Northern High Hills agro-ecological unit extending from Thrissur to Kannur is similar to its southern counterpart except for the longer dry period. This unit comprises 61 panchayats spread over the northern districts. This unit covers around 5, 28,434 ha (13.60 %) in the state.

4.1.3.4.1. Rainfall and Rainy days of Northern high hills (AEU15) in Palakkad district

The monthly rainfall distribution of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 55.

Table 55. Monthly rainfall distribution under projected climate of Northern high hills (AEU15) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	8.6	0	11.2	2.5	0	11	18.8
February	12.8	7.2	16.9	15.7	9.9	16.8	12.6
March	18.2	18.2	15.9	18.5	25.2	16.6	12.6
April	113.5	2.4	23.3	60.4	0.4	34.3	14.9
May	156.7	235	94.1	108.2	332.7	119.5	129.1
June	495.5	272.7	297.4	354.8	412.5	324.5	295.5
July	579.6	556.8	506.9	425.2	511.1	509.6	671.8
August	370.6	411.1	380.6	386	393.2	391.4	355
September	206.8	42.6	80.9	82	47.8	82.2	66.2
October	270	236.5	269.6	283.5	212.7	244.3	200.7
November	135.4	12.3	146.9	144.3	24.1	185.2	96.7
December	30.1	27.5	55.3	25.3	32.3	54.5	48.7
Total	**2397.8**	**1822.3**	**1899**	**1906.4**	**2001.9**	**1989.9**	**1922.6**

Presently, January (8.6 mm.) is the month having low rainfall and the wettest month is (579.6 mm.). As per RCP 4.5 and 8.5, there will be a decreasing trend in rainfall during April, June, July, September and November whereas in August there will be an increase. As per RCP 4.5 and 8.5 the total rainfall shows a decreasing pattern as compared to the present climate.

The monthly rainy days of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 56.

Table 56. Monthly rainy days under projected climate of Northern high hills (AEU15) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	2	1	0	2	1
February	1	1	1	1	2	1	2
March	2	3	2	2	3	2	2
April	10	0	2	4	0	3	2
May	11	9	8	10	11	9	7
June	20	20	14	18	18	18	18
July	24	22	24	22	21	23	26
August	20	18	18	18	19	19	18
September	13	2	4	4	3	4	4
October	16	8	12	13	8	12	10
November	9	1	4	4	3	5	4
December	2	4	7	4	4	7	4
Total	**129**	**88**	**98**	**101**	**92**	**105**	**98**

In the current condition, July has the maximum number of rainy days and it is about 24 days and the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be in July and the minimum in January. In projected climate April and September shows a strong decrease in rainy days. The annual rainy days of projected climate will be less as compared to the present condition.

For the current condition and projected climate, the seasonal rainy days of Northern high hills (AEU15) were examined and presented in table 57.

Table 57. Seasonal rainy days under projected climate of Northern high hills (AEU 15) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	2	21.4	22	288.4	77	1652.6	28	435.4
4.5	2030	1	7.2	12	255.6	62	1283.2	13	276.3
	2050	3	28.1	12	133.3	60	1265.8	23	471.8
	2080	2	18.2	16	187.1	62	1248	21	453.1
8.5	2030	2	9.9	14	358.3	61	1364.6	15	269.1
	2050	3	27.8	14	170.4	64	1307.7	24	484
	2080	3	31.4	11	156.6	66	1388.5	18	346.1

Currently, the maximum number of rainy days occurs during south west monsoon time (77 days) followed by North East (28 days), summer season (22 days) and winter season (2 days). According to projected climate the highest number of rainy days will get in South West monsoon followed by north east. As per RCP 4.5 and 8.5, there will be a decrease in rainy days and rainfall during south west monsoon period and summer season from the present condition. As per RCP 4.5 and 8.5, in winter season and northeast monsoon period rainfall shows an increase during 2050s and 2080s.

4.1.3.4.2. Heavy rainfall events of Northern high hills (AEU15) in Palakkad district

The heavy rainfall events of Northern high hills for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 58.

Table 58. Heavy rainfall events under projected climate of Northern high hills (AEU 15) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	2	0	0	0	7	2	0	0	0
	SW monsoon	24	18	4	2	0	24	18	4	2	0
	NE monsoon	7	0	0	0	0	7	0	0	0	0
	Total	**38**	**20**	**4**	**2**	**0**	**38**	**20**	**4**	**2**	**0**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	1	2	0	0	3	5	2	0	0
	SW monsoon	25	18	1	1	0	22	17	2	2	0
	NE monsoon	6	0	1	1	0	6	2	1	0	0
	Total	**35**	**19**	**4**	**2**	**0**	**31**	**24**	**5**	**2**	**0**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	3	1	0	0	0	6	1	0	0	0
	SW monsoon	27	12	4	1	0	29	10	6	0	0
	NE monsoon	5	3	2	1	0	5	3	2	1	0
	Total	**36**	**16**	**6**	**2**	**0**	**41**	**14**	**8**	**1**	**0**
2080	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	5	1	0	0	0	3	2	0	0	0
	SW monsoon	27	12	3	1	0	29	17	1	0	1
	NE monsoon	3	3	1	2	0	6	1	1	1	0
	Total	**36**	**16**	**4**	**3**	**0**	**39**	**20**	**2**	**1**	**1**

At present the number of rainfall events happening is more in the range of 10 to 50 mm (58). Comparing the present with the projected climate based on RCP 8.5 there will be an increase in the rainfall events in the range of 10 to 25 mm. during 2050 and 2080. Totally, the rainfall events occurring in the range 10 to more than 100 mm. shows a decreasing trend.

4.1.3.5. Rainfall analysis of Attappady hills (AEU18) and impact of projected climate change in Palakkad districts

The agro-ecological unit Attappady Hills spatially distributed as a narrow strip of land along the valley in central part of the hills in North Palakkad represents land areas of comparatively low rainfall. It comprises parts of Sholayur and Agali panchayats. This unit covers 8,872 ha (0.23 %) in the state.

4.1.3.5.1. Rainfall and Rainy days of Attappady hills (AEU18) in Palakkad district

The monthly rainfall distribution of Attappady hills (AEU18) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 59.

Table 59. Monthly rainfall distribution under projected climate of Attappady hills (AEU 18) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	21	7.5	11	12.6	10.5	10.8	11.1
February	37.8	17.5	4.5	17.8	17.4	4.5	0
March	112.7	8.9	14.9	13.1	15.6	15.2	13.4
April	132.3	16.5	33.3	12.4	22.3	17.3	32.1
May	107	60.5	108.4	93.2	77.7	100.6	79.1
June	96	230	203	317.7	265.2	216.6	282.8
July	141.2	342.8	428.1	410.3	349.2	397	470.6
August	219.5	268.6	249.8	244.6	232.1	239.7	279.4
September	279.5	76.6	78.7	72.8	77.8	86	90.8
October	201.3	249.8	260.4	276.1	295.7	266.2	231.3
November	116.3	136	152.5	143.8	137.8	152.1	68.3
December	28.6	58.6	29.5	48.3	56.6	29.4	30.5
Total	**1493.2**	**1473.3**	**1574.1**	**1662.7**	**1557.9**	**1535.4**	**1589.4**

Presently, August and September are the wettest months; having a rainfall of 219.5 mm. and 279.5 mm. and the lowest in January (21 mm.). As per projected climate based on RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during

July and the minimum in January. During the months March, April and September there will be a drastic decrease in the amount of rainfall. As in the case of annual rainfall, the projected climate shows an increasing trend from the present condition.

The monthly rainy days of Attappady hills (AEU18) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 60.

Table 60. Monthly rainy days under projected climate of Attappady hills (AEU18) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	2	1	1	2	2	1	1
February	3	1	1	1	1	1	0
March	8	1	2	2	2	2	2
April	8	1	3	3	2	1	2
May	8	7	8	9	7	7	5
June	8	13	15	15	14	16	18
July	10	19	19	18	19	20	22
August	15	16	15	14	13	14	14
September	16	5	6	5	5	6	7
October	12	10	10	11	11	11	10
November	7	4	4	3	4	4	5
December	3	8	5	4	7	5	4
Total	**100**	**86**	**89**	**87**	**87**	**88**	**90**

At present, August (15) and September (16) have more number of rainy days and the minimum in January (3). According to RCP 4.5 and 8.5, the highest number of rainy days will be happening in July and the base will be in February. The projected climate demonstrates a decreasing pattern in the yearly rainy days of Attappady hills (AEU18) compared with the current condition.

The seasonal rainy days of Attappady hills (AEU18) for the existing condition and projected climate were examined and given in table 61.

Table 61. Seasonal rainy days under projected climate of Attappady hills (AEU18) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	5	58.8	24	352	49	736.3	23	346.2
4.5	2030	2	25	9	85.9	53	918	22	444.4
	2050	2	15.5	13	156.6	55	959.6	19	442.4
	2080	3	30.4	14	118.7	52	1045.4	18	468.2
8.5	2030	3	27.9	11	115.6	51	924.3	22	490.1
	2050	2	15.3	10	133.1	56	939.3	20	447.7
	2080	1	11.1	9	124.6	61	1123.6	19	330.1

At present, the highest number of rainy days happens in south west monsoon period (46 days) followed by summer season (24 days), North east (23 days) and winter season (5 days). As indicated by RCP 4.5 and 8.5 the most elevated number of rainy days and high measure of rainfall will get in South West monsoon period followed by North East monsoon in projected climate. There will be an extreme abatement in precipitation in winter season and summer season when compared with the current condition.

4.1.3.5.2. High rainfall events of Attappady hills (AEU18) in Palakkad district

For the present condition and projected climate, the high rainfall events of Attappady hills (AEU14) were studied and given in table 62.

Table 62. High rainfall events under projected climate of Attappady hills (AEU18) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	1	1	0	0	6	1	1	0	0
	SW monsoon	11	10	0	0	0	11	10	0	0	0
	NE monsoon	1	1	0	0	0	1	1	0	0	0
	Total	**18**	**12**	**1**	**0**	**0**	**18**	**12**	**1**	**0**	**0**
2030	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	3	0	0	0	0	2	1	0	0	0
	SW monsoon	23	8	2	0	0	21	11	1	0	0
	NE monsoon	7	1	4	0	0	7	2	4	0	0
	Total	**34**	**9**	**6**	**0**	**0**	**31**	**14**	**5**	**0**	**0**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	1	0	0	0	4	1	0	0	0
	SW monsoon	22	10	2	0	0	21	11	1	0	0
	NE monsoon	7	2	2	1	0	7	2	2	1	0
	Total	**35**	**13**	**4**	**1**	**0**	**32**	**14**	**3**	**1**	**0**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	4	0	0	0	0	3	1	0	0	0
	SW monsoon	20	10	3	1	0	24	13	1	1	0
	NE monsoon	10	2	2	1	0	6	3	1	0	0
	Total	**35**	**12**	**5**	**2**	**0**	**33**	**17**	**2**	**1**	**0**

At present the number of rainfall events happening in the range of 10 to 50mm is high and there is no rainfall event in the range 75 to more than 100 mm. As indicated by RCP 4.5 and 8.5 the projected climate shows an increasing trend in the high and low rainfall events compared with present climate. In projected climate there will be no rainfall events in the range of more than 100 mm.

4.1.3.6. Rainfall analysis of Attappady dry hills (AEU19) and impact of projected climate change in Palakkad districts

The Attappady Dry Hills unit represents land areas of very low rainfall and dry period around eight months in a year. This unit in the north-eastern corner of Palakkad district comprises parts of Puthur, Agali and Sholayur panchayats. This unit covers 18,495 ha (0.48 %) in the state.

4.1.3.6.1. Rainfall and Rainy days of Attappady dry hills (AEU19) in Palakkad district

The monthly rainfall distribution of Attappady dry hills (AEU19) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 63.

Table 63. Monthly rainfall distribution under projected climate of Attappady dry hills (AEU19) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	10.5	12.6	22.1	23.1	7	21.4	10.4
February	17.5	6	12.8	12.5	20.6	23	20.3
March	54.6	27.5	19.3	19.7	15.8	15.4	29.1
April	92	81.2	53.1	54	38.8	39.7	66.6
May	73.5	123.8	85.8	85.2	104.9	117.5	74.5
June	67.1	284	262.8	264.1	317.7	337.7	303.1
July	101.7	387.2	478.3	476	458.9	511.1	574.1
August	152.7	329.1	376.2	370.6	422.2	428	371.4
September	183.3	49.7	66.8	66.3	23	75	56.4
October	127.1	217.1	193.8	192.1	226.4	268.1	249.9
November	72.6	29.7	129.1	128	18	25.6	25.3
December	14.5	12.3	77.4	80	13.4	54.9	8.1
Total	**967.1**	**1560.2**	**1777.5**	**1771.6**	**1666.7**	**1917.4**	**1789.2**

Presently, September is the wettest month having a rainfall of 183.3 mm. and driest month is January (10.5 mm.). As per RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during July and August and the lowest in January and February. Comparing the projected climate and present condition, the amount of rainfall shows a drastic decrease in the month September where as in May and October it increases. In projected climate the amount of yearly rainfall will be higher than the present condition.

The monthly rainy days of Attappady dry hills (AEU19) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 64.

Table 64. Monthly rainy days under projected climate of Attappady dry hills (AEU19) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	2	2	1	3	1
February	2	1	2	2	1	1	2
March	4	3	2	2	2	1	2
April	5	4	4	4	5	2	4
May	5	6	5	5	8	6	5
June	6	21	19	19	19	19	19
July	8	24	24	24	23	24	24
August	11	20	12	12	20	16	19
September	13	3	3	3	2	3	4
October	10	7	7	7	9	8	7
November	5	4	7	7	1	3	3
December	2	3	5	5	2	4	2
Total	**72**	**97**	**92**	**92**	**93**	**90**	**92**

In the current condition, maximum rainy days are occurring in September (13) and lowest is in January (1).According to RCP 4.5 and 8.5, the maximum rainy days will be in July and the minimum will be in January and February. September shows a drastic decline in the number of rainy days. As per RCP 4.5 and 8.5 the projected climate shows an increasing trend in the annual rainy days compared to the present condition.

For the current condition and projected climate, the seasonal rainy days of Attappady dry hills (AEU19) were examined and presented in table 65.

Table 65. Seasonal rainy days under projected climate of Attappady dry hills (AEU 19) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	3	28.1	14	220.2	39	504.7	16	214.2
4.5	2030	2	18.6	13	232.5	68	1050	14	259.1
	2050	4	34.9	11	158.2	58	1184.1	19	400.3
	2080	4	35.6	11	158.9	58	1177	19	400.1
8.5	2030	2	27.6	15	159.5	64	1221.8	12	257.8
	2050	4	44.4	9	172.6	62	1351.8	15	348.6
	2080	3	30.7	11	170.2	66	1305	12	283.3

Presently, the maximum number of rainy days occurs during south west monsoon time (39 days) followed by North East (16 days), summer season (14 days) and winter season (3 days). In projected climate as per RCP 4.5 and 8.5 the south west monsoon period shows a drastic increase in rainfall whereas in summer and winter season the rainfall will decrease. But in the case of north east monsoon period there will be a slight increase in the amount of rainfall compared to the existing condition.

4.1.3.6.2. Heavy rainfall events of Attappady dry hills (AEU15) in Palakkad district

The heavy rainfall events of Attappady dry hills for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 66.

Table 66. Heavy rainfall events under projected climate of Attappady dry hills (AEU 19) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	1	0	0	1	0	1	0	0	1	0
	SW monsoon	10	4	0	0	0	10	4	0	0	0
	NE monsoon	0	1	0	0	0	0	1	0	0	0
	Total	**11**	**5**	**0**	**1**	**0**	**11**	**5**	**0**	**1**	**0**
2030	Winter	0	0	0	0	0	1	0	0	0	0
	Summer	8	2	0	0	0	7	0	0	0	0
	SW monsoon	26	11	2	0	0	27	12	5	0	0
	NE monsoon	5	1	0	0	1	5	1	0	0	1
	Total	**39**	**14**	**2**	**0**	**1**	**40**	**13**	**5**	**0**	**1**
2050	Winter	1	0	0	0	0	2	0	0	0	0
	Summer	5	2	0	0	0	5	2	0	0	0
	SW monsoon	24	10	5	0	0	26	16	4	1	0
	NE monsoon	9	2	1	1	0	6	1	0	2	0
	Total	**39**	**14**	**6**	**1**	**0**	**39**	**19**	**4**	**3**	**0**
2080	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	5	2	0	0	0	6	2	0	0	0
	SW monsoon	24	10	5	0	0	25	16	2	0	1
	NE monsoon	9	2	1	1	0	3	3	0	0	1
	Total	**39**	**14**	**6**	**1**	**0**	**35**	**21**	**2**	**0**	**2**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm (11) and heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present and the projected climate there will be an increasing trend in the number of rainfall events in the range 10 to more than 100 mm.

4.1.3.7. Rainfall analysis of Palakkad central plains (AEU22) and impact of projected climate change in Palakkad districts

The Palakkad Central Plain agro-ecological unit is delineated to represent the land areas of moderate rainfall and dry period around five months in the Palakkad plain. It is transitional to the drier Eastern Plain and humid western parts (AEU 10). This unit comprises 37 panchayats spread over Alathur, Chittur and Palakkad taluks and the Palakkad Municipality. The unit covers around 1, 12,957 ha (2.91 %) in the state.

4.1.3.7.1. Rainfall and Rainy days of Palakkad central plains (AEU22) in Palakkad district

The monthly rainfall distribution of Palakkad central plains (AEU22) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 67.

Table 67. Monthly rainfall distribution under projected climate of Palakkad central plains (AEU22) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	143.8	8.1	4.2	1	0.5	3.9	0
February	126.6	0	0	0	0	0	0
March	114.7	8.7	10.6	12.4	17.2	7.5	18.9
April	164.2	2.4	37.4	61.5	3.4	25	19.5
May	214.8	196.3	290.9	251	199.7	235.4	158.5
June	233	1066.4	706.2	629.1	1015.6	786.2	759.5
July	302.4	914.1	1086.8	1051.8	964.5	1031	1038.7
August	222.3	445.1	466.7	497.4	437.7	497.2	561.5
September	177.1	2.7	9	7.6	2.7	7.4	14
October	197	218.9	227.9	237.8	223.3	237.6	255.8
November	158.1	40.2	42.3	59	42	42.2	42.2
December	132.1	24.6	20.2	49.1	19	20.5	53.8
Total	**2186.1**	**2927.5**	**2902.2**	**2857.7**	**2925.6**	**2893.9**	**2922.4**

In the existing condition July is the wettest month, having a rainfall of 302.4 mm. Every month is getting an amount of rainfall greater 100mm. Based on RCP 4.5 and 8.5; there will be a probability of getting maximum rainfall during June and July in the projected climate. There will be a severe reduction in the amount of rainfall during the months January, February, March, April, September, November and December. The projected climate shows an increasing trend in annual rainfall compared with the current condition.

The monthly rainy days of Palakkad central plains (AEU22) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 68.

Table 68. Monthly rainy days under projected climate of Palakkad central plains (AEU22) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	6	1	1	0	0	1	0
February	6	0	0	0	0	0	0
March	5	2	2	2	3	1	3
April	7	0	3	1	0	2	2
May	9	10	11	10	11	9	8
June	12	24	21	24	25	26	23
July	13	25	25	24	26	24	27
August	11	15	15	14	15	15	17
September	8	0	1	1	0	1	2
October	10	10	10	10	10	10	10
November	7	3	3	4	3	3	3
December	5	3	3	3	3	3	4
Total	**99**	**93**	**95**	**93**	**96**	**95**	**99**

Currently, the maximum numbers of rainy days are occurring in July (13) and the minimum in March (5) and December (5). Comparing with the present condition the projected climate as per RCP 4.5 and 8.5 the highest number of rainy days will happen during June and July and the lowest in January and February. In projected climate April and September shows a drastic decrease in the number of rainy days. Future climate shows a decrease in rainy days compared with the current condition.

For the current condition and projected climate, the seasonal rainy days of Palakkad central plains (AEU22) were examined and given in table 69.

Table 69. Seasonal rainy days under projected climate of Palakkad central plains (AEU22) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	12	270.4	22	493.8	44	934.8	22	487.2
4.5	2030	1	8.1	12	207.4	64	2428.3	16	283.7
	2050	1	4.2	16	338.9	62	2268.7	16	290.4
	2080	0	1	13	324.9	63	2185.9	17	345.9
8.5	2030	0	0.5	14	238.1	66	2219	16	282.1
	2050	1	3.9	12	267.9	66	2321.8	16	300.3
	2080	0	0	13	196.9	69	2373.7	17	351.8

At present, the maximum numbers of rainy days are occurring in south west monsoon period (44) and minimum in winter season (12). In projected climate based on RCP 4.5 and 8.5 the maximum rainfall will get in south west monsoon period. In projected climate the summer season and north east monsoon period shows a decreasing trend from the present state whereas in winter season a severe decrease in rainfall will happen.

4.1.3.7.2. High rainfall events of Palakkad central plains (AEU22) in Palakkad district

For the present condition and projected climate, the high rainfall events of Palakkad central plain (AEU22) were studied and given in table 70.

Table 70. High rainfall events under projected climate of Palakkad central plain (AEU22) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	15	6	1	2	1	15	6	1	2	1
	Summer	7	1	0	0	1	7	1	0	0	1
	SW monsoon	2	0	0	0	0	2	0	0	0	0
	NE monsoon	7	11	2	1	1	7	11	2	1	1
	Total	**31**	**18**	**3**	**3**	**3**	**31**	**18**	**3**	**3**	**3**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	3	0	0	0	7	0	1	0	0
	SW monsoon	21	15	8	6	3	21	16	11	2	4
	NE monsoon	6	2	1	0	0	6	2	1	0	0
	Total	**30**	**20**	**9**	**6**	**3**	**34**	**18**	**13**	**2**	**4**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	3	0	1	0	4	3	1	0	0
	SW monsoon	18	16	12	2	3	21	17	8	3	4
	NE monsoon	6	2	0	1	0	6	2	0	1	0
	Total	**30**	**21**	**12**	**4**	**3**	**31**	**22**	**9**	**4**	**4**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	1	1	0	4	1	1	0	0
	SW monsoon	24	14	9	5	2	25	16	5	7	3
	NE monsoon	8	3	0	1	0	8	2	0	1	0
	Total	**37**	**19**	**10**	**7**	**2**	**37**	**19**	**6**	**8**	**3**

Currently the number of rainfall events occurring is more in the range of 10 to 50 mm and heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present to the projected climate there will be an increasing trend in the number of rainfall events in the range 10 to more than 100 mm.

4.1.3.8. Rainfall analysis of Palakkad eastern plains (AEU23) and impact of projected climate change in Palakkad districts

The Palakkad Eastern Plain agro-ecological unit is delineated to represent the drier parts of Palakkad plain in the gap region of Western Ghats, having low rainfall, long dry period and fertile soils. The unit comprises 11 panchayats in eastern Palakkad .This unit covers 47,049 ha (1.21 %) in the state.

4.1.3.8.1. Rainfall and Rainy days of Palakkad eastern plains (AEU23) in Palakkad district

The monthly rainfall distribution of Palakkad eastern plains (AEU23) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 71.

Table 71. Monthly rainfall distribution under projected climate of Palakkad eastern plains (AEU23) in Palakkad district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0.9	0	14.5	5.3	0	0	0
February	13.9	0	0	0	0	0	0
March	22.7	15.6	12.9	17.5	13	16.5	26.8
April	59.3	13	11.9	6	11.2	15.2	9.8
May	91.3	250.6	149.8	129.9	146.6	172.7	251.4
June	276.4	291.2	353.8	581.2	350.9	390.2	329.3
July	412	599.9	503.3	491.3	494.3	465	557.8
August	221.7	356.3	338.8	345.1	338.6	416	486.9
September	127.4	4.1	0.3	0.3	0.1	0.3	0.1
October	162.7	170.4	165.7	168.9	164.8	167.4	237.3
November	104.4	50.9	30	30.9	30	30	5.8
December	16.1	42.7	63	69	64	63	68.2
Total	**1508.8**	**1794.7**	**1644**	**1845.4**	**1613.5**	**1736.3**	**1973.4**

At present the monthly rainfall is high in the month July (412 mm.) and the lowest is in January (0.9 mm.). As per RCP 4.5 and 8.5, in projected climate July will be the months having maximum rainfall and there will be an extreme decline in rainfall during February, September and November. In May the projected climate shows an increasing pattern of rainfall. In projected climate the annual rainfall will be higher than the present condition.

The monthly rainy days of Palakkad eastern plains (AEU23) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 72.

Table 72. Monthly rainy days under projected climate of Palakkad eastern plains (AEU23) in Palakkad district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	2	1	0	0	0
February	1	0	0	0	0	0	0
March	1	2	2	3	3	2	3
April	3	2	1	1	1	2	2
May	4	10	12	13	12	11	12
June	15	19	21	22	21	21	21
July	21	25	28	27	28	28	26
August	15	14	14	14	14	16	19
September	8	0	0	0	0	0	0
October	10	10	10	10	10	10	9
November	5	3	2	2	2	2	1
December	1	5	6	6	6	6	9
Total	**85**	**90**	**98**	**99**	**97**	**98**	**102**

In the current condition, July has the maximum number of rainy days (21) and the minimum is in January, February, March and December. According to RCP 4.5 and 8.5, the maximum rainy days will be in July and the minimum in February. As per RCP 4.5 and 8.5 the projected climate shows an increasing trend in the annual rainy days compared with the present condition.

For the current condition and projected climate, the seasonal rainy days of Palakkad eastern plains (AEU23) were examined and given in table 73.

Table 73. Seasonal rainy days under projected climate of Palakkad eastern plains (AEU23) in Palakkad district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	1	14.8	9	173.3	59	1037.6	16	283.2
4.5	2030	0	0	14	279.2	58	1251.5	18	264
	2050	2	14.5	16	174.6	63	1196.2	18	258.7
	2080	1	5.3	17	153.4	63	1417.9	18	268.8
8.5	2030	0	0	16	170.8	63	1183.9	18	258.8
	2050	0	0	15	204.4	65	1271.5	18	260.4
	2080	0	0	17	288	66	1374.1	19	311.3

At present climate the maximum number of rainy days are getting in south west monsoon (59) followed by north east monsoon (16), summer (9) and winter season (1). In projected climate based on RCP 4.5 and 8.5 there will be a slight increase in the amount of rainfall during south west monsoon, north east and summer season compared with the present climate. In the case of winter season, there will be a drastic decrease in the amount of rainfall.

4.1.3.8.2. High rainfall events of Palakkad eastern plains (AEU23) in Palakkad district

For the present condition and projected climate, the high rainfall events of Palakkad eastern plains (AEU23) were studied and given in table 74.

Table 74. High rainfall events under projected climate of Palakkad eastern plains (AEU23) in Palakkad district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	2	0	1	0	2	2	0	1	0
	SW monsoon	20	10	7	2	0	20	10	7	2	0
	NE monsoon	6	3	0	0	0	6	3	0	0	0
	Total	**28**	**15**	**7**	**3**	**0**	**28**	**15**	**7**	**3**	**0**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	3	1	0	0	2	2	0	0	0
	SW monsoon	24	13	4	0	0	30	12	1	0	1
	NE monsoon	6	1	0	1	0	6	1	0	1	0
	Total	**35**	**17**	**5**	**1**	**0**	**38**	**15**	**1**	**1**	**1**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	2	0	0	0	2	2	1	0	0
	SW monsoon	30	12	1	0	1	33	12	2	0	1
	NE monsoon	7	0	0	1	0	7	0	0	1	0
	Total	**39**	**14**	**1**	**1**	**1**	**42**	**14**	**3**	**1**	**1**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	0	0	0	0	5	2	0	1	0
	SW monsoon	26	15	4	0	1	25	17	4	1	0
	NE monsoon	7	0	0	1	0	6	2	0	1	0
	Total	**40**	**15**	**4**	**1**	**1**	**36**	**21**	**4**	**3**	**0**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm (28) and 25 to 50 mm (15) and heavy rainfall which is in the range 50 to more than 100 mm (10) the number of rainfall events is less. Comparing the present to the projected climate there will be an increasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows a decreasing trend.

4.1.4. Rainfall analysis of various AEUs of Malappuram district

The Malappuram district has divided in to five agro-ecological units (Fig. 5) such as Northern coastal plains (AEU2), Kole lands (AEU6), Northern laterites (AEU11), Northern foothills (AEU13), Northern high hills (AEU15) and these units covers an area of 20,941 ha.(5.89%), 14,562 ha.(4.10%), 1,58,936 ha.(44.71%), 36,539 ha.(10.28%) and 1,20,545 ha.(33.91%) respectively.

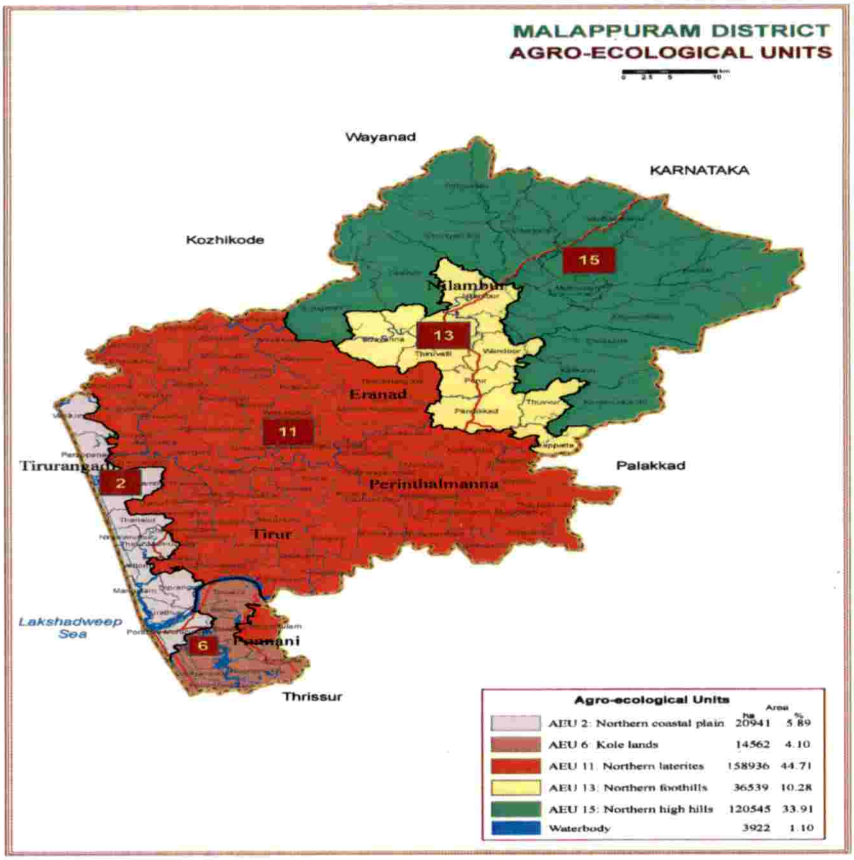

Fig.5 Agro-Ecological Units Map of Malappuram District

4.1.4.1. Rainfall analysis of Northern coastal plains (AEU2) and impact of projected climate change in Malappuram districts

The Northern Coastal Plain agro-ecological unit represents the coastal plain north of Ernakulam district and comprises 77 panchayats along the coast from Thrissur till the northern end of the state. This unit covers around 1, 22,970 ha (3.16 %) in the state.

4.1.4.1.1. Rainfall and Rainy days of Northern coastal plains (AEU2) in Malappuram district

The monthly rainfall distribution of Northern coastal plains (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 75.

Table 75. Monthly rainfall distribution under projected climate of Northern coastal plains (AEU2) in Malappuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	2.1	3	3.7	30.3	1.3	1.5	0
February	5.9	0	0	0	0	0	0
March	23.1	12.9	5.9	33.1	14	14.7	18.8
April	82.8	39.9	10.8	37.7	63.6	7.9	15.2
May	232.2	299	458.3	284.2	394.8	339.5	419.7
June	841.5	941.6	1007.4	748.6	1026.7	1080.9	875.7
July	788.7	1182.9	1220.7	1285.7	1162.5	1153.4	1145.9
August	408.8	444	477.9	386	441.3	383.4	438.8
September	271.4	197.9	201.7	148.1	199.8	81.5	179.5
October	323.1	264.8	270.4	247	293.5	243.8	315.5
November	130.1	29.3	9.4	14.6	49.5	14.6	64.8
December	19	41	27.3	9	41.6	8.8	39.3
Total	**3128.7**	**3456.3**	**3693.5**	**3224.3**	**3688.6**	**3330**	**3513.2**

In the present situation, June is the month having maximum amount of rainfall about 841.5 mm. and the lowest rainfall is in January and February. Based on RCP 4.5 and 8.5 in projected climate there will be a chance of getting high amount of rainfall in June and July as compared to the present climate. There will be a decline in rainfall during February and November. As per RCP 4.5 and 8.5 the amount of yearly rainfall going to occur will be higher than the present condition.

The month to month rainy days of Northern coastal plains (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were investigated and given in table 76.

Table 76. Monthly rainy days under projected climate of Northern coastal plains (AEU2) in Malappuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	1	2	0	0	0
February	1	0	0	0	0	0	0
March	1	2	0	3	3	2	3
April	4	4	1	2	5	1	4
May	9	13	14	13	13	13	13
June	23	26	26	25	27	26	25
July	25	29	29	29	29	29	29
August	19	13	14	12	13	12	13
September	12	4	4	6	4	5	7
October	12	14	14	11	9	11	10
November	6	5	1	2	4	2	4
December	1	5	4	1	3	1	4
Total	**113**	**116**	**108**	**106**	**110**	**102**	**112**

In the current condition, July has more number of rainy days and it is around 25 days and the lowest is in January, February, March and December. According to RCP 4.5 and 8.5, the highest number of rainy days will be happening in June and July and no rainy days are happening in February. The projected climate demonstrates a slight decrease in the yearly rainy days contrasted with the current condition. According to RCP 4.5 there will be small increase in the number of rainy days in 2030 from the present condition.

The seasonal rainy days of Northern coastal plains (AEU2) for the existing condition and projected climate were examined and given in table 77.

Table 77. Seasonal rainy days under projected climate of Northern coastal plains (AEU2) in Malappuram district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	1	7.9	14	338.2	79	2310.4	20	472.2
4.5	2030	1	3	19	351.8	72	2766.4	24	335.1
	2050	1	3.7	15	475	73	2907.7	19	307.1
	2080	2	30.3	18	355	72	2568.4	14	270.6
8.5	2030	0	1.3	21	472.4	73	2830.3	16	384.6
	2050	0	1.5	16	362.1	72	2699.2	14	267.2
	2080	0	0	20	453.7	74	2639.9	18	419.6

Currently, the maximum number of rainy days occurs during south west monsoon period (79days) followed by North East (20 days), summer season (14 days) and winter season (1 day). According to projected climate the highest number of rainy days and high amount of rainfall will get in South west monsoon followed by North East. There will be least number of rainy days occurring in winter season. There will be an increasing pattern in rainfall during south west and summer season as compared to the current condition. There will be a decreasing trend in the north east monsoon rainfall compared with the current condition.

4.1.4.1.2. High rainfall events of Northern coastal plains (AEU2) in Malappuram district

For the present condition and projected climate, the high rainfall events of Northern coastal plains (AEU2) were studied and given in table 78.

Table 78. High rainfall events under projected climate of Northern coastal plains (AEU2) in Malappuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	2	1	2	0	2	2	1	2	0
	SW monsoon	28	23	7	4	2	28	23	7	4	2
	NE monsoon	11	3	1	0	1	11	3	1	0	1
	Total	**41**	**28**	**9**	**6**	**3**	**41**	**28**	**9**	**6**	**3**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	5	1	0	0	8	3	3	0	0
	SW monsoon	17	22	17	4	2	21	17	14	7	3
	NE monsoon	7	1	0	0	1	6	3	0	0	1
	Total	**29**	**28**	**18**	**4**	**3**	**35**	**23**	**17**	**7**	**4**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	2	2	2	0	4	3	2	0	0
	SW monsoon	22	18	13	5	5	24	19	13	4	3
	NE monsoon	5	1	0	0	1	4	3	1	0	0
	Total	**31**	**21**	**15**	**7**	**6**	**32**	**25**	**16**	**4**	**3**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	5	6	1	0	0	4	3	0	2	0
	SW monsoon	23	24	13	1	3	28	18	14	2	3
	NE monsoon	4	3	1	0	0	7	2	0	1	1
	Total	**33**	**33**	**15**	**1**	**3**	**39**	**23**	**14**	**5**	**4**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm (41) and 25 to 50 mm (28) and heavy rainfall which is in the range 50 to more than 100 mm (18) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events in the range of 50 to 100 mm. shows an increasing trend. In projected climate there will be slight variations in rainfall events in the range of more than 100 mm.

4.1.4.2. Rainfall analysis of Kole lands (AEU6) and impact of projected climate change in Malappuram districts

The Kole Lands agro-ecological unit, spread over the coastal part of Thrissur district and extending to southern coastal parts of Malappuram district covers 40 panchayats. This unit covers 71,142 ha (1.83 %) in the state.

4.1.4.2.1. Rainfall and Rainy days of Kole lands (AEU6) in Malappuram district

The monthly rainfall distribution of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and presented in table 79.

Table 79. Monthly rainfall distribution under projected climate of Kole lands (AEU6) in Malappuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3.1	0	1.5	1.5	1.8	1.6	7.7
February	11.9	0	0	0	0	0	0
March	21.1	14.9	11.2	21.4	12.4	14.7	9.6
April	98	87.1	25.7	65.9	28.1	9.2	15.9
May	244.6	289.4	328.6	312.5	334.4	296.7	270.9
June	768.5	1084.1	1021.7	1068.7	1367.8	1161.4	832.8
July	630.8	1035.1	1307.3	1056.1	1310.2	1065.1	1006.1
August	398.2	431.7	400.2	377.9	367.2	425.8	492.9
September	294.8	196.6	81.4	77.5	6.7	78.4	214
October	351.7	264.2	247.2	243.6	276	227.6	241.6
November	110.1	33.9	14.8	14.4	15.8	21.4	19.5
December	12.3	60.5	8.5	8.5	9.2	14.9	14.6
Total	**2945.1**	**3497.5**	**3448.1**	**3248**	**3729.6**	**3316.8**	**3125.6**

In the existing condition June and July are the wettest months; having a rainfall of 768.5 mm and 630 mm. and the lowest is in January (3.1 mm.). Based on RCP 4.5 and

8.5, there will be a probability of getting maximum rainfall during June and July in the projected climate. And the driest month will be February. Compared to the present condition the rainfall of projected climate shows a drastic decrease during February and November. According to RCP 4.5 and 8.5 there will be an increase in the yearly rainfall from the present condition.

The monthly rainy days of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 80.

Table 80. Monthly rainy days under projected climate of Kole land (AEU6) in Malappuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	0	0	0	0	1
February	1	0	0	0	0	0	0
March	1	2	1	3	2	3	2
April	5	4	3	3	4	2	2
May	10	12	13	13	12	12	11
June	24	28	28	27	26	27	26
July	24	29	25	28	28	27	25
August	18	14	12	12	12	13	18
September	13	4	5	5	1	5	5
October	14	14	11	11	13	10	10
November	6	6	2	2	2	2	2
December	1	7	1	1	1	2	1
Total	**118**	**120**	**101**	**105**	**101**	**103**	**103**

In the current condition, June and July have more number of rainy days and it is 24 days and the lowest is in January, February, March and December. As indicated by RCP 4.5 and 8.5, in projected climate the maximum rainy days will be in July and there will be a declining trend in January and February. The annual rainy days of projected climate shows a decreasing pattern from the present condition whereas in 2030 as per RCP 4.5 there will be a slight increase.

For the current condition and projected climate, the seasonal rainy days of Kole lands (AEU6) were examined and given in table 81.

Table 81. Seasonal rainy days under projected climate of Kole lands (AEU6) in Malappuram district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	1	15	16	363.6	80	2092.3	21	474.1
4.5	2030	0	0	18	391.4	75	2747.5	27	358.6
	2050	0	1.5	17	365.5	70	2810.6	14	270.5
	2080	0	1.5	19	399.8	72	2580.2	14	266.5
8.5	2030	0	1.8	18	374.9	67	3051.9	16	301
	2050	0	1.6	17	320.6	72	2730.7	14	263.9
	2080	1	7.7	15	296.4	74	2545.8	13	275.7

Presently, the maximum number of rainy days occurs during south west monsoon season (80 days) followed by North East (21 days), summer season (16 days) and winter season (1 day). According to projected climate the highest number of rainy days will get in South West monsoon followed by summer season. In the case of winter season there will be a great decrease in the amount of rainfall. But as per RCP 4.5 and 8.5 the rain during summer shows a slight increase from the present state but in the case of north east monsoon there will be a decreasing trend in rainfall amount.

4.1.4.2.2. Heavy rainfall events of Kole lands (AEU6) in Malappuram district

The heavy rainfall events of Kole lands for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 82.

Table 82. High rainfall events under projected climate of Kole lands (AEU 6) in Malappuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	0	2	1	0	1	0	2	1	0	1
	SW monsoon	32	20	5	3	1	32	20	5	3	1
	NE monsoon	10	5	1	0	0	10	5	1	0	0
	Total	**42**	**27**	**7**	**3**	**2**	**42**	**27**	**7**	**3**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	1	2	2	1	0	5	1	2	1	0
	SW monsoon	19	22	9	6	4	19	20	12	5	4
	NE monsoon	8	1	0	0	1	5	3	1	0	0
	Total	**28**	**25**	**11**	**7**	**5**	**29**	**24**	**15**	**6**	**4**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	2	1	1	0	3	4	0	1	0
	SW monsoon	18	24	7	6	5	25	21	11	1	6
	NE monsoon	4	3	1	0	0	4	3	1	0	0
	Total	**28**	**29**	**9**	**7**	**5**	**32**	**28**	**12**	**2**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	5	0	1	0	4	1	1	1	0
	SW monsoon	24	18	13	2	4	21	24	13	2	2
	NE monsoon	4	3	1	0	0	6	2	1	0	0
	Total	**33**	**26**	**14**	**3**	**4**	**31**	**27**	**15**	**3**	**2**

At present, the number of rainfall events occurring is more in the range of 10 to 25 mm (42) and 25 to 50 mm (27) and heavy rainfall which is > 50 mm, the number of rainfall events is less (12). Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 25 mm per day whereas the heavy rainfall events in the range of 25 to more than 100 mm. shows an increasing trend.

4.1.4.3. Rainfall analysis of Northern laterites (AEU11) and impact of projected climate change in Malappuram districts

The Northern Laterites agro-ecological unit is delineated to represent midland laterites from Malappuram to Kasaragod districts experiencing long dry period. It is spread over 163 panchayats and 6 municipalities. This unit covers around 4, 60,257 ha. (12.36 %) in the state.

4.1.4.3.1. Rainfall and Rainy days of Northern laterites (AEU11) in Malappuram district

The monthly rainfall distribution of Northern laterites (AEU11) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 83.

Table 83. Monthly rainfall distribution under projected climate of Northern laterites (AEU11) in Malappuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3.3	0	0	1.2	0	0	0
February	4.9	0	0	0	0	0	0
March	24.6	11.9	18.8	19.6	16.9	17.5	16.1
April	99.4	43.5	31.6	44	10.3	26.3	28.3
May	192.8	367.4	265.2	317.7	443.6	213.7	323.1
June	762.9	907.6	1115	1125.6	932.9	1109.2	954.5
July	771.5	1194.4	1167.3	1083.2	1153.9	1301.4	1016.6
August	403.2	465.9	533.5	554.2	515.8	550.8	521.3
September	276.2	0.4	2.8	3.4	2.9	3.4	32.9
October	337	251.5	300	311.7	296.5	307.7	395.7
November	146.7	36.9	38.5	26.2	38.2	40.1	41
December	31.9	40.7	42.4	47.8	42.7	43.5	54.1
Total	**3054.4**	**3320.2**	**3515.1**	**3534.6**	**3453.7**	**3613.6**	**3383.6**

Presently, June (762.9 mm.) and July (771.5 mm.) are the months having maximum rainfall and lowest during January (3.3 mm.). As per RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during June and July. And there will be a decline in rainfall during January and February. Comparing the projected climate and present condition, the rainfall distribution shows a drastic decrease in the months September and November. There will be a chance of high rainfall during May. As per RCP 4.5 and 8.5 the total rainfall shows an increasing trend from the present condition.

The monthly rainy days of Northern laterites (AEU11) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 84.

Table 84. Monthly rainy days under projected climate of Northern laterites (AEU11) in Malappuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	0	0	0	0	0
February	1	0	0	0	0	0	0
March	1	3	2	3	3	4	3
April	4	5	2	2	2	2	3
May	8	15	11	14	14	13	12
June	22	27	26	26	26	27	25
July	25	29	28	25	29	25	25
August	19	14	15	15	15	15	16
September	13	0	1	1	1	1	2
October	14	10	9	9	9	9	10
November	7	3	3	3	3	3	3
December	1	3	3	6	3	3	5
Total	**116**	**109**	**100**	**104**	**105**	**102**	**104**

In the current condition, the minimum rainy days are occurring during January, February, March and December and the highest is in July. According to RCP 4.5 and 8.5, the maximum rainy days will be in July and the chance of occurrence of rainy days in

January and February will be zero. As per RCP 4.5 and 8.5 the projected climate shows a decreasing trend in the annual rainy days compared to the present condition.

For the current condition and projected climate, the seasonal rainy days of Northern laterites (AEU11) were examined and presented in table 85.

Table 85. Seasonal rainy days under projected climate of Northern laterites (AEU 11) in Malappuram district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	1	8.2	13	316.8	79	2213.8	22	515.6
4.5	2030	0	0	23	422.8	70	2568.3	16	329.1
	2050	0	0	15	315.6	70	2818.6	15	380.9
	2080	0	1.2	19	381.3	67	2766.4	18	385.7
8.5	2030	0	0	19	470.8	71	2605.5	15	377.4
	2050	0	0	19	257.5	68	2964.8	15	391.3
	2080	0	0	18	367.5	68	2525.3	18	490.8

Presently, the maximum number of rainy days occurs during south west monsoon time (79 days) followed by North East (22 days), summer season (13 days) and winter season (1 day). According to projected climate as per RCP 4.5 and 8.5 the south west monsoon rain shows an increasing trend. The north east monsoon and winter rain shows a decreasing trend from the present condition whereas in summer season there will be a small increase in the amount of rainfall compared to the existing condition.

4.1.4.3.2. Heavy rainfall events of Northern laterites (AEU11) in Malappuram district

The heavy rainfall events of Northern laterites for the existing condition and projected climate based on RCP 4.5 and 8.5 were examined and presented in table 86.

Table 86. Heavy rainfall events under projected climate of Northern laterites (AEU 11) in Malappuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	0	1	1	0	4	0	1	1	0
	SW monsoon	26	23	7	6	1	26	23	7	6	1
	NE monsoon	8	3	1	1	1	8	3	1	1	1
	Total	**38**	**26**	**9**	**8**	**2**	**38**	**26**	**9**	**8**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	2	0	0	4	4	2	1	0
	SW monsoon	24	18	13	2	4	20	20	14	2	5
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**35**	**23**	**15**	**2**	**5**	**30**	**27**	**16**	**3**	**6**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	5	2	1	0	0
	SW monsoon	19	21	14	5	3	17	18	12	5	5
	NE monsoon	6	3	0	0	1	6	3	0	0	1
	Total	**30**	**26**	**16**	**5**	**4**	**28**	**23**	**13**	**5**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	3	3	0	0	5	1	2	1	0
	SW monsoon	19	14	11	5	6	18	19	9	5	4
	NE monsoon	5	3	0	0	1	8	3	0	0	2
	Total	**27**	**20**	**14**	**5**	**7**	**31**	**23**	**11**	**6**	**6**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm (38) and 25 to 50 mm (26) and heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events in the range of 50 to more than 100 mm shows an increasing trend.

4.1.4.4. Rainfall analysis of Northern foothills (AEU13) and impact of projected climate change in Malappuram districts

The Northern Foothills agro-ecological unit represents foothills from Thrissur to Kasaragod and differs from its southern counterpart for longer dry period. It covers 27 panchayats of Palakkad, Malappuram, Kannur and Kasargod districts. This unit covers 1, 44, 181 ha (3.71 %) in the state.

4.1.4.4.1. Rainfall and Rainy days of Northern foothills (AEU13) in Malappuram district

The monthly rainfall distribution of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 87.

Table 87. Monthly rainfall distribution under projected climate of Northern foothills (AEU13) in Malappuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1.7	0.6	7.9	0	8.6	2.9	0
February	11.3	0	0	0	0	0	0
March	33.4	6.1	14.3	19.6	5.5	9.7	18.6
April	114.8	100.9	17.2	16.5	17.4	36.6	7.1
May	165.1	297	284.8	306	332.4	276.4	175.7
June	515.2	846	865.8	710.3	925.1	900.9	1108.3
July	571.9	1189.4	1191.8	1091.1	1077.7	1152.1	1082
August	332	545.4	450.5	466.3	544.7	487.8	614.4
September	266.8	6.6	28.3	29.2	6.7	29.6	37.2
October	371	294.2	209.6	216.8	229.3	208.5	307.5
November	158.5	24.7	39.1	41.4	32.7	22.6	34
December	18.3	34.7	19.4	14	37.6	44.1	53
Total	**2560**	**3345.6**	**3128.7**	**2911.2**	**3217.7**	**3171.2**	**3437.8**

In the existing condition June and July are the wettest months, having a rainfall of 515.2 mm. and 571.9 mm. and the driest month is January. Based on RCP 4.5 and 8.5; there will be a probability of getting maximum rainfall during July in the projected climate. There will be a severe reduction in the amount of rainfall during the months February, March, September and November. As per RCP 4.5 and 8.5 there will be an increase in the yearly rainfall distribution with the current state.

The monthly rainy days of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 88.

Table 88. Monthly rainy days under projected climate of Northern foothills (AEU13) in Malappuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	1	0	1	1	0
February	1	0	0	0	0	0	0
March	2	1	1	3	0	1	3
April	6	4	3	2	3	2	1
May	8	16	15	14	15	14	9
June	20	26	24	25	25	24	21
July	23	29	28	25	29	25	25
August	17	15	14	14	15	15	17
September	12	1	2	2	2	2	2
October	16	12	8	8	7	7	8
November	7	4	3	3	3	2	3
December	1	4	3	2	3	5	5
Total	**114**	**112**	**102**	**98**	**103**	**98**	**94**

Currently the maximum numbers of rainy days are occurring in July (23) and the minimum in January, February and December. Comparing with the present condition the projected climate as per RCP 4.5 and 8.5 the highest number of rainy days will happen during June and July and the lowest in January and February. In projected climate the annual rainy days shows a decreasing trend.

For the current condition and projected climate, the seasonal rainy days of Northern foothills (AEU13) were examined and given in table 89.

Table 89. Seasonal rainy days under projected climate of Northern foothills (AEU13) in Malappuram district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	1	13	16	313.3	72	1685.8	24	547.8
4.5	2030	0	0.6	21	404	71	2587.4	20	353.6
	2050	1	7.9	19	316.3	68	2536.4	14	268.1
	2080	0	0	19	342.1	66	2296.9	13	272.2
8.5	2030	1	8.6	18	355.3	71	2554.2	13	299.6
	2050	1	2.9	17	322.7	66	2570.4	14	275.2
	2080	0	0	13	201.4	65	2841.9	16	394.5

At present, the maximum numbers of rainy days are occurring in south west monsoon period and the minimum in winter season. In projected climate based on RCP 4.5 and 8.5 the maximum rainfall will get in south west monsoon period. In projected climate the rain during north east monsoon period and winter season shows a decreasing trend where as in summer season it shows an increasing trend.

4.1.4.4.2. High rainfall events of Northern foothills (AEU13) in Malappuram district

For the present condition and projected climate, the high rainfall events of Northern foothills (AEU13) were studied and given in table 90.

Table 90. High rainfall events under projected climate of Northern foothills (AEU13) in Malappuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	3	0	0	0	3	3	0	0	0
	SW monsoon	25	24	9	1	1	25	24	9	1	1
	NE monsoon	7	2	0	0	1	7	2	0	0	1
	Total	**35**	**29**	**9**	**1**	**2**	**35**	**29**	**9**	**1**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	10	2	2	0	0	3	1	1	0	1
	SW monsoon	18	18	12	3	5	23	19	12	4	3
	NE monsoon	7	1	0	0	1	6	1	0	0	1
	Total	**35**	**21**	**14**	**3**	**6**	**32**	**21**	**13**	**4**	**5**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	3	1	0	0	4	4	1	0	0
	SW monsoon	20	21	12	3	3	20	17	12	5	3
	NE monsoon	5	2	0	1	0	5	2	0	1	0
	Total	**29**	**26**	**13**	**4**	**3**	**29**	**23**	**13**	**6**	**3**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	9	3	1	0	0	3	3	0	0	0
	SW monsoon	21	19	11	4	2	18	20	17	3	3
	NE monsoon	5	2	0	1	0	6	3	0	0	1
	Total	**35**	**24**	**12**	**5**	**2**	**27**	**26**	**17**	**3**	**4**

At present the number of rainfall events occurring is more in the range of 10 to 25 mm (35) and 25 to 50 mm (29) and heavy rainfall which is in the range 50 to more than 100 mm (12) the number of rainfall events is less. Comparing the present to the projected climate there will be an increasing trend in the heavy rainfall events whereas it shows a decreasing trend in the number of rainfall events below 50 mm per day.

4.1.4.5. Rainfall analysis of Northern high hills (AEU15) and impact of projected climate change in Malappuram districts

The Northern High Hills agro-ecological unit extending from Thrissur to Kannur is similar to its southern counterpart except for the longer dry period. This unit comprises 61 panchayats spread over the northern districts. The unit covers 5,28, 434 ha (13.60 %) in the state.

4.1.4.5.1. Rainfall and Rainy days of Northern high hills (AEU15) in Malappuram district

The monthly rainfall distribution of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 91.

Table 91. Monthly rainfall distribution under projected climate of Northern high hills (AEU15) in Malappuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	8.6	0	4.1	7.5	3.9	3.8	0
February	12.8	0	0	0	0	0	0
March	18.2	7	4	13	6.3	9.3	15.1
April	113.5	42.4	29.8	43.9	94.4	20.9	3.7
May	156.7	403.5	271.3	289.8	394.1	325.7	206.5
June	495.5	676.4	777.2	524.4	651.4	463.9	673.2
July	579.6	1229.5	1122.9	1235.9	1132	910.9	1024.5
August	370.6	477.4	553	613.2	468.9	514.3	570.8
September	206.8	7.1	11.1	8.7	7.1	12.3	218.3
October	270	249.9	259	270.5	253.1	256.1	280.2
November	135.4	35.7	37.6	41.4	37.3	38.6	19
December	30.1	24.3	22.2	61.2	21.5	21.6	87
Total	**2397.8**	**3153.2**	**3092.2**	**3109.5**	**3070**	**2577.4**	**3098.3**

At present the amount of monthly rainfall is high in July and having a rainfall of 579.6 mm. and the minimum is 8.6 mm. during January. As per RCP 4.5 and 8.5, in projected climate July will be the month having maximum rainfall and there will be a decline in rainfall during February, April, September and November. In May and July the projected climate shows a drastic increase in the amount of rainfall. In projected climate the annual rainfall will be higher than present condition.

The monthly rainy days of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were analyzed and represented in table 92.

Table 92. Monthly rainy days under projected climate of Northern high hills (AEU15) in Malappuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	0	1	1	1	1	0
February	1	0	0	0	0	0	0
March	2	1	1	2	0	1	3
April	10	2	3	2	4	2	0
May	11	15	13	13	15	12	10
June	20	22	22	22	22	21	20
July	24	25	24	24	25	27	27
August	20	15	15	15	15	15	18
September	13	1	2	2	1	2	6
October	16	10	10	10	10	10	10
November	9	3	3	3	3	3	2
December	2	3	3	4	3	3	7
Total	**129**	**97**	**97**	**98**	**99**	**97**	**103**

In the current condition, July has the maximum number of rainy days and it is 24 days and the lowest in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be in July and the chance of occurrence of rainy days in

February will be zero. As per RCP 4.5 and 8.5 the annual rainy days of projected climate will be lesser than that of the present condition.

For the current condition and projected climate, the seasonal rainy days of Northern high hills (AEU15) were examined and given in table 93.

Table 93. Seasonal rainy days under projected climate of Northern high hills (AEU15) in Malappuram district

RCP	Season	Winter		Summer		South West		North East	
	Year	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall	Rainy Days	Rainfall
	Present	2	21.4	22	288.4	77	1652.6	28	435.4
4.5	2030	0	0	18	452.9	63	2390.4	16	309.9
	2050	1	4.1	17	305.1	63	2464.2	16	318.8
	2080	1	7.5	17	346.7	63	2382.2	17	373.1
8.5	2030	1	3.9	19	494.8	63	2259.4	16	311.9
	2050	1	3.8	15	355.9	65	1901.4	16	316.3
	2080	0	0	13	225.3	71	2486.8	19	386.2

At the present climate the maximum numbers of rainy days are getting in south west monsoon followed by north east monsoon and summer season. In projected climate based on RCP 4.5 and 8.5 there will be an increasing trend in the amount of rainfall during south west monsoon period and summer season whereas in north east monsoon period and winter season, the rainfall shows a decreasing trend.

4.1.4.5.2. High rainfall events of Northern high hills (AEU15) in Malappuram district

For the present condition and projected climate, the high rainfall events of Northern high hills (AEU15) were studied and given in table 94.

Table 94. High rainfall events under projected climate of Northern high hills (AEU15) in Malappuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	2	0	0	0	7	2	0	0	0
	SW monsoon	24	18	4	2	0	24	18	4	2	0
	NE monsoon	7	0	0	0	0	7	0	0	0	0
	Total	**38**	**20**	**4**	**2**	**0**	**38**	**20**	**4**	**2**	**0**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	3	1	0	1	5	3	2	0	1
	SW monsoon	17	15	10	4	4	17	13	11	4	3
	NE monsoon	5	3	0	1	0	5	3	0	1	0
	Total	**29**	**21**	**11**	**5**	**5**	**27**	**19**	**13**	**5**	**4**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	2	1	0	0	5	4	2	0	0
	SW monsoon	24	14	7	5	5	22	15	9	3	0
	NE monsoon	5	3	0	1	0	5	3	0	1	0
	Total	**36**	**19**	**8**	**6**	**5**	**32**	**22**	**11**	**4**	**0**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	2	2	0	0	6	2	0	0	0
	SW monsoon	17	19	6	8	3	24	21	11	2	3
	NE monsoon	8	3	0	1	0	7	3	0	1	0
	Total	**31**	**24**	**8**	**9**	**3**	**37**	**26**	**11**	**3**	**3**

At present the rainfall events occurring are higher in the range of 10 to 50 mm (38) whereas lower in the range of 50 to 100 mm and no rainfall events are happening in the range of more than 100 mm. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 25 mm per day whereas the heavy rainfall events shows an increasing trend.

4.2. The lengths of growing period of various AEUs of Ernakulam, Thrissur, Palakkad and Malappuram districts

The lengths of growing period of various AEUs were calculated for the four districts viz. Ernakulam, Thrissur, Palakkad, Malappuram comprises central Kerala and represented in table 95.

Table95. The lengths of growing period of various AEUs of Ernakulam, Thrissur, Palakkad and Malappuram districts

LGP		RCP 4.5			RCP 8.5		
(Weeks)	Present	2030	2050	2080	2030	2050	2080
Ernakulam							
AEU5	26	21	23	25	24	28	27
AEU9	27	24	25	25	23	26	27
AEU12	27	25	24	27	25	27	26
AEU14	31	25	29	25	26	24	24
Thrissur							
AEU2	25	22	24	24	24	23	22
AEU5	26	24	24	25	26	23	20
AEU6	25	21	24	21	24	23	23
AEU10	22	21	19	23	19	20	18
AEU14	31	23	27	25	20	25	24
AEU15	24	23	22	21	20	21	22
Palakkad							
AEU10	22	20	19	21	19	20	21
AEU13	22	21	20	23	21	23	28
AEU14	31	26	28	27	25	25	25
AEU15	24	20	23	21	24	25	22
AEU18	14	23	23	19	22	19	23
AEU19	9	24	24	22	21	24	21
AEU22	18	19	20	19	19	20	19
AEU23	19	19	17	21	17	20	23
Malappuram							
AEU2	25	23	20	22	23	21	23
AEU6	25	23	20	21	21	20	20
AEU11	23	20	22	21	21	20	20
AEU13	22	21	20	20	19	20	20
AEU15	24	22	21	22	21	20	21

Considering the AEUs of Ernakulam district such as Pokkali lands (AEU5), South central laterites (AEU9), Southern and central foothills (AEU12) and Southern high hills (AEU14) at present condition these AEUs shows a length of growing period of 26, 27, 27 and 31 weeks respectively. Considering AEU5, AEU9, AEU12 and AEU14, there will be a decrease in length of growing period in the projected climate as indicated by RCP 4.5 and 8.5 from the present condition. In AEU5 there will be an increase in length of growing period as per RCP 8.5 during 2050 and 2080 in projected climate from the present condition.

In Thrissur district, the present length of growing period of AEUs such as Northern coastal plain (AEU2), Pokkali lands (AEU5), Kole lands (AEU6), North central laterites (AEU10), Southern high hills (AEU14) and Northern high hills (AEU15) are 25, 26, 25, 22, 31 and 24 weeks respectively. In projected climate as per RCP 4.5 and 8.5 all the AEUs shows a decreasing trend in length of growing period from the present condition.

Considering the AEUs of Palakkad districts such as North central laterites (AEU10), Northern foothills (AEU13), Southern high hills (AEU14), Northern high hills (AEU15), Attappady hills (AEU18), Attappady dry hills (AEU19), Palakkad central plains (AEU22) and Palakkad eastern plains (AEU23) at current condition these AEUs have a length of growing periods 22, 22, 31, 24, 14, 9, 18 and 19 weeks respectively. In projected climate as per RCP 4.5 and 8.5 AEU10, AEU14 and AEU15 shows a decreasing trend in length of growing period from the present climate whereas in remaining AEUs an increasing trend will happen. In the case of AEU18 and aeu19 a high increase in length of growing period will happen during projected climate from the current situation.

In Malappuram district, the present length of growing period of AEUs such as Northern coastal plain (AEU2), Kole lands (AEU6), Northern laterites (AEU11), Northern foothills (AEU13) and Northern high hills (AEU15) are 25, 25, 23, 22 and 24 weeks respectively. In projected climate as per RCP 4.5 and 8.5 all the AEUs shows a decreasing trend in length of growing period from the present climate.

4.3. Water Balance

4.3.1. Computed water balance of various AEUs in Ernakulam district

4.3.1.1. Monthly potential evapotranspiration, deficit and surplus of Pokkali lands (AEU5) in Ernakulam district

The monthly potential evapotranspiration of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 96.

Table 96. Monthly potential evapotranspiration under projected climate of Pokkali lands (AEU5) in Ernakulam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	151.2	150.8	154	158	151.6	155.2	164.4
February	169.2	154.8	158.4	161.2	155.6	159.2	165.6
March	227.7	198.5	202.5	207	199.5	205.5	212
April	179.8	157.2	160.4	164.4	158	170.4	176.4
May	198.9	203.5	207	212	204	209	227
June	140.6	167.6	170.8	174.8	168.4	170.8	184
July	179.3	200.5	204	209	201.5	215.5	222
August	149.9	164	167.2	170.8	164.4	164.8	177.2
September	181.4	203.5	207.5	211.5	205	208.5	220.5
October	170	156.8	160	163.2	158	164	166.8
November	134	154	156	159.6	154.8	159.2	167.2
December	134	151.2	154.4	157.2	152	158	167.2
Total	**1980**	**2062.8**	**2103**	**2148.9**	**2072.9**	**2140.7**	**2249.5**

At the current situation, the monthly potential evapotranspiration is maximum in March (227.7 mm.) and the lowest is 134 mm. (in November and December). In projected climate based on RCP 4.5 and 8.5, every months shows potential evapotranspiration greater than 150 mm. The maximum values will occur during May, July and September and the minimum will be in January. Totally there will be an increase in potential evapotranspiration during projected climate from the present condition.

The monthly deficit of Pokkali lands (AEU5) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 97.

Table 97. Monthly deficit under projected climate of Pokkali lands (AEU5) in Ernakulam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	134.2	142.7	132.1	135.2	129.7	132.2	134.5
February	153.2	154	157.5	160.3	154.7	158.3	164.9
March	62.2	148.7	169.9	171.2	162.7	176	172.9
April	0	132.1	106.5	109.5	121.3	127.5	143.6
May	11.1	28	37.9	38.9	2.6	38.3	43.1
June	28.1	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	34.1	38.7	12.4	18.4	38.8	14.8	14.8
September	130.5	153.1	157.7	114.9	154.2	116.4	122.8
October	131.7	78.6	82.4	53.9	78.2	16.4	0
November	114	124.9	122	118.6	125.3	97.4	118.2
December	134	138.4	141.7	144.4	138.7	108.4	124.2
Total	**933.1**	**1139.6**	**1119.8**	**1065.6**	**1106.4**	**985.9**	**1039**

At present the maximum amount of deficit occurs during the month February and it is about 153.2 mm. and there is no deficit during April and July. As per RCP 4.5 and 8.5 in projected climate all the months will shows an amount of deficit except in June and July. Comparing the present and future climate during the months March and April there will be a drastic increase in deficit where as in October and June it shows a decreasing trend.

The monthly surplus of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 98.

Table 98. Monthly surplus under projected climate of Pokkali lands (AEU5) in Ernakulam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	50.2	0	0	0	0	0
April	704.2	0	0	0	0	0	0
May	178.2	540.1	509	493.6	619.2	506.5	267
June	462.5	778.4	669.4	684.9	838.7	667.2	667.3
July	741.7	1048.3	1081.2	1164.5	1037.9	1105	974.5
August	10.5	122.2	46.4	42.7	123.2	124.1	165
September	20.8	164.6	206.5	248.8	168.4	233.7	141.5
October	0	90.5	101.4	190.7	93.7	172.4	198.7
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**2168.1**	**2744.1**	**2613.6**	**2825.3**	**2881.2**	**2808.5**	**2414.7**

Currently, there is surplus during the months April, May, June, July, August and September whereas in remaining months the surplus is zero. The maximum amount of surplus is occurring in April and July. As per RCP 4.5 and 8.5, in projected climate the maximum surplus will occur during the month July. In projected climate the month were surplus begins will shift from April to May and the ending month will shift from September to October.

4.3.1.2. Monthly potential evapotranspiration, deficit and surplus of South central laterites (AEU9) in Ernakulam district

The monthly potential evapotranspiration of South central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 99.

Table 99. Monthly potential evapotranspiration under projected climate of South central laterites (AEU9) in Ernakulam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	148.4	151.6	155.6	149.2	155.6	164.4
February	156.8	150.4	154	158	151.6	156.8	164.4
March	209.3	195	199	203.5	195.5	201	212.5
April	162.4	163.2	166.8	170	163.6	167.6	174.4
May	182.7	209	213.5	217.5	210.5	216.5	223
June	135.8	162	166	169.6	163.2	175.2	182
July	175.7	204	208	213	205	209.5	227.5
August	144.9	164.4	168	171.2	165.6	168.4	180.8
September	170.8	194	199	203	196	209.5	215.5
October	123.2	156	159.6	162.8	156.8	157.6	169.2
November	128.8	155.2	158.4	161.6	156	159.2	167.6
December	128.8	152	155.2	158.4	153.2	159.6	162
Total	**1862**	**2053.8**	**2098.9**	**2144.2**	**2066.3**	**2136.4**	**2242.7**

At the present condition, the maximum potential evapotranspiration is occurring during March (209.3 mm.) and the minimum is 123.2 mm. in October. In projected climate based on RCP 4.5 and 8.5 the potential evaopotranspiration shows an increasing trend from the present value. The maximum values will occur in May and July and the minimum will be in January.

The monthly deficit of South central laterites (AEU9) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 100.

Table 100. Monthly deficit under projected climate of South central laterites (AEU9) in Ernakulam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	114.1	129.1	130.1	122.6	130.6	145.8
February	154.8	149.5	152.9	156.9	150.5	156.2	163
March	208.5	160.8	166.5	168.6	162.2	166.4	175.3
April	59.8	121.3	108.7	136.6	106.6	134.5	155.5
May	62.7	15.4	5.8	30.5	5.5	30.3	0
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	6.3	0.4	2.3	7.1	28.4	6.6	6.6
September	24.6	83.5	143.4	99.4	146.7	103	79
October	0	45.9	36.7	23	45.6	0	16.4
November	70.6	129.8	119.2	127.8	130.2	100.3	127.3
December	68.6	113.4	149.1	115.3	112.1	103.3	99.2
Total	**798.5**	**934**	**1013.5**	**995.4**	**1010.6**	**930.9**	**967.9**

In the current climate the maximum amount of deficit occurs in March (208.5 mm.) and there is no deficit happening in June, July and October. August have a deficit below 10 mm. In the projected climate as per RCP 4.5 and 8.5 the maximum deficit will occur in March where as in June and July the deficit will be zero. In the case of October in projected climate there will be an increase in deficit compared to the present climate.

The monthly surplus of South central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 101.

Table 101. Monthly surplus under projected climate of South central laterites (AEU9) in Ernakulam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	72.4	588.2	478	351.7	463.6	346.5	305.7
June	381.2	621.2	755	527.4	658.8	525.9	591.8
July	791.3	1036.2	1036.1	1014.6	991.8	996	973.7
August	481.4	249	146	156.7	249.8	185.7	212.9
September	259.8	97.1	150.5	104.7	90.3	123.2	68.6
October	162.8	90.3	110.1	59.8	94.9	195.5	349.9
November	5.8	0	0	0	0	5.5	0
December	83.8	0	0	0	0	0	0
Total	**2238.5**	**2681.7**	**2675.7**	**2214.9**	**2549.3**	**2378.1**	**2502.8**

In the present condition the surplus during January, February, March and April is zero whereas in November the surplus is below 10 mm. The maximum amount of surplus is occurring in July and it is about 791.3 mm. As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April, November and December the amount of surplus will be zero. The maximum amount of surplus will occur in July. Annually the amount of deficit will be higher in projected climate than the present condition.

4.3.1.3. Monthly potential evapotranspiration, deficit and surplus of Southern and central foothills (AEU12) in Ernakulam district

The monthly potential evapotranspiration of Southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 102.

Table 102. Monthly potential evapotranspiration under projected climate of Southern and central foothills (AEU12) in Ernakulam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	150.8	154	157.2	151.6	159.6	171.6
February	147.2	152	154.4	158.8	152.4	158.8	171.2
March	168.5	190	195	200	191	202	216.5
April	132.1	159.6	164.4	167.2	160.4	164.4	176.4
May	166	203	207	212	204	212.5	224
June	145.1	164.4	168.4	171.6	165.2	170.8	179.2
July	202.1	206.5	210.5	215.5	207.5	212.5	224.5
August	175.6	166.4	170.4	173.2	166.8	170.4	177.2
September	214.4	204.5	208.5	213	205.5	211.5	218
October	157.1	152.8	155.6	160	153.6	165.2	170.4
November	139.2	151.6	154.8	158	152.4	156.4	168.8
December	142.4	152.8	156.4	159.2	153.6	156	167.6
Total	**1940.1**	**2054.1**	**2099.6**	**2145**	**2063.6**	**2139.5**	**2265.3**

In the current condition, the maximum amount of potential evapotranspiration is occurring in September followed by July and it is about 214.4 mm and 202.1 mm and the minimum in April (132.1 mm.). In projected climate the maximum potential evapotranspiration will occur in May, July and September and the minimum will occur during January and November. In the yearly value it shows an increasing trend compared to the present condition.

The monthly deficit of Southern and central foothills (AEU12) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 103.

Table 103. Monthly deficit under projected climate of Southern and central foothills (AEU12) in Ernakulam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	104.1	124.4	128.2	132	124.7	137.3	157.2
February	134	150.7	152.9	157.5	151.1	154.9	159.1
March	164.7	164.3	170	170.8	164.8	173.2	190.6
April	55.5	106.5	110.1	109.3	106.6	116.2	121.8
May	0	0	0	0	0.6	0	12
June	30.6	0	0	0	0	0	0
July	77.4	0	0	0	0	0	0
August	0	2.1	8.1	12.2	1.9	0	0
September	0	116.8	122.4	78.2	116.7	112.9	115.7
October	26.5	39.8	41.1	24.4	39.4	31.1	0
November	60.2	130.2	131.2	120.2	130.7	107.3	119.4
December	8.1	94.8	94.5	89.9	92.9	87	97.6
Total	**661.2**	**929.5**	**958.3**	**894.4**	**929.2**	**919.6**	**973**

At present the maximum deficit occurs during the month March (164.7 mm.) and there is no deficit during May, August and September. December shows an amount of deficit below 10 mm. As per RCP 4.5 and 8.5 in projected climate every months will show a deficit except in May, June and July. In the projected climate March will be the month having maximum deficit whereas august shows a deficit below 10 mm. Annually the projected climate shows an increasing trend in deficit.

The monthly surplus of Southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 104.

Table 104. Monthly surplus under projected climate of Southern and central foothills (AEU12) in Ernakulam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	24.4	0	0	0	0	0	0
May	233.7	343.1	354.9	299.3	351.8	312.6	252.3
June	40.5	646.8	755.8	514.8	673.9	400.6	613.6
July	40.7	1093.9	1132.1	1139.3	1097.2	1237.6	1063.7
August	239.8	355.5	234.4	262.7	358.9	273.1	324.2
September	612.6	5.7	0	24.8	6.4	1.1	44
October	364.7	305.7	357.4	367.4	316.8	385.4	370.9
November	76	0	0	0	0	0	0
December	145	0	0	0	0	0	0
Total	**1777.5**	**2750.9**	**2834.3**	**2608.3**	**2805.1**	**2610.1**	**2668**

Currently, there is surplus in all the months except January, February and March and the maximum amount of surplus is occurring in September (612.6 mm.). As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August, September and October whereas in remaining months the surplus will be zero. In projected climate the month were surplus begins will shift from April to May and the maximum surplus will occur during the month July. Yearly surplus shows an increasing trend in projected climate.

4.3.1.4. Monthly potential evapotranspiration, deficit and surplus of Southern high hills (AEU14) in Ernakulam district

The monthly potential evapotranspiration of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 105.

Table 105. Monthly potential evapotranspiration under projected climate of Southern high hills (AEU14) in Ernakulam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	146.8	154.4	159.6	162.4	157.2	164.4	173.6
February	162.8	153.6	159.2	162.4	156.8	164	173.6
March	215	195	200	204	196.5	206.5	219.5
April	167.8	158	164	168	161.2	168.4	179.2
May	188.2	204.5	206	211	202.5	213	226
June	137.8	164.8	169.2	173.2	166	170	182
July	180.6	204.5	208.5	213	205	214	223
August	150.4	164.4	165.6	170	163.2	168.8	178.8
September	177.4	205.5	206	210.5	202.5	207.5	218
October	127.6	160	162.4	165.2	159.6	163.2	170
November	131.2	150.4	159.6	162.8	157.2	161.6	168
December	131.2	150.8	152	156	149.6	160.8	167.6
Total	**1916.8**	**2065.5**	**2112.8**	**2158.5**	**2077.8**	**2162.2**	**2279.5**

At the present condition, the maximum potential evapotranspiration is during March (215 mm.) and the minimum is in October (127.6 mm.). In projected climate based on RCP 4.5 and 8.5 the annual potential evaopotranspiration shows an increasing trend. In projected climate the maximum values will occur in May, July and September and the minimum will be in November and December.

The monthly deficit of Southern high hills (AEU14) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 106.

Table 106. Monthly deficit under projected climate of Southern high hills (AEU14) in Ernakulam district

Deficit(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	145.8	129.2	152.5	155	148.9	157.2	158.9
February	140.8	151.7	137.2	141.9	138.3	143.3	161.8
March	156.4	162.7	167.6	168.7	163.5	171.2	184.4
April	103.4	125.5	130.6	129.5	128.4	131.5	148.5
May	60.4	0.5	15.9	56.4	16.1	66.6	56.5
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	3.9	0	0	0	0	0	0
September	34.1	146.6	107.7	116.2	141.4	114.3	117.8
October	7.2	69.5	0	0.1	29.9	0	0
November	20.8	108.9	105.7	108.6	114.8	107	111.6
December	85.1	95.6	87.3	85.3	92.5	93.5	80.4
Total	**757.9**	**989.6**	**904.7**	**961.7**	**974**	**984.7**	**1019.9**

In the current climate the maximum amount of deficit occurs in March (156.4 mm.) and there is no deficit during June and July. August and October have a deficit below 10 mm. In the projected climate as per RCP 4.5 and 8.5 the maximum will occur in March whereas in June, July and August the deficit will be zero. In projected climate the yearly deficit shows an increasing trend from the current condition.

The monthly surplus of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 107.

Table 107. Monthly surplus under projected climate of Southern high hills (AEU14) in Ernakulam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	155.5	362.4	278.7	238.7	276.9	203.4	197.2
June	170.4	519.3	691.9	503.1	641.9	533.1	512.8
July	271.4	1162.2	1107.7	1173.2	1114.8	1165.9	1070.1
August	301.5	367.1	308.7	334.1	434.3	378	345
September	94.7	0	36.8	3.7	1.2	4.1	40.4
October	257	344	199.6	209	317	211.8	255.5
November	13.8	0	0	0	0	0	61.7
December	0	0	0	0	0	0	0
Total	**1264.3**	**2754.7**	**2622.9**	**2461.7**	**2785.8**	**2496**	**2482.6**

In the present condition the surplus during January, February, March, April and December is zero and the maximum amount of surplus is occurring in August (301.5 mm.). As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April, November and December the amount of surplus will be zero and the maximum amount of surplus will be in July. Projected climate shows an increasing trend in annual surplus from the current condition.

4.3.2. Computed water balance of various AEUs in Thrissur district

4.3.2.1. Monthly potential evapotranspiration, deficit and surplus of Northern coastal plains (AEU2) in Thrissur district

The monthly potential evapotranspiration of Northern coastal plains (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 108.

Table 108. Monthly potential evapotranspiration under projected climate of Northern coastal plains (AEU2) in Thrissur district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	149.2	148	152.4	156	148.8	174.8	164.4
February	165.6	150.4	153.2	156.8	151.2	157.6	164.8
March	219.4	195	196	201.5	195.5	225	213
April	172.3	163.2	164	168	164.4	165.6	174.8
May	192.3	209.5	213	217	210.5	242	223.5
June	139.6	162.8	172.8	176.4	163.6	174.8	182.4
July	181	204.5	206	211	205.5	242.5	228
August	151.3	165.2	165.2	168.8	166	166.8	180.8
September	180.5	195	206	210.5	196	233.5	216
October	130.8	156.8	154.4	158	157.6	163.2	169.2
November	133.2	155.2	156	159.6	156	172.4	167.6
December	133.2	152.4	156.8	159.6	153.2	157.6	162
Total	**1948.4**	**2057.8**	**2095.6**	**2142.6**	**2068.7**	**2275.4**	**2246**

At present condition, the maximum potential evapotranspiration is during March (219.4 mm.) and the minimum is in October (130.8 mm.). In projected climate based on RCP 4.5 and 8.5 the annual potential evaopotranspiration shows an increasing trend from the present value. The maximum values will occur in May and July and the minimum will be in January.

The monthly deficit of Northern coastal plains (AEU2) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 109.

Table 109. Monthly deficit under projected climate of Northern coastal plains (AEU2) in Thrissur district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	149.1	139.1	142.3	154.4	139.9	165.9	163.4
February	165.6	142.7	152.5	152.6	151.2	157.6	164.8
March	217	189	177.2	176	180.8	211	198.8
April	124.2	121.3	148.6	145.6	118.9	122	147.4
May	59.2	76.3	40	40.8	77.8	68.4	41.6
June	13.6	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	26.3	9.4	9.6	22.1	9.4	16.1	15.9
September	46.6	148.7	156.8	118.3	149.4	136.7	95.2
October	0	48.7	0.8	55.8	48.1	56.6	65.9
November	110.8	108.2	109.4	114.3	107.7	123.8	123.1
December	131	117.8	119.1	118.1	116.4	109.8	121
Total	**1043.4**	**1101.1**	**1056.4**	**1097.5**	**1100.1**	**1167.7**	**1136.6**

In the current climate the maximum amount of deficit occurs in March and it is about 217 mm. and there is no deficit happening in July and October. In the projected climate as per RCP 4.5 and 8.5 the maximum deficit will occur in March. June and July will be the months were the deficit value will become zero. In the projected climate the amount of annual deficit shows an increasing trend from the current condition.

The monthly surplus of Northern coastal plains (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 110.

Table 110. Monthly surplus under projected climate of Northern coastal plains (AEU2) in Thrissur district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	45.5	0	0	0	0	23.1	0
May	165.2	268.8	310.7	349.5	268.2	218.1	193.6
June	365.7	1085.3	797.6	779.2	1105.8	715.2	610.9
July	987.6	1097.9	1053.7	1179.9	1086.9	1309.2	1102.3
August	583.5	152.5	174.4	192.9	147.9	191.8	209.4
September	0	140.3	105.9	100.1	144.2	3.1	71.1
October	322.3	93.7	145.6	65.3	97.9	151.6	203.7
November	0	0	17	12.6	0	0	0
December	0	0	0	0	0	0	0
Total	**2469.8**	**2838.7**	**2604.9**	**2679.7**	**2851**	**2612**	**2391**

In the present condition the surplus during January, February, March, September, November and December is zero. The maximum amount of surplus is occurring in July and it is about 987.6 mm. As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April and December the amount of surplus will be zero. The maximum amount of surplus will occur in July. In projected climate June and September shows a drastic increase in surplus and also the yearly surplus will increase compared to the current condition.

4.3.2.2. Monthly potential evapotranspiration, deficit and surplus of Pokkali lands (AEU5) in Thrissur district

The monthly potential evapotranspiration of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 111.

Table 111. Monthly potential evapotranspiration under projected climate of Pokkali lands (AEU5) in Thrissur district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	151.2	148	151.6	174.8	148.8	151.6	164.4
February	169.2	150.4	154	179.2	151.2	154	164.8
March	227.7	194.5	199	231	195.5	199	213
April	179.8	162.8	166.8	190.4	163.6	166.8	174.4
May	198.9	209.5	213.5	242.5	211	213.5	223.5
June	140.6	162.4	166.4	192	163.2	166.4	182.4
July	179.3	204.5	208.5	241	205.5	208.5	228
August	149.9	165.6	168	192.8	166	168	180.8
September	181.4	194.5	199	228	196	199	216
October	134	156.4	159.6	182.4	157.2	159.6	169.2
November	134	155.2	158.4	180.4	155.6	158.4	167.6
December	134	152.8	155.2	176.4	153.2	155.2	161.6
Total	**1980**	**2055.5**	**2100.1**	**2411.1**	**2067.2**	**2100.1**	**2245.3**

In the current condition, the maximum amount of potential evapotranspiration is occurring in March (227.7 mm.) and the minimum is during October, November and December. As per RCP 4.5 and 8.5 in projected climate, the yearly value shows an increasing trend compared to the present condition. The maximum potential evapotranspiration will occur in May and July whereas the minimum will be in January.

The monthly deficit of Pokkali lands (AEU5) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 112.

Table 112. Monthly deficit under projected climate of Pokkali lands (AEU5) in Thrissur district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	134.2	146	147.4	152	145	147.4	163.4
February	153.2	147.8	148.7	173.5	141.6	148.7	164.2
March	57	179	180.8	205.7	180.7	180.8	179.7
April	0	116.8	139.3	180.5	123.2	139.3	171.4
May	6.3	4.9	35.2	69.3	0	35.2	24.3
June	22.9	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	28.9	33.9	5.4	27.6	4.9	5.4	11.1
September	130.5	100.1	149.9	123.6	148	149.9	88.2
October	126.5	40.9	44.1	69.1	42.3	44.1	60.9
November	114	112.5	108.6	116.2	106.7	108.6	123.1
December	134	115.6	120.8	147.3	114	120.8	114.4
Total	**907.5**	**997**	**1080.6**	**1264.5**	**1007.1**	**1080.6**	**1100.5**

At present the maximum deficit occurs during the month February and it is about 153.2 mm. and there is no deficit occurring in April and July. May shows a deficit which is below 10 mm. As per RCP 4.5 and 8.5 in projected climate every month will show a deficit except in June and July. In the projected climate March will be the month having maximum deficit. The yearly deficit value shows an increasing trend compared to the current climate.

The monthly surplus of Pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 113.

Table 113. Monthly surplus under projected climate of Pokkali lands (AEU5) in Thrissur district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	114.8	0	0	0	0	0	0
April	629.2	0	0	0	0	0	0
May	173.4	478.6	198.5	164.9	328.5	198.5	153.7
June	457.3	1189.7	1188.1	1029.1	1474.7	1188.1	925.1
July	741.7	1125	1002.2	1110.2	1042.3	1002.2	987.9
August	10.5	256.2	143.4	147.1	144.4	143.4	207
September	15.6	139.9	134	137.4	143.2	134	69.8
October	0	95.3	153.1	73.5	102	153.1	205.3
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**2142.5**	**3284.1**	**2819.2**	**2661.8**	**3234.9**	**2819.2**	**2548.7**

Currently, every month show a surplus except January, February, October, November and December and the maximum amount of surplus is in July (741.7 mm.). As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October whereas in remaining months the surplus will be zero. In projected climate the maximum surplus will occur during the month June whereas in March and April there will be a drastic decrease. The annual surplus shows an increasing trend compared with the present condition.

4.3.2.3. Monthly potential evapotranspiration, deficit and surplus of Kole lands (AEU6) in Thrissur district

The monthly potential evapotranspiration of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 114.

Table 114. Monthly potential evapotranspiration under projected climate of Kole lands (AEU6) in Thrissur district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	150.4	170	152.4	176.8	149.2	153.6	165.2
February	170.8	150	152.8	157.2	150.4	157.6	166.4
March	231.6	225	196.5	229	193.5	200	210.5
April	184.1	163.6	164	168.4	161.2	165.6	175.6
May	202.1	238	213	243	209.5	214	222.5
June	140	162.4	172.8	176	170.4	175.2	180.4
July	177.3	236.5	206	238	202.5	218	226
August	149.5	165.6	165.2	168.8	162.8	166.8	180.8
September	182.2	222.5	206.5	236.5	203.5	206.5	222
October	135.6	156.4	154.8	158	152	162.8	168
November	134.8	177.2	156.4	178.8	154.4	154.4	165.2
December	134.8	152.4	156.8	159.6	154.4	157.2	166
Total	**1993.2**	**2219.8**	**2096.5**	**2290.3**	**2062.9**	**2131.4**	**2247.7**

At present condition, the maximum potential evapotranspiration occurring is 231.6 mm. during March and the minimum is 134.8 mm. during November and December. In projected climate based on RCP 4.5 and 8.5 the yearly potential evapotranspiration will be higher than the present condition. In projected climate the maximum values will occur in March, May, July and September and the minimum will be in February.

The monthly deficit of Kole lands (AEU6) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 115.

Table 115. Monthly deficit under projected climate of Kole lands (AEU6) in Thrissur district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	150.4	161.2	141.6	175.2	140.5	144.7	164.2
February	170.8	142.4	152.1	153.2	150.4	157.6	166.4
March	231.6	218.6	180.6	210.3	178.1	188	197.4
April	135.5	121.6	148.4	160.6	117.3	121.3	148.5
May	88.4	87.6	35.1	74.4	77.4	54.6	35.4
June	0	0	0	0	0	0	0
July	1.7	0	0	0	0	0	0
August	21.9	5.8	3.7	8.3	5.3	5.8	17.3
September	50.9	170.2	155	128.1	154.8	111	93.9
October	8.8	43.4	0.3	76	40.3	52.2	60.3
November	89	131	104.7	135.8	109.6	110.2	121.3
December	113.6	118.1	113.6	123	115.1	110	126.7
Total	**1062.6**	**1200.3**	**1034.7**	**1244.7**	**1088.4**	**1055.3**	**1130.7**

In the current climate the maximum amount of deficit occurs in March and it is about 231.6 mm. and the deficit is zero in June. July is the month having deficit below 10 mm. In the projected climate as per RCP 4.5 and 8.5 the maximum will occur in March whereas in June and July the deficit will be zero. In projected climate August shows a deficit below 10 mm and the annual values shows an increasing trend except in 2050s.

The monthly surplus of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 116.

Table 116. Monthly surplus under projected climate of Kole lands (AEU6) in Thrissur district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	7.1	0
May	147.5	236	172.4	278.7	209.4	260.1	180.9
June	463.1	1040.4	1304.9	890.9	1083.5	664.4	602.4
July	576.2	1081.6	1056.3	982.4	1084.1	1068.9	1113.3
August	486.4	155.5	169.2	178.1	177.6	178.8	196.2
September	52	131.7	95.1	115.6	129	29	84.4
October	190.2	95.6	152.2	59.7	113.7	106.7	201.4
November	53.6	0	9.6	0	0	0	0
December	0	0	0	0	0	0	0
Total	**1969**	**2741**	**2960.1**	**2505**	**2797.6**	**2314.9**	**2378.7**

In the present condition the surplus during January, February, March, April and December is zero and the maximum amount of surplus is occurs in July (576.2 mm.). As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April, November and December the amount of surplus will be zero. The maximum amount of surplus will occur in July and the yearly value shows an increase from the current condition.

4.3.2.4. Monthly potential evapotranspiration, deficit and surplus of North central laterites (AEU10) in Thrissur district

The monthly potential evapotranspiration of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 117.

Table 117. Monthly potential evapotranspiration under projected climate of North central laterites (AEU10) in Thrissur district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	150.8	148.4	152	155.6	149.6	153.6	164.8
February	170.4	150.4	153.2	156.8	150.8	157.2	166.4
March	231.3	195	196.5	201.5	193.5	200.5	211
April	183.2	164	164.4	168	161.6	166	175.6
May	202.1	210.5	213.5	217.5	210	214.5	223.5
June	140.2	163.2	172.8	176.4	170.4	175.6	181.2
July	177.2	204	206.5	211.5	202.5	218.5	226
August	149.1	165.6	165.2	169.2	162.4	166.8	180.8
September	181.7	194.5	206.5	210.5	203	207	222
October	134.8	156.4	154.8	158.4	152	162.8	168
November	134.8	155.2	156	159.2	154	154.4	165.6
December	134.8	152.4	156.4	159.6	154	157.6	166
Total	**1990.4**	**2059.5**	**2097.7**	**2144.4**	**2063.8**	**2134.4**	**2250.6**

At current situation, the monthly potential evapotranspiration is highest in March and it is about 231.3 mm. and the base value is 134.8 mm. during October, November and December. In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during March, May, July and September and the minimum will be in January. Totally there will be an increase in potential evapotranspiration during projected climate from the present condition.

The monthly deficit of North central laterites (AEU10) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 118.

Table 118. Monthly deficit under projected climate of North central laterites (AEU10) in Thrissur district

Deficit(mm) / Months	Present	RCP 4.5			RCP 8.5		
		203	2050	2080	2030	2050	2080
January	150.8	147.4	151	154.6	148.6	152.1	163.3
February	216.6	175.7	187.6	183.3	184	196.9	208.6
March	185.1	149	152.7	159.5	148	150.2	159.3
April	159.6	160.4	160.2	97.1	151.5	152.5	169
May	88.9	57.3	61.6	39.9	65.2	76.1	72.8
June	1.4	0	0	0	0	0	0
July	16.6	0	0	0	0	0	0
August	18.6	19.5	17.1	17	15.2	12.7	18
September	58.2	155.3	163.9	167.1	161.2	174.7	185.5
October	0.5	74	48.7	50	46.9	51.6	61.1
November	108.7	127.4	117.3	113.7	116.3	118.9	159.2
December	113.3	120.5	145.8	112.9	144	145	149.6
Total	**1118.3**	**1186.4**	**1205.6**	**1095.2**	**1180.7**	**1230.7**	**1346.2**

At present the maximum deficit occurs during the month February and it is about 216.6 mm whereas in June and October the deficit is below 10 mm. As per RCP 4.5 and 8.5 in projected climate every month will show a deficit except in June and July. February will be the month having maximum deficit and there will be a drastic increase during September and October from the present condition.

The monthly surplus of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 119.

Table 119. Monthly surplus under projected climate of North central laterites (AEU10) in Thrissur district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	1.1	0	0	0
May	235	185	392.5	161.7	180	195.4	165.1
June	290.6	784.9	845.2	862.6	1174.4	833.2	731.6
July	772.8	857.8	955.5	829.2	828.4	964.2	1092
August	344.4	231.9	252.6	246.1	251.2	247.1	248.1
September	62.5	124	69.7	69.2	67.2	0	0
October	175.1	19	51.2	51.2	50.9	126.7	123.8
November	0	0	0	2.3	0	0	0
December	0	0	0	0	0	0	0
Total	**1880.4**	**2202.7**	**2566.6**	**2223**	**2551.9**	**2366.7**	**2360.3**

Currently, there is surplus during May to October whereas in remaining months the surplus is zero. The maximum amount of surplus is occurring in July (772.8 mm.). As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August, September and October. In projected climate the maximum surplus will occur during the month July. The annual surplus will be higher in projected climate than the present.

4.3.2.5. Monthly potential evapotranspiration, deficit and surplus of Southern high hills (AEU14) in Thrissur district

The monthly potential evapotranspiration of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 120.

Table 120. Monthly potential evapotranspiration under projected climate of Southern high hills (AEU14) in Thrissur district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	146.8	144	148	151.6	144.8	152	165.6
February	162.8	143.2	146.8	151.2	144	152.8	165.6
March	215	186.5	190.5	196	187.5	192	209
April	167.8	152.8	156.4	160.8	153.6	161.2	171.2
May	188.2	196	200.5	206	197	204.5	216
June	137.8	160.8	164.8	168.8	161.2	166.4	176.8
July	180.6	202	207.5	212.5	203	208.5	218
August	150.4	161.6	165.2	168.8	162.4	167.6	173.2
September	177.4	189	194	198.5	190	206.5	214.5
October	127.6	148.8	152.8	156	149.6	154	168.4
November	131.2	149.6	152.8	156	150	152.4	165.6
December	131.2	142	145.6	148.8	142.8	154	158.8
Total	**1916.8**	**1976.5**	**2024.7**	**2075.1**	**1986.8**	**2072.2**	**2201.6**

At present condition, the maximum potential evapotranspiration occurring is 215 mm. during March and the minimum is 127.6 mm. in October. In projected climate based on RCP 4.5 and 8.5 the annual potential evaopotranspiration shows an increasing trend from the present value. The maximum values will occur in March, May, July and September and the minimum will be in December.

The monthly deficit of Southern high hills (AEU14) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 121.

Table 121. Monthly deficit under projected climate of Southern high hills (AEU14) in Thrissur district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	145.8	142.8	126.8	147.9	142	149.6	164.6
February	140.8	140.5	140.3	138.3	131	150.1	163.8
March	156.4	156	176.4	171.1	164.2	158.9	179.2
April	103.4	127.9	134.4	140.7	136.2	120.2	157.8
May	59.8	5.5	20.2	16.1	11.8	12.6	38
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	3.7	26.6	5.4	8.8	26.7	13.3	0.1
September	33.5	142.2	76.7	111.3	142.9	99.8	118.2
October	6.9	37.3	46.9	49.3	45.3	48.1	26.2
November	20.1	127.2	128.8	130.4	143.3	127	130.8
December	84.5	129.4	87	85	132.6	94	100
Total	**755**	**1035.6**	**943.1**	**999.5**	**1076.5**	**974.1**	**1078.1**

In the current climate the maximum amount of deficit occurs in March and it is about 156.4 mm. and the deficit is zero during June and July. August and October have deficits below 10 mm. In the projected climate as per RCP 4.5 and 8.5 the maximum will occur in March whereas in June and July the deficit will be zero. The projected climate shows an increasing trend in annual deficit.

The monthly surplus of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 122.

Table 122. Monthly surplus under projected climate of Southern high hills (AEU14) in Thrissur district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	154.9	285.9	357.6	247	290.6	123.6	158
June	169.8	765.7	735.7	854.6	1041.3	820	1005.2
July	271.4	939.3	1050	996.3	964.6	1080.9	931.5
August	301.3	352.1	235.5	249.5	353.7	236.8	240.8
September	94.1	0	0	0	0	0	106
October	256.7	201.3	195.9	205.6	240.9	206.4	196.2
November	13.1	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**1261.4**	**2543.9**	**2574.6**	**2552.8**	**2890.9**	**2467.4**	**2637.3**

In present condition the surplus is zero during January, February, March, April and December and the maximum amount of surplus is occurs in August and it is about 301.3 mm. As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April, September, November and December the amount of surplus will be zero. The maximum amount of surplus will occur in July and the annual surplus value shows an increasing trend.

4.3.2.6. Monthly potential evapotranspiration, deficit and surplus of Northern high hills (AEU15) in Thrissur district

The monthly potential evapotranspiration of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 123.

Table 123. Monthly potential evapotranspiration under projected climate of Northern high hills (AEU15) in Thrissur district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	141.2	149.6	150.8	154.4	148	156.4	165.2
February	153.2	150.4	178	180	152	156.4	166.8
March	209.6	193.5	196.5	201.5	193.5	202	211
April	163.4	161.6	187.6	190	160.4	166	175.6
May	184.4	209.5	210.5	215	207	212.5	224
June	135	170	195.2	197.2	170	173.6	181.6
July	166.9	203	214.5	219	211.5	217.5	226.5
August	138.5	162.8	187.6	190	161.6	173.2	180.8
September	164.6	203	203	207.5	200	205	222.5
October	122.4	152	182.8	184.4	158.4	160.8	168
November	123.6	154	152	155.2	149.6	160.4	166
December	123.6	154	175.6	177.6	152.8	153.2	166.4
Total	**1826.4**	**2062.6**	**2234.4**	**2272**	**2064.4**	**2136.5**	**2254.8**

In the current condition, the maximum amount of potential evapotranspiration is in March (209.6 mm.) and the minimum is 122.4 mm. during October. In projected climate every month will show potential evapotranspiration greater than 150 mm. In the yearly value it shows an increasing trend compared to the present condition. The maximum amount will occur in May, July and September and the minimum will occur during the month January.

The monthly deficit of Northern high hills (AEU15) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 124.

Table 124. Monthly deficit under projected climate of Northern high hills (AEU15) in Thrissur district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	141.2	144.8	141	151.9	139.4	147.4	164.2
February	124.3	149.4	177.3	175.6	152	155.6	159.5
March	199.4	174.7	174.1	173	175.9	163.5	193
April	80.2	133.4	172.5	172.4	116.6	128.7	164.4
May	40	36.4	25.5	0	65.8	65.8	70.3
June	0	0	0	0	0	0	0
July	29.8	0	0	0	0	0	0
August	0	4.2	8.2	13.3	2.6	10.6	15.1
September	17.6	152.4	110.5	160.7	148.7	166.8	93.9
October	50.3	48.4	66.2	67.9	51	55.9	57.8
November	104.3	132	140	142.2	139	154.2	122.1
December	108.5	124.8	168.7	170.1	146.2	139.6	116.2
Total	**895.6**	**1100.1**	**1184.2**	**1227.2**	**1137.1**	**1187.8**	**1157**

At present the maximum deficit occurs during the month March and it is about 199.4 mm. and there is no deficit during June and August. As per RCP 4.5 and 8.5 in projected climate every month will show a deficit except in June and July. In the projected climate March will be the month having maximum deficit and the yearly value shows an increasing pattern compared with the current condition.

The monthly surplus of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 125.

Table 125. Monthly surplus under projected climate of Northern high hills (AEU15) in Thrissur district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	28.3	269.4	145.8	236.7	151.9	98.8	130.8
June	247.5	761.9	1089.9	838.8	1002.7	777.5	892.8
July	120.4	986.9	1001.4	1059.8	1000.2	1065.3	1044.2
August	596.9	176.6	159.8	169.8	172.8	241	194.1
September	69.1	89.7	0	0	7.8	0	12.2
October	0	107.7	92.5	102.2	196.1	123.2	205.2
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**1062.2**	**2392.1**	**2489.3**	**2406.8**	**2531.5**	**2305.7**	**2479.1**

Currently, there is surplus during every month except January, February, March, April, October, November and December. The maximum amount of surplus is occurring in August and it is about 596.9 mm. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October whereas in remaining months the surplus will be zero. In projected climate the maximum surplus will occur during the month July followed by June and the annual surplus will be higher than the current condition.

4.3.3. Computed water balance of various AEUs in Palakkad district

4.3.3.1. Monthly potential evapotranspiration, deficit and surplus of North central laterites (AEU10) in Palakkad district

The monthly potential evapotranspiration of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 126.

Table 126. Monthly potential evapotranspiration under projected climate of North central laterites (AEU10) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.8	147.6	151.6	155.6	149.2	153.2	164.8
February	170.4	150	153.2	156.8	150.4	157.2	166.4
March	231.3	194	196	201	193.5	200	210.5
April	183.2	163.6	163.6	168	161.2	166	175.6
May	202.1	209.5	212.5	217.5	209.5	214	223.5
June	140.2	162.8	172.8	176.4	170.4	175.6	181.2
July	177.2	203.5	206.5	211.5	203	218.5	226
August	149.1	165.2	164.8	169.2	162.4	166.8	180.8
September	181.7	195	206	210.5	203	206.5	222
October	134.8	156.4	154.4	158	152	162.8	167.6
November	134.8	154.8	155.6	158.8	153.6	154.4	165.2
December	134.8	151.6	156	159.2	154	156.8	165.6
Total	**1990.4**	**2054.1**	**2093.1**	**2142.2**	**2062.4**	**2131.3**	**2248.7**

At the present condition, the maximum potential evapotranspiration occurring is 231.3 mm. during March and the minimum is 134.8 mm. during October, November and December. In projected climate based on RCP 4.5 and 8.5 the potential evaopotranspiration shows an increasing trend from the present value. The maximum values will occur in May and July. And the minimum will be in January.

The monthly deficit of North central laterites (AEU10) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 127.

Table 127. Monthly deficit under projected climate of North central laterites (AEU10) in Palakkad district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.8	146.6	150.6	154.6	148.2	152.2	163.8
February	170.4	150	153.2	156.8	150.4	157.2	166.4
March	231.3	187.4	182.4	176.5	183.2	186.9	199.6
April	159.6	132.4	156.9	140.1	154.1	162.1	166.3
May	89.3	65.5	67.4	79.1	74	54.8	75.5
June	1.5	0	0	0	0	0	0
July	16.9	0	0	0	0	0	0
August	19	16.6	18.8	25.8	24.7	17	26.8
September	58.6	152.1	160.8	167.5	161.6	174	121.1
October	0.5	56.9	55.8	49.6	47.1	51.8	61.4
November	109.1	127.8	127.6	113.3	115.5	119.1	159
December	113.3	125.6	128.6	111.3	142.1	142	147.7
Total	**1120.3**	**1160.7**	**1202.5**	**1174.5**	**1200.9**	**1216.7**	**1287.3**

In the current climate all the months shows deficit and the maximum amount of deficit occurs in March and it is about 231.3 mm. June and October have a deficit below 10 mm. In the projected climate as per RCP 4.5 and 8.5 the maximum deficit will occur during March. Based on projections every month shows deficit except in June and July. In the case of September and October in projected climate there will be a drastic increase in deficit compared to the present climate. Annually the deficit shows an increasing trend from the present condition.

The monthly surplus of North central laterites (AEU10) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 128.

Table 128. Monthly surplus under projected climate of North central laterites (AEU10) in Palakkad district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	235.8	283.9	151.5	182	191.4	193.3	118.1
June	290.6	802.8	969.3	776.8	883.3	743	680.6
July	773.2	990.6	1115.8	913.4	1045.5	895.7	1021.5
August	344.8	135.5	159.8	193.2	199.7	186.1	157.6
September	62.9	53.7	49.7	71.5	70.5	0	0
October	175.1	44.1	55.3	52.8	53.3	130.2	127.4
November	0	0	0	2.5	0	0	0
December	0	0	0	0	0	0	0
Total	**1882.4**	**2310.3**	**2501.3**	**2192.5**	**2443.5**	**2148.4**	**2105.3**

In the present condition the surplus occurring during January, February, March, April, November and December is zero. The maximum amount of surplus is occurring in July and it is about 773.2 mm. As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April, November and December the amount of surplus will be zero. The maximum amount of surplus will occur in July followed by June. Yearly surplus value shows an increasing trend in projected climate.

4.3.3.2. Monthly potential evapotranspiration, deficit and surplus of Northern foothills (AEU13) in Palakkad district

The monthly potential evapotranspiration of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 129.

Table 129. Monthly potential evapotranspiration under projected climate of Northern foothills (AEU13) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	150.4	151.6	155.2	148.4	156.8	167.6
February	151.6	151.6	155.6	159.2	153.2	157.2	168.4
March	195	195	197.5	203	195	203	214.5
April	162.4	162.4	164	167.6	161.6	167.2	175.6
May	211.5	211.5	211.5	216.5	208.5	213.5	226
June	171.6	171.6	174	177.6	171.6	174.4	182.4
July	205	205	216.5	220.5	214	219.5	226.5
August	163.6	163.6	165.2	169.2	162.4	174	180.4
September	204.5	204.5	204	208.5	201	206.5	223
October	153.2	153.2	161.6	164.8	159.2	161.6	173.2
November	154.8	154.8	152.8	156.4	150.4	160.8	165.6
December	154.8	154.8	155.6	158.8	153.6	154.4	164.8
Total	**2077.8**	**2077.8**	**2109.4**	**2157.1**	**2078.1**	**2148.5**	**2268.5**

In the current condition, the maximum amount of potential evapotranspiration is occurring in May (211.5 mm.) and the minimum in January (150.4 mm.). In projected climate every month will show potential evapotranspiration greater than 150 mm. In the yearly value it shows an increasing trend compared to the present condition. The maximum amount will occur in May, July and September and the minimum will occur in January and February.

The monthly deficit of Northern foothills (AEU13) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 130.

Table 130. Monthly deficit under projected climate of Northern foothills (AEU13) in Palakkad district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	149.4	150.6	154.2	147.4	155.8	166.6
February	151.6	151.6	155.6	159.2	153.2	157.2	168.4
March	159.5	159.5	187.2	184	167.2	162.4	185.9
April	158	158	153.8	137.3	145.1	131.6	170.5
May	70.5	70.5	31.9	25.9	56.9	28	55.7
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	22.6	22.6	15.7	19.3	14.8	22.3	1.7
September	162.9	162.9	171.9	174.2	169.9	176.7	162
October	45.1	45.1	48.9	51.3	47.5	49.6	69.7
November	119.9	119.9	109.4	111.8	107.8	116.2	120.4
December	141.3	141.3	116.9	107.6	114.5	113.6	100.4
Total	**1181.4**	**1180.4**	**1141.7**	**1124.7**	**1124**	**1112.9**	**1201.7**

At present the maximum deficit occurs during the month September (162.9 mm.) and the deficit during June and July is zero. As per RCP 4.5 and 8.5 in projected climate every month will show a deficit except in June and July. In the projected climate March and September will be the months having maximum deficit. Annually the deficit shows a decreasing trend except in 2080 as per RCP 8.5.

The monthly surplus of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 131.

Table 131. Monthly surplus under projected climate of Northern foothills (AEU13) in Palakkad district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	66.6	66.6	91.7	146.5	177.1	71.4	175.5
June	585.7	585.7	705.1	768.9	573.4	477.8	450.4
July	958.1	958.1	959.9	1000.5	912.9	945.4	884.6
August	195.3	195.3	183.7	189.4	184.3	241.9	184.3
September	62.3	62.3	0	0	0	0	0
October	50.1	50.1	126.8	133.4	123.8	140.2	177.3
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**1918.2**	**1918.2**	**2066.7**	**2238.8**	**1971.6**	**1876.7**	**1872**

Currently, there is surplus in all the months except January, February and March, April, November and December. The maximum amount of surplus is occurring in July and it is about 958.1 mm. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August and October whereas in remaining months the surplus will be zero. In projected climate the maximum surplus will occur during the month July.

4.3.3.3. Monthly potential evapotranspiration, deficit and surplus of Southern high hills (AEU14) in Palakkad district

The monthly potential evapotranspiration of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 132.

Table 132. Monthly potential evapotranspiration under projected climate of Southern high hills (AEU14) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	146.8	106.8	103.2	107.6	108	111.2	124
February	162.8	100.8	112.4	117.6	101.6	108.8	120
March	215	122.5	134	140	123.5	149	164.5
April	167.8	97.6	104.4	109.6	98.4	114.8	131.2
May	188.2	118.5	129.5	135	119	139.5	185.5
June	137.8	93.2	99.2	103.2	94	108	135.6
July	180.6	111.5	120	125.5	112.5	127.5	159.5
August	150.4	92	91.6	96.4	92.8	99.2	122
September	177.4	111	117	122.5	112	116	141
October	127.6	87.2	89.6	94.4	88	94	107.2
November	131.2	88.4	88	92.4	89.2	90.8	100.8
December	131.2	92	90.8	94.8	92.8	90.4	105.2
Total	**1916.8**	**1221.2**	**1278.7**	**1337.6**	**1231.3**	**1349.4**	**1595.9**

At the present condition, the maximum potential evapotranspiration is during March (215 mm.) and the minimum in October (127.6 mm.). In projected climate based on RCP 4.5 and 8.5 the annual potential evaopotranspiration shows an increasing trend. In projected climate the maximum values will occur in March and the minimum will be in October and November.

The monthly deficit of Southern high hills (AEU14) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 133.

Table 133. Monthly deficit under projected climate of Southern high hills (AEU14) in Palakkad district

Deficit(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	145.8	88.2	82.6	86	91.7	91.9	105
February	140.8	82.6	95.1	101.8	95.8	103.4	90.5
March	156.4	96	96.7	110.8	106.1	131.7	119.6
April	103.4	69	73.3	78.3	62.1	76.7	66.8
May	60.1	36.8	25.2	26.5	35.5	26.2	66.3
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	3.8	0	0	0	0	0	0
September	33.8	99.9	105.7	111.1	69.6	72.8	102.2
October	7	2.3	0	0	0	1	41.3
November	20.5	64.1	56.3	59	52.6	53.4	62.1
December	84.8	26.2	25.2	24.7	18	7.2	35.7
Total	**756.4**	**565.1**	**559.8**	**597.5**	**531.3**	**564.7**	**689.2**

In the current climate the maximum amount of deficit occurs in March and it is about 156.4 mm. and the deficit in June and July is zero. August and October have a deficit below 10 mm. In the projected climate as per RCP 4.5 and 8.5 maximum deficits will occur during March and September whereas in June, July and August the deficit will be zero. Annually the amount of deficit shows a decreasing trend.

The monthly surplus of Southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 134.

Table 134. Monthly surplus under projected climate of Southern high hills (AEU14) in Palakkad district

Surplus(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	155.2	160.9	68.5	101	164.1	61.1	1.7
June	170.1	456.7	560.7	439.1	326.9	440.4	295.4
July	271.4	702.4	637	689.9	682.1	550	683.3
August	301.4	243.7	296.1	291.7	178	263.8	278.5
September	94.4	0	0	0	4.2	7.3	0
October	256.8	167.7	176.8	188.4	172.2	194.3	201.7
November	13.5	0	0	0	60.6	71.4	0
December	0	9.7	10.9	14.4	23.1	14.4	7.9
Total	**1262.8**	**1741.4**	**1750.7**	**1725.1**	**1611.1**	**1602.7**	**1468.5**

In the present condition the surplus during January, February, March, April and December is zero and the maximum is in August (301.4 mm.). As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March and April the amount of surplus will be zero. The maximum amount of surplus will occur in July. As per RCP 4.5 the surplus will be zero during September and November. There will be an increasing trend in the annual surplus during projected climate.

4.3.3.4. Monthly potential evapotranspiration, deficit and surplus of Northern high hills (AEU15) in Palakkad district

The monthly potential evapotranspiration of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 135.

Table 135. Monthly potential evapotranspiration under projected climate of Northern high hills (AEU15) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	141.2	124.8	127.2	142	135.2	138.8	152.8
February	153.2	138	139.2	141.2	127.6	139.2	155.2
March	209.6	163.5	175	187.5	177.5	183	196
April	163.4	127.6	150.8	150	136.4	148.8	161.2
May	184.4	158	186	186	165.5	197	202.5
June	135	122	137.6	140.8	128.8	154.8	168
July	166.9	146.5	165	166	151.5	185.5	205.5
August	138.5	111.2	124.4	128.8	116.8	136.4	166.8
September	164.6	141.5	149	151	137	159	199
October	122.4	108.8	110.4	122	110.4	121.6	150.8
November	123.6	107.2	112.8	118.4	107.2	113.2	145.6
December	123.6	108	110	117.6	106.8	117.2	141.2
Total	**1826.4**	**1556.9**	**1687.3**	**1750.3**	**1601.2**	**1795**	**2045.7**

At current situation, the maximum monthly potential evapotranspiration is during March (209.6 mm.) and the base value is 122.4 mm. in October. In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during March, May, July and September and the minimum will be in November and December. The yearly potential evapotranspiration during projected climate will be less as compared to the present condition.

The monthly deficit of Northern high hills (AEU15) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 136.

Table 136. Monthly deficit under projected climate of Northern high hills (AEU15) in Palakkad district

Deficit(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	141.2	123.8	115	138.5	134.2	126.8	133
February	124.3	130.8	122.3	125.5	117.7	122.4	142.6
March	199.4	145.3	159.1	169	152.3	166.4	179
April	80.2	125.2	128.4	89.5	136	114.5	150.7
May	40.3	48.9	88.9	72.5	6.2	85.5	98
June	0	2.7	0	0	0	4	0
July	30.1	0	0	0	0	0	0
August	0	0	0	0	0	0	0
September	17.9	97.5	56.2	67.2	95	47.8	135.3
October	50.6	16.9	0.1	0.6	13.6	20.4	45.2
November	104.3	95.2	68.6	77.1	88.6	62	77.5
December	108.5	80.5	54.7	92.3	74.5	62.7	92.5
Total	**896.8**	**866.5**	**793.4**	**831.8**	**818.4**	**813.1**	**1054.6**

At present the maximum deficit occurs during the month March and it is about 199.4 mm. and the deficit is zero during June and August. As per RCP 4.5 and 8.5 in projected climate every month will show a deficit except in June, July and August. In projected climate the maximum amount of deficit occurs during March.

The monthly surplus of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 137.

Table 137. Monthly surplus under projected climate of Northern high hills (AEU15) in Palakkad district

Surplus(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	28.9	141.2	0	0.4	172.7	11.3	58
June	247.5	144.7	161.2	285.3	293.4	167.9	120.3
July	120.7	559.9	392.7	247.5	436.2	376.5	438.1
August	596.9	142.3	206.6	206.9	196.6	196	192.7
September	69.4	0	16.4	17.2	0	14	0
October	0	144.8	120.6	122.3	121.4	136.9	98.3
November	0	0	108.6	108.9	0	106.5	25.4
December	0	0	0	0	0	0	0
Total	**1063.4**	**1132.9**	**1006.1**	**988.9**	**1220.1**	**1009.1**	**932.4**

Currently, there is surplus from May to September whereas in remaining months the surplus is zero. The maximum amount of surplus is occurring in August. As per RCP 4.5 and 8.5, in projected climate there will be surplus from May to November and during the remaining months the surplus will be zero. In projected climate the maximum surplus will occur during the month July. Annually the surplus shows a decreasing trend in projected climate except in 2030s.

4.3.3.5. Monthly potential evapotranspiration, deficit and surplus of Attappady hills (AEU18) in Palakkad district

The monthly potential evapotranspiration of Attappady hills (AEU18) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 138.

Table 138. Monthly potential evapotranspiration under projected climate of Attappady hills (AEU18) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.2	140.4	140	143.6	136.4	148.8	152.4
February	164.8	138.8	141.6	148.8	142.8	147.6	156.4
March	219	185	185.5	188	178.5	186.5	202.5
April	171	147.2	150.4	160.4	153.6	153.2	168.4
May	191.8	174.5	199.5	199.5	189	200.5	215.5
June	139.6	136.4	156.8	156.4	142.8	160	172
July	181.5	159	188	190.5	171	204.5	211.5
August	151.4	125.2	146.4	147.2	127.2	157.2	166.4
September	180.1	144.5	163	178	154.5	187	207
October	130	117.6	125.6	127.2	114	142.4	159.2
November	132.8	114	116.4	135.2	116	135.2	158.8
December	132.8	113.6	119.2	126.4	114	133.2	153.6
Total	**1944**	**1696.4**	**1831.7**	**1900.7**	**1739.5**	**1955.4**	**2124.3**

At present condition, the maximum potential evapotranspiration occurring is 219 mm. during March and the minimum is 130 mm. in October. In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in March, May, July and September and the minimum will be in November and December. Annual values show a decreasing trend except in 2050 and 2080 as per RCP 8.5.

The monthly deficit of Attappady hills (AEU18) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 139.

Table 139. Monthly deficit under projected climate of Attappady hills (AEU18) in Palakkad district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	129.2	131.9	128	130	124.9	137	140.3
February	151.8	121.3	137.1	131	125.4	143.1	156.4
March	65.6	176.1	170.6	174.9	162.9	171.3	189.1
April	115	130.7	117.1	148.6	132.2	135.9	136.3
May	152.8	101.2	96.8	100.9	108.6	118.7	122.4
June	77	4.4	6.7	3.9	0	0.9	27.7
July	60.3	0	0	0	0	16.8	0
August	18.6	1.3	14.3	14.7	8.3	4.6	10.3
September	67.1	83.9	52	85.2	64	61.8	106.6
October	117.5	14.4	29.6	16.8	5.4	24.1	8.1
November	127.8	72.6	65.3	89.4	70.1	79.4	127.2
December	128.8	55	89.7	78.1	57.4	103.8	123.1
Total	**1211.5**	**892.7**	**907.1**	**973.3**	**859.3**	**997.1**	**1147.9**

In the current climate the maximum amount of deficit occurs in May and it is about 152.8 mm. and every month is showing deficit. In the projected climate as per RCP 4.5 and 8.5 the maximum will occur in March whereas the minimum will be in June and July. The yearly values of deficit shows an decreasing trend in the projected climate compared to the present condition.

The monthly surplus of Attappady hills (AEU18) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 140.

Table 140. Monthly surplus under projected climate of Attappady hills (AEU18) in Palakkad district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	00
February	0	0	0	0	0	0	0
March	29.6	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	0	0	8.8	0	0	20.4	1.6
June	10.4	73.5	48.2	200.2	121.6	52.1	118.1
July	39.3	241	283.8	217.8	210.9	225.1	300.8
August	186.2	107.7	74.4	82	85.1	73.6	83.1
September	0	7.6	5.2	9.6	17.5	2.7	0
October	0	139	138.6	128.4	143.8	107.4	110.8
November	0	102.2	91.3	98.4	99.6	96.7	0
December	0	0	0	0	0	0	0
Total	**265.5**	**670.6**	**650.4**	**736.3**	**678.8**	**578.1**	**614**

In the present condition the months March, June, July and August is showing some surplus and the deficit in remaining months is zero. The maximum amount of surplus is occurring in August (186.2 mm.). As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April and December the amount of surplus will be zero. The maximum amount of surplus will occur in July. The project climate shows an increased amount of annual surplus.

4.3.3.6. Monthly potential evapotranspiration, deficit and surplus of Attappady dry hills (AEU19) in Palakkad district

The monthly potential evapotranspiration of Attappady dry hills (AEU19) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 141.

Table 141. Monthly potential evapotranspiration under projected climate of Attappady dry hills (AEU19) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	147.2	88.8	86.4	90.4	103.6	114.8	122
February	163.2	92	91.2	95.6	104	117.2	128.8
March	213.6	119.5	119.5	124.5	127.5	145	176
April	166.9	95.2	100	105.2	114.4	118.4	146
May	187.3	120	130	137	139.5	144.5	188
June	138	92.8	102.4	107.2	120.8	126.8	150
July	181.7	125	123.5	129	140.5	150.5	175
August	151.6	94	94	98	105.2	126.4	132.8
September	178.9	124	124	129	124.5	146	180
October	127.2	89.6	92.4	96.8	92	106.4	130.4
November	131.2	82.4	96.8	100.8	87.2	100.8	138.8
December	131.2	79.2	89.2	94	82.4	95.2	127.6
Total	**1918**	**1202.3**	**1249.5**	**1306.9**	**1340.6**	**1492.2**	**1795.3**

At the current situation, the maximum monthly potential evapotranspiration is during March (213.6 mm.) and the minimum in October (127.2 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during March, May, July and September and the minimum will be in December. Totally there will be a decrease in potential evapotranspiration during projected climate from the present condition.

The monthly deficit of Attappady dry hills (AEU19) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 142.

Table 142. Monthly deficit under projected climate of Attappady dry hills (AEU19) in Palakkad district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	141.2	75.1	63.4	66.3	95.6	92.4	110.6
February	155.2	86	78.4	83.1	83.4	94.2	108.5
March	144.3	92	100.2	104.8	111.7	124.3	146.9
April	135.9	27.9	56	59.8	75.6	84	83.5
May	177.3	45.6	57.6	62.7	62.9	74.6	103.2
June	109	0	0.3	1.1	0	0	14
July	99.4	0	0	0	0	0	0
August	28.9	0.7	0	0	0	3.6	0
September	105.4	87.2	79.4	83.5	90	103.9	124.4
October	126.2	26	23.1	24.2	27.3	26.6	35.7
November	129.2	60	43.1	45.9	65.7	63.9	118.9
December	129.2	66.9	30.9	33	69	51.7	119.5
Total	**1481.2**	**567.4**	**532.5**	**564.2**	**680.8**	**719.4**	**964.9**

At present the maximum deficit occurs during the month May and it is about 177.3 mm. and the minimum deficit is 28.9 during August. As per RCP 4.5 and 8.5 in projected climate every month will show a deficit except July. June and August shows small amount of deficit which will be less than 10 mm. In projected climate the maximum deficit will occurs during March and the yearly deficit values will be less as compared to the present condition.

The monthly surplus of Attappady dry hills (AEU19) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 143.

Table 143. Monthly surplus under projected climate of Attappady dry hills (AEU19) in Palakkad district

Surplus(mm) / Months	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	38.7	0	0	0	0	0	0
April	0	13.8	9.1	8.6	0	0	0
May	0	59.5	25.4	23.6	27.2	64.3	0
June	0	169.6	149.8	146.8	205	182.7	167.6
July	25.2	307.2	397	388.3	391.1	410.4	431.6
August	75.3	190.8	227.3	218.4	226.5	297	193.4
September	0	24.4	33.7	32.3	0	2.8	6.9
October	0	160.8	177.3	171.8	158.3	177.2	160.6
November	0	0	22.8	21.1	0	0	0
December	0	0	16.9	17.1	0	11.4	0
Total	**139.2**	**926.4**	**1059.3**	**1027.9**	**1007.9**	**1145.6**	**959.9**

Currently, there is surplus during the months March, July, and August whereas in remaining months the surplus is zero. The maximum amount of surplus is occurring in August. As per RCP 4.5 and 8.5, in projected climate there will be surplus during every month except January, February and March. In projected climate the maximum surplus will occur during July. In projected climate the surplus shows a high increase in the annual values.

4.3.3.7. Monthly potential evapotranspiration, deficit and surplus of Palakkad central plains (AEU22) in Palakkad district

The monthly potential evapotranspiration of Palakkad central plains (AEU22) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 144.

Table 144. Monthly potential evapotranspiration under projected climate of Palakkad central plains (AEU22) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	151.2	151.2	152.8	156.4	152	158	168.8
February	152.8	152.8	156.8	160.4	153.6	158	168.8
March	195.5	195.5	199.5	203.5	196.5	204.5	215.5
April	205.6	205.6	207.7	212.6	206.6	211.1	221.8
May	169.6	169.6	170	173.6	170.4	172.4	181.6
June	172.4	172.4	174.8	178.4	173.2	175.6	182.8
July	205.5	205.5	217.5	222	206.5	220.5	227.5
August	164.4	164.4	166.4	170	165.2	175.6	181.2
September	206	206	205.5	210	207	208	223.5
October	154.4	154.4	162.8	165.6	154.8	162.8	174
November	155.6	155.6	154.4	157.6	156.4	162	166.4
December	156	156	156.8	160	156.4	155.6	165.6
Total	**2089.3**	**2089.3**	**2124.5**	**2170.6**	**2098.8**	**2164.1**	**2276.9**

At present condition, the maximum potential evapotranspiration occurring is 206 mm. during September and the minimum is 151.2 mm. during January. In projected climate based on RCP 4.5 and 8.5 the annual potential evaopotranspiration shows an increasing trend from the present value. The maximum values will occur in March, April, July and September and the minimum will be in January.

The monthly deficit of Palakkad central plains (AEU22) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 145.

Table 145. Monthly deficit under projected climate of Palakkad central plains (AEU22) in Palakkad district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	136	142.1	147.6	154.4	150.5	153.1	167.8
February	152.8	152.8	156.8	160.4	153.6	158	168.8
March	186.8	186.8	176.3	191	179.3	197	196.6
April	160.8	160.8	140.4	124.7	160.6	143	159
May	82	82	78.4	60.5	81.9	76.7	127.3
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	63.6	63.6	58.5	62.8	65	64.2	35
September	123.6	123.6	136.4	137.8	124.2	141.6	178.1
October	53.5	53.5	53	55.2	52.5	53.6	73.2
November	122	122	122.5	112.9	121.6	133.8	124.2
December	140.2	140.2	141.9	111.7	145.9	136.3	111.8
Total	**1221.3**	**1227.4**	**1211.5**	**1171.7**	**1235.1**	**1257.7**	**1341.5**

In the current climate maximum amount of deficit occurs in March and it is about 186.8 mm whereas in June and July the deficit is zero. In the projected climate as per RCP 4.5 and 8.5 there will be deficit in every month except June and July. In the projected climate maximum deficit will occurs in March. Annual deficit shows an increasing trend as per RCP 8.5 whereas in 4.5 it shows a decreasing trend.

The monthly surplus of Palakkad central plains (AE22) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 146.

Table 146. Monthly surplus under projected climate of Palakkad central plains (AEU22) in Palakkad district

Surplus(mm) / Months	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	9.8	0	0	0
May	167.5	167.5	150.6	101.9	96.9	98.5	77.7
June	798.2	798.2	706.4	456.2	856.9	624	646.6
July	815.7	815.7	844.5	992	826.1	922.3	926.1
August	193.3	193.3	182.7	187.8	187.9	224.8	182.5
September	51.4	51.4	0	0	53.3	0	0
October	40.8	40.8	105.8	112.3	42	118.8	155
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**2066.9**	**2066.6**	**1990.2**	**1859.8**	**2062.9**	**1988.5**	**1988**

In the present condition the surplus is zero during January, February, March, April, November and December and the maximum amount of surplus is occurring in July (815.7 mm.). As per RCP 4.5 and 8.5 in projected climate, the present pattern of surplus will continue and September shows a drastic decline. The maximum amount of surplus will occur in July and the annual value shows a decreasing trend in the projected climate.

4.3.3.8. Monthly potential evapotranspiration, deficit and surplus of Palakkad eastern plains (AEU23) in Palakkad district

The monthly potential evapotranspiration of Palakkad eastern plains (AEU23) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 147.

Table 147. Monthly potential evapotranspiration under projected climate of Palakkad eastern plains (AEU23) in Palakkad district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	151.2	148.8	154.4	158	152	160.8	173.6
February	169.2	152.8	154.4	158.4	178.4	160.8	188
March	229.9	195	199.5	204.5	196.5	204	219.5
April	182.3	161.2	164	167.6	187.2	166.4	196.8
May	201.2	207	210	215	207	215	227.5
June	140.6	171.2	171.6	175.2	196.4	172.8	202
July	177.9	213	216	220.5	213	214.5	225
August	149.2	162.8	171.6	174.8	193.2	171.2	198
September	181.3	201	203	207.5	200	213	219.5
October	134.4	159.6	159.6	162.4	182.8	165.6	188
November	134	151.2	159.2	162	156.8	157.6	167.6
December	134	153.6	152.4	156	172.8	156.8	182.4
Total	**1985.2**	**2076.9**	**2115.5**	**2162.2**	**2236.4**	**2158.7**	**2387.2**

In the current condition, the maximum amount of potential evapotranspiration is occurring in March (229.9 mm.) and the minimum is in November (134 mm.) and December (134 mm.). In projected climate, the yearly value shows an increasing trend compared to the present condition. The maximum amount will occur in May, July and September and the minimum will be in January.

The monthly deficit of Palakkad eastern plains (AEU23) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 148.

Table 148. Monthly deficit under projected climate of Palakkad eastern plains (AEU23) in Palakkad district

Deficit(mm) / Months	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	151.2	147.8	138.9	151.7	151	159.8	172.6
February	169.2	152.8	154.4	158.4	178.4	160.8	188
March	229.9	173.4	186.6	187	183.5	187.5	192.7
April	155.3	154.2	152.1	161.6	176	153.3	187
May	103.8	35.6	85.1	79.1	84.8	84.3	33
June	49.8	2	5	0	9.1	0.8	1.3
July	26.8	0	0	0	0	0	0
August	20.2	17.3	30.4	31.2	35.8	3.3	6.1
September	35.1	165.6	178.1	182.2	173.3	207.8	216.5
October	13.8	91.4	87.9	90.3	106.9	85.3	43.5
November	104.1	107.5	113.4	115.5	111.6	127.6	161.9
December	127	104.4	106.2	103.6	124.9	93.8	114.2
Total	**1186.2**	**1151.6**	**1238**	**1261**	**1335.5**	**1264.4**	**1316.3**

At present there is deficit in every month and maximum deficit occurs during March (229.9 mm.) whereas October shows the least amount of deficit. As per RCP 4.5 and 8.5 in projected climate every month will show a deficit except July. In June there will be a deficit below 10 mm. In the projected climate March and September will be the months having maximum deficit. Annually the deficit shows an increasing trend in projected climate compared to the current condition.

The monthly surplus of Palakkad eastern plains (AEU23) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 149.

Table 149. Monthly surplus under projected climate of Palakkad eastern plains (AEU23) in Palakkad district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Months		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	62.1	67	19.7	0	19.1	84.5	65.5
June	160.7	150.5	193.5	393.3	169.9	178	123.8
July	566	470	346.1	339.5	339.5	369.6	428.9
August	124	115.7	137.7	139.5	122	123.8	192.6
September	27.9	0	0	0	0	0	0
October	40.9	67.6	70.6	72.8	63.2	87.2	92.9
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**981.6**	**870.4**	**767.5**	**945.3**	**713.6**	**843**	**903.5**

Currently, there is surplus in every month except January, February, March, April, November and December. The maximum amount of surplus is occurring in July and it is about 566 mm. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August and October and there will be no surplus occurs during in the remaining months. In projected climate the maximum surplus will occur during the month July and there will be a severe decline in surplus during September from the current condition. Yearly surplus shows a decreasing trend in the projected climate.

4.3.4. Computed water balance of various AEUs in Malappuram district

4.3.4.1. Monthly potential evapotranspiration, deficit and surplus of Northern coastal plains (AEU2) in Malappuram district

The monthly potential evapotranspiration of Northern coastal plains (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 150.

Table 150. Monthly potential evapotranspiration under projected climate of Northern coastal plains (AEU2) in Malappuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.2	147.6	150.8	154	148.4	153.6	162
February	165.6	152	153.2	156.4	153.2	156.8	166
March	219.4	197.5	198.5	203	198.5	202.5	211
April	172.3	164	166.8	170	164.8	169.6	175.2
May	192.3	200.5	213	228	202	217.5	226
June	139.6	164	166.4	170	165.6	169.6	184
July	181	208	208.5	213	209	213	228.5
August	151.3	158.4	168	171.2	159.2	171.6	176.4
September	180.5	201	197.5	203	202	202.5	217.5
October	130.8	158.4	159.2	162.4	159.2	162	171.2
November	133.2	152.8	157.2	160.4	153.6	160.4	162.8
December	133.2	151.6	154	156.8	152	157.2	164.8
Total	**1948.4**	**2055.4**	**2092.7**	**2148.2**	**2067.2**	**2136.4**	**2245.6**

At the current situation, the maximum monthly potential evapotranspiration is during March (219.4 mm.) and the minimum is in October (130.8 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during May, July and September and the minimum will be in January. Totally there will be an increase in potential evapotranspiration during projected climate from the present condition.

The monthly deficit of Northern coastal plains (AEU2) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 151.

Table 151. Monthly deficit under projected climate of Northern coastal plains (AEU2) in Malappuram district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.1	143.6	146.1	122.7	146.1	151.1	161
February	165.6	152	153.2	156.4	153.2	156.8	166
March	217	184.6	192.6	169.9	184.5	187.8	186.5
April	122.9	139.6	164.8	134.6	113	167.4	165.7
May	57.9	17.8	62.6	79.5	33.8	55.9	38.8
June	12.3	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	25	22.5	25.1	14.9	22.7	14.7	14.1
September	45.3	116.4	114.3	112.4	117	112.1	82.9
October	0	77.4	78.9	62.8	68.5	62.5	65.8
November	109.5	122.3	142	142.9	108	143	119.5
December	131	114.3	132.5	150.7	112.2	151.2	122
Total	**1035.6**	**1090.4**	**1211.8**	**1146.9**	**1059.1**	**1202.7**	**1122.3**

At present the maximum deficit occurs during the month March (217 mm.) and there is no deficit during July and October. As per RCP 4.5 and 8.5 in projected climate all the months will show a deficit except in June and July. Comparing the future with the present climate during the month October there will be a drastic increase in deficit. In projected climate the maximum deficit will occurs during March and the annual deficit shows an increasing trend.

The monthly surplus of Northern coastal plains (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 152.

Table 152. Monthly surplus under projected climate of Northern coastal plains (AEU2) in Malappuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	44.2	0	0	0	0	0	0
May	162.6	207.3	345.7	170.7	346.7	433	247.9
June	365.7	816.7	816.8	667.2	867.1	667.1	726.7
July	986.3	970.6	1108.2	1043.8	947.6	1026.4	1015.6
August	533.5	198.1	234.2	137.3	196.8	135.3	150.4
September	48.7	299.7	287.4	159	274.3	90.9	60.3
October	321	0	21.3	45.9	49.2	44.5	188.1
November	0	0	0	0	0	0	2.3
December	0	0	0	0	0	0	0
Total	**2462**	**2492.3**	**2813.6**	**2224**	**2681.5**	**2397.2**	**2391**

Currently, there is surplus during the months April, May, June, July, August, September and October whereas in remaining months the surplus is zero. The maximum amount of surplus is in July (986.3mm.). As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August, September and October and the maximum will be in July. In projected climate the month were surplus begins will shift from April to May and the ending month will shift from September to October.

4.3.4.2. Monthly potential evapotranspiration, deficit and surplus of Kole lands (AEU6) in Malappuram district

The monthly potential evapotranspiration of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 153.

Table 153. Monthly potential evapotranspiration under projected climate of Kole lands (AEU6) in Malappuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	148.8	150.8	154.8	148.8	155.6	164.4
February	170.8	152.4	154	157.2	150.8	156.4	164.8
March	231.6	198	199	203.5	195	200.5	213
April	184.1	164.4	166.4	170.4	164.4	167.6	175.2
May	202.1	201.5	214	218	211	217	224
June	140	164.8	166.4	170.4	163.6	176.4	182.8
July	177.3	209	209	213	205	211	228.5
August	149.5	158.8	168.4	171.6	166	168.8	181.6
September	182.2	201.5	199	203.5	196	210	216
October	135.6	158.8	159.2	162.8	157.2	157.6	169.2
November	134.8	153.2	158	161.2	156	158.8	167.6
December	134.8	152	154.8	158	152.8	159.2	161.6
Total	**1993.2**	**2062.9**	**2099.3**	**2145.3**	**2066.5**	**2138.8**	**2248.5**

At present condition, the maximum potential evapotranspiration occurring is 231.6 mm. during March and the minimum is 134.8 mm. in November and December. In projected climate based on RCP 4.5 and 8.5 the annual potential evaopotranspiration shows an increasing trend from the present value. The maximum values will occur in May, July and September and the minimum will be in January.

The monthly deficit of Kole lands (AEU6) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 154.

Table 154. Monthly deficit under projected climate of Kole lands (AEU6) in Malappuram district

Deficit(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	150.4	147.8	148.3	152.3	146	153	155.7
February	170.8	152.4	154	157.2	150.8	156.4	164.8
March	231.6	183.1	187.8	182.1	182.6	185.8	203.4
April	135.5	142.8	143.3	125.7	140.1	162.9	159.3
May	83.7	19.1	78.8	64.7	57.7	74.8	75.2
June	0	0	0	0	0	0	0
July	1.1	0	0	0	0	0	0
August	17.2	13.8	15.4	8.3	4.1	7.6	15.4
September	44.7	108.4	102.3	103.3	146.1	106.8	90.7
October	6.5	68.9	53.3	54.2	29.4	51.4	56.8
November	81.9	118.4	140.4	144.1	137.1	141.9	161.1
December	113.6	95	149.1	152.2	146.7	153.5	148
Total	**1037**	**1049.7**	**1173**	**1144.8**	**1140.4**	**1194.3**	**1230.3**

In the current climate the maximum amount of deficit occurs in March and it is about 231.6 mm. and there is no deficit in June. July and August have a deficit below 10 mm. In the projected climate as per RCP 4.5 and 8.5 every months show a deficit except in June and July. The annual deficit shows an increasing trend from the current condition.

The monthly surplus of Kole lands (AEU6) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 155.

Table 155. Monthly surplus under projected climate of Kole lands (AEU6) in Malappuram district

Surplus(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	142.8	241.2	211.6	294	246.8	168.9	130.6
June	458.4	933	975.2	799	1263.1	1066.2	630.8
July	575.6	838.1	1063	908.4	1061.4	872	888.7
August	481.7	192.8	146.6	131.5	124.3	155.2	235.5
September	50.2	280.5	80.2	69.1	62.8	58.4	102.7
October	185.8	0	46.2	44.7	46.2	52.3	120.3
November	48.9	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**1943.4**	**2485.3**	**2522.8**	**2248.5**	**2804.5**	**2373.3**	**2108.4**

In the present condition there surplus during January, February, March, April and December is zero and the maximum amount of surplus is in July (575.6 mm.). As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April, November and December the amount of surplus will be zero and the maximum will be in June. Annually the surplus will shows an increasing trend from the existing condition. .

4.3.4.3. Monthly potential evapotranspiration, deficit and surplus of Northern laterites (AEU11) in Malappuram district

The monthly potential evapotranspiration of Northern laterites (AEU11) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 156.

Table 156. Monthly potential evapotranspiration under projected climate of Northern laterites (AEU11) in Malappuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	151.2	145.2	148.8	152.4	146.4	152.4	162
February	170.4	147.6	150.4	154.4	147.6	154	162.8
March	232	191	193.5	197.5	189.5	197	210
April	184.3	161.2	161.6	165.2	158.8	164.8	173.2
May	203.7	206	210	214	206.5	214	221.5
June	141.8	160	170.4	174	168	174.4	180.8
July	178.4	200.5	203	208	199	207.5	226
August	149.9	162.4	162.4	166	159.6	166	179.2
September	181.9	191	203	207.5	199.5	207	213.5
October	135.2	153.6	151.6	155.2	148.8	155.2	167.2
November	134	152.4	153.2	156.8	150.8	156.8	165.6
December	134	149.2	153.6	156.8	151.2	156.8	159.2
Total	**1996.8**	**2019.9**	**2060.9**	**2107.9**	**2025.9**	**2106.1**	**2220.3**

In the current condition, the maximum amount of potential evapotranspiration is occurring in March (232 mm.) and the minimum in November (134 mm.) and December (134 mm.). In projected climate, the yearly value shows an increasing trend compared to the present condition. The maximum amount will occur in May and July whereas the minimum will be in January.

The monthly deficit of Northern laterites (AEU11) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 157.

Table 157. Monthly deficit under projected climate of Northern laterites (AEU11) in Malappuram district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	144.5	144.2	147.8	150.2	145.4	151.4	161
February	169.4	147.6	150.4	154.4	147.6	154	162.8
March	232	179.1	174.7	177.9	172.6	179.5	193.9
April	142.4	138.9	130	121.2	148.5	138.5	144.9
May	90.5	29	59.8	69.8	29.1	67.2	65
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	10.2	14.7	14.8	13.8	13.9	13.6	6.4
September	55.1	152.4	162.1	165.1	159.2	164.7	165.4
October	0	90.1	62.1	63.9	60.6	64	52.6
November	83.9	107.3	109.3	124.1	107.6	111.7	126.7
December	131	116.7	117.9	116.9	115	119.6	121.6
Total	**1059**	**1119.8**	**1128.5**	**1157.2**	**1099.7**	**1164.2**	**1199.8**

At present the maximum deficit occurs during the month March (232 mm.) and the deficit during June, July and October is zero. As per RCP 4.5 and 8.5 in projected climate all the months will show a deficit except in June and July. The maximum amount of deficit will occur during March. Annually the deficit shows an increasing trend in the projected climate.

The monthly surplus of Northern laterites (AEU11) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 158.

Table 158. Monthly surplus under projected climate of Northern laterites (AEU11) in Malappuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	100.5	244.2	154	189.2	283.6	177.7	156
June	350.5	720.5	906	943.1	758.1	1057.3	807.5
July	1085.8	1077.8	1087.7	999.4	1061.5	990.4	893.6
August	337.9	228.8	264.6	273.1	255.5	271.1	244.2
September	87.7	132.6	92.8	98.7	91.6	96.6	0
October	356.1	17.3	78.5	81.7	78.3	79.8	262.6
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**2318.5**	**2421.2**	**2583.6**	**2584.9**	**2528.5**	**2672.7**	**2364.1**

Currently, there is surplus in all the months except January, February and March, April, November and December. The maximum amount of surplus is occurring in July and it is about 1085.8 mm. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August, September and October whereas in remaining months the surplus will be zero. In projected climate the maximum surplus will occur during the month July and annually it shows an increasing trend.

4.3.4.4. Monthly potential evapotranspiration, deficit and surplus of Northern foothills (AEU13) in Malappuram district

The monthly potential evapotranspiration of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 159.

Table 159. Monthly potential evapotranspiration under projected climate of Northern foothills (AEU13) in Malappuram district

PET(mm) Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	146	146	149.6	153.6	147.2	154.8	166.8
February	150.4	150.4	154	157.2	151.2	155.2	166.8
March	191	191	196	200.5	192	201	213
April	158.8	158.8	162.4	166	159.6	165.2	174.4
May	205	205	209.5	214	206	212	224.5
June	168.8	168.8	172.4	176	169.6	172.8	180.8
July	210	210	214.5	218.5	211	217.5	224.5
August	159.6	159.6	163.6	167.2	160.4	172.8	178.4
September	197.5	197.5	202	206.5	198.5	204	221.5
October	156.8	156.8	160	163.6	157.6	160	172
November	147.2	147.2	150.8	154	148	159.2	164
December	150.8	150.8	153.6	157.2	151.6	152.4	163.2
Total	**2042.2**	**2042.2**	**2088.5**	**2133.9**	**2053**	**2126.8**	**2249.5**

At the present condition, the maximum potential evapotranspiration occurring is 210 mm. during July and the minimum is 146 mm. in January. In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and July and the minimum will be in January. The yearly potential evapotranspiration will be higher in projected climate than present condition.

The monthly deficit of Northern foothills (AEU13) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 160.

Table 160. Monthly deficit under projected climate of Northern foothills (AEU13) in Malappuram district

Deficit(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	145.4	144.4	140.7	152.6	137.6	150.9	165.8
February	150.4	150.4	154	157.2	151.2	155.2	166.8
March	184.9	184.9	181.7	180.9	186.5	191.3	194.4
April	67.2	67.2	145.2	149.5	142.2	128.6	167.7
May	26.1	26.1	29.6	47.3	47.5	29.3	83.4
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	11.5	11.5	4.1	5.3	11.3	6.9	0
September	157.5	157.5	154.4	156.6	158.2	154.5	174
October	56.1	56.1	83.8	85.7	104.2	90.8	93.2
November	127.7	127.7	124.6	125.7	115.3	149	130
December	119.5	119.5	138.4	147.8	115.7	111.1	110.2
Total	**1046.3**	**1045.3**	**1156.5**	**1208.2**	**1169.7**	**1167.5**	**1284.9**

In the current climate the maximum amount of deficit occurs in March and it is about 184.9 mm. and the deficit is zero in June and July. In the projected climate as per RCP 4.5 and 8.5 the maximum will occur in March whereas in June and July the deficit will be zero. In projected climate during August there will deficit below 10 mm. Annually the deficit shows an increasing trend compared with the current condition.

The monthly surplus of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 161.

Table 161. Monthly surplus under projected climate of Northern foothills (AEU13) in Malappuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0.9	0.9	0	0	0	0	0
May	143.1	143.1	93.3	154.5	183	94.4	175.5
June	657.3	657.3	782.3	516.8	744.1	724.8	809.9
July	1130.5	1130.5	1040.3	1022.8	1015.3	1058.8	1053.5
August	255.5	255.5	172.1	177.2	255.4	220.7	206.7
September	1.2	1.2	4.2	2.2	0	0	0
October	161.5	161.5	105.9	113.1	137.9	114.2	228.8
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**2349.7**	**2349.7**	**2197.7**	**1986.5**	**2335.3**	**2212.9**	**2474.2**

In the present condition the surplus is zero during January, February, March, November and December and the maximum amount of surplus is in July (1130.5 mm.). As per RCP 4.5 and 8.5 in projected climate, during the months January, February, March, April, November and December the amount of surplus will be zero. The maximum amount of surplus will occur in July. Based on projections annual value of deficit shows a decreasing trend but there will be an increase in 2080 as per RCP 8.5.

4.3.4.5. Monthly potential evapotranspiration, deficit and surplus of Northern high hills (AEU15) in Malappuram district

The monthly potential evapotranspiration of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 162.

Table 162. Monthly potential evapotranspiration under projected climate of Northern high hills (AEU15) in Malappuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	141.2	150.4	154.8	158	151.2	157.6	171.2
February	153.2	150.8	179.2	160	151.6	159.6	172
March	209.6	195	196.5	202.5	195.5	202	218
April	163.4	160.4	189.6	168.8	161.2	168.8	178.4
May	184.4	205.5	210	215	207	215	227.5
June	135	168	196.4	174.4	169.2	174	182.4
July	166.9	212.5	212.5	217.5	213.5	217.5	227.6
August	138.5	168.8	194	174.8	169.2	174.8	179.6
September	164.6	198.5	209.5	214	200	214	219.5
October	122.4	155.6	180.8	161.2	156.8	160.8	171.6
November	123.6	155.2	155.2	158.8	155.6	158.4	169.2
December	123.6	148	178	159.6	149.2	159.2	167.6
Total	**1826.4**	**2068.1**	**2256.6**	**2163.7**	**2080.4**	**2160.8**	**2284.2**

At current situation, the maximum potential evapotranspiration is in March (209.6 mm.) and the base value is 122.4 mm. in October. In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during May and July and the minimum will be in January and December. Totally there will be an increase in potential evapotranspiration during projected climate from the present condition.

The monthly deficit of Northern high hills (AEU15) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 163.

Table 163. Monthly deficit under projected climate of Northern high hills (AEU15) in Malappuram district

Deficit(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	141.2	149.4	149.7	149.5	146.3	152.8	170.2
February	124.3	150.8	179.2	160	151.6	159.6	172
March	199.4	188	192.5	189.5	189.2	192.7	202.9
April	80.2	118	159.8	124.9	70.4	147.9	176.6
May	38.7	14	26.7	35.1	33.9	24.6	82.9
June	0	0	0	0	0	0	0
July	27.6	0	0	0	0	0	0
August	0	18.3	23	20.9	18.5	17	5.7
September	15.4	170	176.5	180.3	171.3	180.8	147.4
October	48.1	46	58.5	49.6	46.2	47.7	27.7
November	104.3	132.4	130.6	117.4	131.5	133.4	129.2
December	108.5	124.8	156.9	111.8	128.8	138.7	101.6
Total	**887.7**	**1111.5**	**1253.6**	**1138.4**	**1088.2**	**1194.6**	**1215.9**

At present the maximum deficit occurs during the month March and it is about 199.4 mm. and the deficit is zero during June and August. As per RCP 4.5 and 8.5 in projected climate every months will show a deficit except in June and July. Comparing the present and future climate during the month August there will be an increase in deficit from zero whereas in July there will be a drastic decrease.

The monthly surplus of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 164.

Table 164. Monthly surplus under projected climate of Northern high hills (AEU15) in Malappuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	24.8	199.6	79.4	132.3	220.5	142	61.9
June	247.5	558.9	689.5	361.9	543.2	291.6	533.7
July	118.2	1100.6	1011.9	1227.6	981.5	859.3	917.7
August	596.9	210.3	184.5	219.4	203.1	187.2	234.2
September	66.9	0	0	0	0	0	147
October	0	128.1	124.7	144.1	130.4	132.2	136.4
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**1054.3**	**2197.6**	**2090.2**	**2085.2**	**2078.8**	**1612.2**	**2031.1**

Currently, there is surplus during the months May, June, July, August and September whereas in remaining months the surplus is zero. The maximum amount of surplus is occurring in August. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August and October. In projected climate the maximum surplus will occur during the month July. There will be a drastic increase in the amount of surplus during October whereas in September the surplus shows a decline.

4.4. Water requirement

4.4.1. Water requirement of major cropping systems of various AEUs in Ernakulam district and impact of climate change

Crop evapotranspiration of major cropping systems of various AEUs in Ernakulam district were studied and given in table 165.

Considering AEU5, the major cropping systems practiced in this unit are Rice-Fallow-Fallow followed by Coconut based cropping system. In rice-fallow-fallow cropping system rice is cultivated during the first season called as virippu. Second and third season is leaving as fallow. The duration of crop is from May to August. The date of transplanting is on June 1st week and harvesting is carried on last week of August. As per RCP 4.5 and 8.5 there will be an increasing trend in crop evapotranspiration in future climate from the present condition. Coconut is a perennial crop so that in coconut based cropping system the planting date is considered on January 1st week and the crop evapotranspiration is calculated for a year. In this cropping system the crop evapotranspiration shows a decreasing trend in future climate based on RCP 4.5 and 8.5. In 2080 as per RCP 8.5 annually the crop evapotranspiration will be higher than the existing climate.

The major cropping systems practiced in AEU9 are Rice-Rice-Fallow and Coconut based. In Rice-Rice-Fallow cropping system, the first and second season is cultivated with rice known as virippu and mundakan were the duration of first crop starts from May to August and the second crop starts from August to January. The date of transplanting of first crop is on June 1st week and harvesting on last week of August. And for second crop transplanting is done on September last week and harvesting is carried on January 1st week. In projected climate the evapotranspiration shows an increasing trend compared with the present climate. In coconut based cropping system the crop evapotranspiration in future climate will be less compared to the present condition. But in 2080 as per RCP 8.5 there will be an increase in crop evapotranspiration from the existing condition.

Considering AEU12 the cropping systems practiced in this unit are Rice-Fallow-Fallow and rubber based. In Rice-Fallow-Fallow cropping system the crop evapotranspiration shows an increasing trend in projected climate as indicated by RCP 4.5 and 8.5 from the current condition. But as in the case of Rubber based cropping system the amount of crop evapotranspiration shows a decreased value in future climate from the present condition. As per RCP 8.5 in 2080 there will be a chance of crop evapotranspiration higher than the existing condition.

Rice-Rice-Fallow and rubber based are the major cropping systems carried out in AEU14. In Rice-Rice-Fallow cropping system considering the annual crop evapotranspiration the projected climate based on RCP 4.5 and 8.5 shows an increase from the current state. In the case of rubber based cropping system the crop evapotranspiration will be less in future climate compared to the present condition. Only in 2080 as per RCP 8.5 the crop evapotranspiration shows a greater amount than the present climate.

The water requirements of major cropping systems of various AEUs in Ernakulam district were studied and represented in table166.

In AEU5 considering the Rice-Fallow-Fallow cropping system there will not have much variation in the water requirement in projected climate compared to the present condition. In coconut based cropping system the water requirement shows an increasing trend from the current climate. At present state irrigation is not required during 7 months whereas in projected climate this period will reduce to 5 months. The periods were irrigation required increases in projected climate. Annually the water requirement in future climate will be higher as compared to the present condition.

Considering AEU9, the cropping systems performed in this unit are Rice-Rice-Fallow and coconut based. In Rice-Rice-Fallow cropping system there will not have any variation in water requirement during first crop season but in the case of second crop the value of water requirement will increase during projected climate from the present condition. Annually also the requirement shows a drastic increase. In coconut based cropping system annually the future climate shows a high value of water requirement than the current condition. In projected climate during January, February and March the water requirement shows a decreased value compared to the present condition whereas in April, September, November and December there will be an increase in water requirement during future climate.

Rice-Fallow-Fallow and Rubber based cropping systems are carried out in AEU12. In Rice-Fallow-Fallow cropping system there will not have much variation in water requirement during projected climate compared to the present condition. In rubber based cropping system the number of months where irrigation is required shows an increase during projected climate from the current condition. In projected climate as per RCP 4.5 and 8.5 January and December shows a decreased value of water requirement compared to the present state. But during April, September and October the amount of water required for irrigation shows a drastic increase.

Considering AEU14, Rice-Rice-Fallow and rubber are the major cropping systems in this unit. In Rice-Rice-Fallow cropping system the first crop doesn't show much variation in water requirement during projected climate compared to the present condition. But in the case of second crop there will be fluctuations in irrigation requirement. Annually the water requirement shows an increasing trend during projected climate from present condition. In rubber based cropping system, there will be an increase in water requirement during projected climate. At present condition from May to November irrigation is not required but in future climate the number of months were irrigation required will increase. In projected climate there will be a drastic increase in water requirement during September and November. Comparing all the cropping systems rubber based cropping system in AEU12 and AEU14 will have the high water requirement.

Table165. Crop evapotranspiration of major cropping systems of various AEUs in Ernakulam district

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
			Crop evapotranspiration ET_c (mm)													
AEU5 Pokkali lands	Rice-Fallow-Fallow		Present	*	*	*	*	19.9	123.6	127.7	90.7	*	*	*	*	**361.9**
		4.5	2030	*	*	*	*	19.4	126.1	130.1	94.9	*	*	*	*	**370.5**
			2050	*	*	*	*	19.5	127.4	131.2	95.6	*	*	*	*	**373.7**
			2080	*	*	*	*	19.7	129	132.8	96.7	*	*	*	*	**378.2**
		8.5	2030	*	*	*	*	19.4	126.4	130.5	95	*	*	*	*	**371.3**
			2050	*	*	*	*	19.5	127.4	137.2	95.5	*	*	*	*	**379.6**
			2080	*	*	*	*	20.5	133.3	138.8	99.7	*	*	*	*	**392.3**
	Coconut		Present	103.9	99.5	110.6	100	88.1	84.1	85.2	84.6	84.9	90.5	87	96.1	**1114.5**
		4.5	2030	96.8	88.3	95.4	85.6	79.9	86	87.2	88.6	88.8	92.6	88.3	94	**1071.5**
			2050	98	89.4	96.3	86.4	80.2	86.8	88	89.2	89.7	93.5	89.2	95.1	**1081.8**
			2080	99.6	90.7	97.8	87.6	81.2	87.8	89	90.3	90.8	94.7	90.1	96.2	**1095.8**
		8.5	2030	96.5	87.5	94.8	84.7	108.6	86.2	87.4	88.6	89	92.9	88.4	94.4	**1099**
			2050	99	90.6	98	89.5	79.3	86.8	90.7	89	89.5	95	90	96.7	**1094.1**
			2080	103.3	93.5	101.1	92.7	84	90.7	92.5	92.8	93	95.8	92.6	100.9	**1132.9**
AEU9 South central laterites	Rice-Rice-Fallow		Present	4.6	*	*	*	21.4	125.1	127.7	91.6	50.7	133.4	135.9	143.4	**833.8**
		4.5	2030	4.4	*	*	*	21.2	126.3	133.4	97.8	51.5	135.5	136.4	139.9	**846.4**
			2050	4.4	*	*	*	21.3	127.7	134.8	98.8	52.1	137.1	137.9	141.8	**855.6**
			2080	4.5	*	*	*	21.6	129.2	136.5	100.1	52.6	138.8	140	143.6	**866.9**
		8.5	2030	4.5	*	*	*	21.2	126.7	133.7	196.2	51.7	135.9	136.9	142.6	**949.4**
			2050	4.6	*	*	*	21.6	131	134.9	98.1	53.4	136.6	137.4	144.7	**862.3**
			2080	4.6	*	*	*	22.1	134.4	141.4	102.6	54.7	142.8	143.2	144.7	**890.5**
	Coconut		Present	105.1	101.2	113.8	102.8	101.4	85.2	85.2	84.6	84.9	90.6	87.8	96.1	**1138.7**
		4.5	2030	106.2	101.7	111.5	98.5	91.2	73.7	75.5	76.1	82.2	92.2	89.7	98.1	**1096.6**
			2050	107.5	102.4	112.6	99.4	92.2	74.4	76	76.7	83.2	93.2	90.7	99.3	**1107.6**
			2080	109	104.5	114.4	100.7	93.3	75.3	77	77.6	84.1	94.4	92	100.6	**1122.9**
		8.5	2030	106.7	102	111.8	98.5	91.5	73.8	75.6	76.2	82.5	92.5	90	99.6	**1100.7**
			2050	109.5	103.6	113.2	99.5	92.5	75.5	75.7	76.9	86.1	92.9	90.6	101.2	**1117.2**
			2080	112.7	107	116.9	102.1	94.5	77.8	79.6	79.6	87.1	97.1	94.3	102	**1150.7**

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				Crop evapotranspiration ET_c (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU12 Southern and central foothills	Rice-Fallow-Fallow		Present	*	*	*	*	21.4	125.1	127.7	90.7	*	*	*	*	**364.9**
		4.5	2030	*	*	*	*	20.8	127.2	135.6	97.8	*	*	*	*	**381.4**
			2050	*	*	*	*	21.1	128.5	137.1	98.8	*	*	*	*	**385.5**
			2080	*	*	*	*	21.4	130.2	139	100.1	*	*	*	*	**390.7**
		8.5	2030	*	*	*	*	20.9	127.5	135.9	97.9	*	*	*	*	**382.2**
			2050	*	*	*	*	21.4	129.1	137.2	99.2	*	*	*	*	**386.9**
			2080	*	*	*	*	22.1	133.3	141	100.5	*	*	*	*	**396.9**
	Rubber		Present	133.8	130.5	145.7	131.1	105.7	108	107.8	107.2	107.1	113.4	108.2	120.8	**1419.3**
		4.5	2030	120	115.2	126.1	116.9	95.9	109.7	112.9	113.6	110.5	109.6	100.7	110.9	**1342**
			2050	121.5	116.3	127.5	118	96.8	110.8	113.9	114.6	11.7	110.8	101.8	112.2	**1255.2**
			2080	123.9	118.1	129.8	120.2	98.2	112.3	115.1	115.9	113.3	112.7	103.5	114.4	**1377.4**
		8.5	2030	120.3	115.2	126.3	117.1	96.1	109.9	113.2	113.8	110.8	109.9	100.8	111.1	**1344.5**
			2050	123.4	117.5	129.8	119	98.4	111.4	114.5	115.2	112.5	113.8	102.4	111.9	**1369.8**
			2080	132.3	125.8	137	124.1	101.5	115	118.1	117.8	115.1	117.3	108.3	118.9	**1431.2**
AEU14 Southern high hills	Rice-Rice-Fallow		Present	4.6	*	*	*	21.5	125.3	127.7	92.6	50.7	133.1	133.5	142.5	**831.5**
		4.5	2030	4.5	*	*	*	21	127.1	135.6	99.2	53.2	138.2	133.9	140.6	**853.3**
			2050	4.5	*	*	*	21.1	129	135	98.6	53.4	139.3	138	141.3	**860.2**
			2080	4.6	*	*	*	21.4	130.7	136.7	100.1	54.2	141.2	139.9	143.6	**872.4**
		8.5	2030	4.5	*	*	*	21	127.8	133.9	98	53.1	137.9	136.5	140.1	**852.8**
			2050	4.7	*	*	*	21.4	129.7	133.9	98	53.7	140.1	139.2	146.1	**866.8**
			2080	4.9	*	*	*	22.2	135	141.2	103	55.1	144	143.6	150.9	**899.9**
	Rubber		Present	130.9	127.8	143.7	131.2	109.4	108	107.8	106.7	105.6	111	105.6	118.3	**1406**
		4.5	2030	122.8	116.9	128.7	117.7	105.3	109.7	112.7	112.5	108.5	109.8	100.2	111.4	**1356.2**
			2050	132.7	122.6	129.9	119.5	115.7	99.8	101.7	102.3	93.1	120.1	114.8	123.6	**1375.8**
			2080	134.4	124.2	131.7	121.2	117.5	101.2	103	103.7	94.4	121.5	116.4	125.1	**1394.3**
		8.5	2030	131.7	121.7	129.2	118.8	115	99.1	101	101.7	92.4	118.9	113.6	122.4	**1365.5**
			2050	136.5	125.2	132.9	121	117.7	99.7	100.3	101.1	93.4	120.7	115.6	127.5	**1391.6**
			2080	142	131.3	138.6	126.4	121.7	103.9	105.4	106	95.9	124	119	131.5	**1445.7**

Table166. Water requirement of major cropping systems of various AEUs in Ernakulam district

				Water Requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU5 Pokkali lands	Rice-Fallow-Fallow		Present	*	*	*	*	129.6	0	0	0	*	*	*	*	**129.6**
		4.5	2030	*	*	*	*	129.6	0	0	0	*	*	*	*	**129.6**
			2050	*	*	*	*	129.6	0	0	0	*	*	*	*	**129.6**
			2080	*	*	*	*	129.6	0	0	0	*	*	*	*	**129.6**
		8.5	2030	*	*	*	*	129.6	0	0	0	*	*	*	*	**129.6**
			2050	*	*	*	*	129.6	0	0	0	*	*	*	*	**129.6**
			2080	*	*	*	*	129.7	0	0	0	*	*	*	*	**129.7**
	Coconut		Present	89.5	53	0.8	0	0	0	0	0	0	0	11.5	80.5	**235.3**
		4.5	2030	89.7	75.3	85	27.5	0	0	0	0	79.1	0	55.5	80.3	**492.4**
			2050	78	85.8	70.5	23	0	0	0	0	81.4	0	51.6	81.2	**471.5**
			2080	78.5	84.7	71.4	22.6	0	0	0	0	0	0	48	82.3	**387.5**
		8.5	2030	76.4	84.5	66.1	36.4	0	0	0	0	79.2	0	55	80.3	**477.9**
			2050	77.6	89.5	70	35	0	0	0	0	0	0	31.4	49.2	**352.7**
			2080	75.7	88.2	68.5	61.5	0	0	0	0	12.3	0	52.7	45.1	**404**
AEU9 South central laterites	Rice-Rice-Fallow		Present	4.6	*	*	*	85.5	0	0	0.9	89	2	71.9	32.7	**286.6**
		4.5	2030	4.4	*	*	*	85.5	0	0	0.9	106.4	4.3	121.8	94.7	**418**
			2050	4.4	*	*	*	85.5	0	0	0.9	131.8	0	103.6	132.9	**459.1**
			2080	4.5	*	*	*	85.5	0	0	0.9	102	6.2	121.4	91.1	**411.6**
		8.5	2030	4.5	*	*	*	85.5	0	0	0.9	131.4	2.4	122.1	95.3	**442.1**
			2050	4.6	*	*	*	85.5	0	0	0.9	101.2	0	75.4	93.6	**361.2**
			2080	4.6	*	*	*	85.6	0	0	1	89.4	1.6	105.9	85.5	**373.6**
	Coconut		Present	105	99.3	112.7	18.6	0	0	0	0	0	0	24	5.5	**365.1**
		4.5	2030	74.7	100.7	79.3	55.6	0	0	0	0	21.6	0	75.1	52.8	**459.8**
			2050	86.8	92.7	89.6	43.6	0	0	0	0	73.7	0	56.4	90.4	**533.2**
			2080	85.4	92.7	91.1	64.5	0	0	0	0	9.7	0	73.4	48.1	**464.9**
		8.5	2030	82.1	92	88.4	43.5	0	0	0	0	72.4	0	75	82.1	**535.5**
			2050	86.3	92.3	90.5	68.2	0	0	0	0	11.2	0	28.6	50	**427.1**
			2080	94.9	99.4	88.1	83.6	0	0	0	0	0	0	57.1	42.9	**466**

				Water Requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU12 Southern and central foothills	Rice-Fallow-Fallow		Present	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
		4.5	2030	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
			2050	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
			2080	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
		8.5	2030	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
			2050	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
			2080	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
	Rubber		Present	117.4	83.1	72.5	2.5	0	0	0	0	0	0	0	76.9	**352.4**
		4.5	2030	94.9	114.4	101.5	68.2	0	0	0	0	60.2	0	64.9	56.4	**560.5**
			2050	96.8	115.4	103.3	68.4	0	0	0	0	68.6	0	64.4	54.4	**571.3**
			2080	99.9	117.3	102	67.5	0	0	0	0	10.6	0	7.1	50.1	**454.5**
		8.5	2030	94.6	114.5	101.4	67.9	0	0	0	0	59.8	0	64.2	54.5	**556.9**
			2050	99.6	116.7	102.4	67.3	0	0	0	0	34	0	5.8	50.4	**476.2**
			2080	109	124.4	112.1	72.6	0	0	0	0	9.7	0	0	43	**470.8**
AEU14 Southern high hills	Rice-Rice-Fallow		Present	4.6	*	*	*	127.8	0	0	0.9	131.9	0	8.5	108.1	**381.8**
		4.5	2030	4.5	*	*	*	127.7	0	0	0.9	157.7	0	95.2	90.5	**476.5**
			2050	4.5	*	*	*	127.7	0	0	0.9	141	4.1	101.8	64.7	**444.7**
			2080	4.6	*	*	*	127.8	0	0	0.9	148.7	3.7	105	60.9	**451.6**
		8.5	2030	4.5	*	*	*	127.7	0	0	0.9	157.2	0.3	113.2	74	**477.8**
			2050	4.7	*	*	*	127.8	0	0	0.9	148.2	2.5	86	66.2	**436.3**
			2080	4.9	*	*	*	127.8	0	0	1	141.2	0	11.6	75.9	**362.4**
	Rubber		Present	129.8	106.6	90.8	73.3	0	0	0	0	0	0	0	83.9	**484.4**
		4.5	2030	98.5	115.8	98.3	80.5	0	0	0	0	60.8	0	61.4	61.1	**576.4**
			2050	106.7	121.3	99.3	87.8	0	0	0	0	15	0	78.5	47	**555.6**
			2080	109.5	122.9	98.5	84.9	0	0	0	0	34.8	0	81.4	42.6	**574.6**
		8.5	2030	107.8	120.4	98.1	87.7	0	0	0	0	56.7	0	90.2	56.3	**617.2**
			2050	111.7	123.9	99.7	85.9	0	0	0	0	32.8	0	62.4	47.7	**564.1**
			2080	120.9	127.4	105.6	97.1	108	0	0	0	14.1	0	1.4	56.5	**631**

4.4.2. Water requirements of major cropping systems of various AEUs in Thrissur district and impact of climate change

Crop evapotranspiration of major cropping systems of various AEUs in Thrissur district were studied and presented in table167.

Considering AEU2 the major cropping systems carried out in this unit are Rice-Fallow-Fallow and coconut. In Rice-Fallow-Fallow cropping system the duration of crop is from May to August. The future climate shows an increasing trend in crop evapotranspiration as per RCP 4.5 and 8.5. In coconut based cropping system the crop evapotranspiration in future climate shows an increasing trend from the present condition. There will be a decrease in crop evapotranspiration as per RCP 4.5 during 2050. In AEU5, Rice-Rice-Vegetable and coconut based are the main cropping systems. In Rice-Rice-Vegetable cropping system the first and second season is cultivated with rice. And the duration of first and second crop is from May to August and August to January. The third crop is vegetable were its planting date is on 3rd week of January and harvesting is done on May 3rd week. As per RCP 4.5 and 8.5 the crop evapotranspiration shows an increasing trend in projected climate compared to the present condition.

Considering AEU6, Rice-Fallow-Fallow and coconut+ pepper+ banana are the major cropping systems. In Rice-Fallow-Fallow cropping system as per RCP 4.5 and 8 annually the amount of crop evapotranspiration happening in future climate will be higher than the current condition. In projected climate the maximum crop evapotranspiration will happens during June and July. In coconut+ pepper+ banana based cropping system the crop evapotranspiration shows a slight variation in projected climate from the current condition as per RCP 4.5 and 8.5 and in 2080 there will be an increase in crop evapotranspiration compared to the present climate. In view of AEU10 the major cropping systems practiced in this unit are Rice-Rice-Fallow and coconut based. In Rice-Rice-Fallow based cropping system the amount of crop evapotranspiration happens in projected climate will be higher than that of the existing condition. In the case of coconut based cropping system the future values of crop evapotranspiration shows a decreasing trend from the current condition.

In view of AEU14, Rice-Rice-Fallow and coconut+ banana are the major cropping systems carried out in this unit. In Rice-Rice-Fallow cropping system as indicated by RCP 4.5 and 8.5 the crop evapotranspiration shows an increasing trend compared to the present condition. Maximum crop evapotranspiration occur during June, July, October, November and December. In coconut+ banana based cropping system the amount of crop evapotranspiration happens during projected climate will be lesser than the present condition. In projected climate based on RCP 4.5 and 8.5 there will be a higher value of crop evapotranspiration occurs during 2080. Considering AEU15 the major cropping systems in this unit are Rice-Rice-Fallow and rubber based. In Rice-Rice-Fallow cropping system as indicated by RCP 4.5 and 8.5 the crop evapotranspiration shows an increasing trend compared to the current condition. In rubber based cropping system the amount of crop evapotranspiration happens during projected climate will be lesser than the present condition. In projected climate based on RCP 4.5 and 8.5 there will be a higher value of crop evapotranspiration occurs during 2080 in contrast with the current climate.

Water requirement of major cropping systems of various AEUs in Thrissur district were studied and presented in table168.

In AEU2 the major cropping systems are Rice-Rice-Fallow and coconut. In Rice-Rice-Fallow cropping system the future climate will not have any considerable change in water requirement as compared to the present condition. In coconut based cropping system the water requirement shows an increasing trend during projected climate. As per RCP 8.5 in 2050 the amount of water requirement will become lower than the present condition. The periods were irrigation needed also increase during future climate. Considering AEU5 Rice-Rice-Vegetable and coconut are the major cropping systems. In Rice-Rice-Vegetable cropping system the projected climate shows a high increase in water requirement as per RCP 4.5 and 8.5 compared to the present climate. The periods were irrigation required also increases during future climate. The irrigation will be needed maximum during May and September. In coconut based cropping system the projected climate shows a severe increase in water requirement compared to the present condition. At present irrigation is needed during four months. But in the case of future climate it will expand to seven months.

Considering AEU6, Rice-Fallow-Fallow and coconut+ pepper+ banana are the major cropping systems. In Rice-Fallow-Fallow cropping system there will not be any visible variations in water requirement during projected climate. In the case of coconut+ pepper+ banana cropping system during projected climate the water requirement shows an increase in 2030 and 2050. But in 2080 as per RCP 4.5 and 8.5 the water requirement shows a value which will be lower than the present condition. The numbers of periods were irrigation required will increase during future climate. In AEU10 the major cropping systems are Rice-Rice-Fallow and coconut based. In Rice-Rice-Fallow cropping system compared to the current condition the projected climate shows an increased amount of irrigation requirement. During cropping season all months need irrigation except June and July. In coconut based cropping system the projected water requirement shows an increased value compared to the present condition. There will be a decrease during 2050 as per RCP 4.5 and 8.5. The periods were irrigation required will increase and September shows a drastic increase during projected climate.

In view of AEU14, Rice-Rice-Fallow and coconut+ banana are the major cropping systems. In Rice-Rice-Fallow cropping system during projected climate as per RCP 4.5 and 8.5 the water requirement shows an increased value compared to the current climate. There will be a drastic increase in water requirement during November. In the case of coconut+ banana cropping system the future water requirement value will be higher than that of the present condition. The periods were irrigation required will also increase during projected climate. Considering AEU15, the major cropping systems practiced in this unit are Rice-Rice-Fallow and rubber based. In Rice-Rice-Fallow cropping system the future climate shows an increasing trend in irrigation requirement. Only in 2080 shows a decreased value as per RCP 4.5 and 8.5. The period of water requirement will increase during projected climate. In rubber based cropping system annually there will be a high increase in water requirement during projected climate compared to the present condition. The period of water requirement will increase and there will be a drastic increase in water requirement during September and November in projected climate. As per RCP 8.5, the water requirement shows a decreased value in 2080. Rice-Rice-Vegetable cropping system in AEU5 and Rubber based cropping systems in AEU15 needs the maximum amount of irrigation water

Table167. Crop evapotranspiration of major cropping systems of various AEUs in Thrissur district

				Crop evapotranspiration ET_c (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU2 Northern coastal plain	Rice-Fallow-Fallow		Present	*	*	*	*	20.3	122.2	121	89.1	*	*	*	*	**352.6**
		4.5	2030	*	*	*	*	20.4	126	130.3	97.2	*	*	*	*	**373.8**
			2050	*	*	*	*	20.5	129.2	130.4	96.5	*	*	*	*	**376.5**
			2080	*	*	*	*	20.7	130.8	132	97.5	*	*	*	*	**381.1**
		8.5	2030	*	*	*	*	20.3	126.2	130.6	97.4	*	*	*	*	**374.4**
			2050	*	*	*	*	20.5	130	133.8	96.9	*	*	*	*	**381.3**
			2080	*	*	*	*	21.2	133.8	138.3	101.8	*	*	*	*	**395.1**
	Coconut		Present	92.7	99.1	115.1	99	85.9	68.8	66.7	69.4	79.9	88.2	85.2	94.6	**1044.2**
		4.5	2030	86.5	85.4	97.6	92.5	85.3	85.8	86.1	89.4	87.5	91.8	88.5	94.5	**1071**
			2050	91	84.7	84.3	94.2	86.6	88.9	86.1	86.9	90.8	90	90.7	88.1	**1062.3**
			2080	88.6	85.7	97.4	90	85.7	89.1	87.7	90.7	91.3	92.4	89.5	98.2	**1086.2**
		8.5	2030	85.8	83.9	95.3	88.2	83.4	85.9	86.3	89.7	87.7	92	88.8	95.4	**1062.6**
			2050	86.9	84.6	94.9	87.6	85.4	88.5	89	90.1	90.2	94.2	88	96.3	**1075.9**
			2080	91.3	86.5	97.9	89.4	87	91.2	91.6	94.6	93	96.4	92.9	98.4	**1110.2**
AEU5 Pokkali lands	Rice-Rice-vegetable		Present	46	85.5	143	144.8	97.3	122.3	121.4	90	50.1	129.9	128.6	125	**1283.9**
		4.5	2030	45.7	82.5	135.4	142.4	96.6	125.9	130.9	98.3	52	134.9	132.7	125.5	**1302.8**
			2050	46.3	83.1	135.4	138.6	96.1	127.2	132.1	99.1	52.4	136.2	134.4	128.8	**1309.7**
			2080	47	84	137.3	140.4	97.4	128.7	133.7	100.4	53.1	137.7	136.2	130.6	**1326.5**
		8.5	2030	45.9	82.7	136.5	138	95.4	126.2	131.2	98.5	52.1	135.2	133.1	127.9	**1302.7**
			2050	47.2	84	136.7	139.9	97	130.5	132.1	98.3	53.8	135.7	133.8	131.5	**1320.5**
			2080	48.5	86.7	139.9	141.4	98.6	133.8	138.9	102.9	55.1	141.9	139.2	131.3	**1358.2**
	Coconut		Present	89.4	92.4	107.8	98.4	88.4	83.3	81.2	83.6	84.5	88.3	84	84.9	**1066**
		4.5	2030	87	85.7	97.7	92.7	85.4	85.9	86.5	89.7	87.5	91.7	87.2	85.8	**1062.8**
			2050	87.3	84.8	96.4	89.1	84.3	86.6	87.4	90.4	88.4	92.6	88.4	87.4	**1063**
			2080	88.7	85.8	98	90.5	85.5	87.7	88.4	91.5	89.5	93.8	89.4	88.6	**1077.5**
		8.5	2030	87.1	85	98.3	89.8	84.2	85.9	86.6	89.9	87.8	91.9	87.5	87	**1060.9**
			2050	89.1	85.7	97.3	89.9	85.3	88.9	88	90.5	91.3	92.2	88.1	89	**1075.4**
			2080	90.4	86.8	98.1	89.6	86.9	91.1	92.1	94.6	93.1	96.5	91.7	89.3	**1100.1**

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
				Crop evapotranspiration ET_c (mm)												
AEU6 Kole lands	Rice-Fallow-Fallow		Present	*	*	*	*	20.3	122.3	121.5	89.1	*	*	*	*	**353.4**
		4.5	2030	*	*	*	*	20.3	126	130.9	97.4	*	*	*	*	**374.5**
			2050	*	*	*	*	20.5	129.3	131.1	96.6	*	*	*	*	**377.3**
			2080	*	*	*	*	20.8	130.9	132.7	97.8	*	*	*	*	**382.1**
		8.5	2030	*	*	*	*	20.4	128.3	130.1	95.8	*	*	*	*	**374.5**
			2050	*	*	*	*	20.5	130.4	134.5	97	*	*	*	*	**382.5**
			2080	*	*	*	*	21	133	138.6	102	*	*	*	*	**394.5**
	Coconut + pepper + banana		Present	89.3	92.2	107.8	98.4	88.5	83.3	81.2	83.6	84.5	88.1	84	84.6	**1065.4**
		4.5	2030	81.8	84.9	84.7	95	86	94.9	84.3	87.3	90.2	87.9	91.5	83.7	**1052.5**
			2050	88	84.9	96.2	89	84.6	88.1	87.1	89.6	90.3	91.3	87.2	88	**1064.2**
			2080	89.1	85.1	97.2	90.2	86	89.2	88.2	90.7	91.3	92.4	88.2	89	**1076.7**
		8.5	2030	87.2	84.1	95.6	88.3	84.1	87.4	86.4	88.9	90.7	90.9	86.5	87.4	**1057.3**
			2050	87.4	84.6	94.9	87.7	86	88.9	89.5	90.2	90.2	94.2	86.6	87.4	**1067.6**
			2080	91.1	87.7	98.3	90.6	84.7	90.5	91.7	94.4	94.5	96.2	90.6	91.1	**1101.5**
AEU10 North central laterites	Rice-Rice-Fallow		Present	3.9	*	*	*	20.3	122.5	121.7	90.1	50.1	129.5	128.2	124.4	**790.7**
		4.5	2030	3.9	*	*	*	20.4	126.6	131.5	98.7	52	134.7	132.9	127.6	**828.3**
			2050	4	*	*	*	20.5	129.6	131.9	97.9	53.4	134.3	132.4	130	**834**
			2080	4	*	*	*	20.8	131.4	133.5	99.4	53.9	136	134.2	131.7	**844.9**
		8.5	2030	4	*	*	*	20.4	128.7	130.7	97.1	52.8	133.3	131.6	129.2	**827.8**
			2050	4	*	*	*	20.7	130.7	135.5	98.6	53.7	138.4	130.7	128.8	**841.1**
			2080	4.1	*	*	*	21.2	133.6	139.2	103.4	55.9	141.5	138.1	135	**872**
	Coconut		Present	88.8	90.2	107.3	98.4	88.5	83.5	81.4	83.6	84.3	88	83.7	84.3	**1062.1**
		4.5	2030	86.5	83.7	96.6	89.6	84.9	86.2	86.8	89.8	87.5	91.6	87.2	86.5	**1056.7**
			2050	88.2	84.3	97.1	89.9	85.8	88.3	87.5	89.8	90.4	91.3	87	88.1	**1067.5**
			2080	89.3	84.6	97.9	90.9	86.8	89.5	88.6	91.1	91.5	92.5	88.1	89.1	**1079.9**
		8.5	2030	87.4	83.6	96.3	89.2	85.1	87.7	86.7	89	89.5	90.6	86.5	87.4	**1058.9**
			2050	87.6	84.2	95.9	88.8	86.6	89	89.8	90.5	90.4	94.2	86.8	87.6	**1071.4**
			2080	91.2	87.2	99	91.5	85.8	91	92	94.6	94.5	96.3	90.8	91.3	**1105.1**

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			Crop evapotranspiration ET_c (mm)													
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU14 Southern high hills	Rice-Rice-Fallow		Present	3.9	*	*	*	20.2	121.6	120.6	89.9	50.1	129.9	128.6	125	**789.8**
		4.5	2030	3.8	*	*	*	19.7	125.2	129.9	97.2	51.5	132.7	131.3	123.7	**815**
			2050	3.8	*	*	*	20	126.8	131.5	98.2	52.1	134.2	132.7	124.8	**824.1**
			2080	3.9	*	*	*	20.2	128.3	133.6	99.7	52.8	135.8	134.4	126.5	**835.2**
		8.5	2030	3.8	*	*	*	19.8	125.3	130.2	97.5	51.7	133.1	131.6	123.8	**816.8**
			2050	4	*	*	*	20.1	127.4	132.9	99.3	53.5	135.1	132.4	129.8	**834.5**
			2080	4.1	*	*	*	20.7	131.3	134	100.6	55.1	141.8	138.4	131.7	**857.7**
	Coconut+ Banana		Present	89.4	92.4	107.8	98.4	88.4	82.9	80.6	83.5	84.5	88.3	84	84.9	**1065**
		4.5	2030	85.4	82.6	93.9	85.9	83.9	85.3	85.7	88.7	87.1	90.2	85.9	83.8	**1038.3**
			2050	86	83.1	94.3	85.7	84.6	86.3	86.8	89.6	88	91.3	86.8	84.6	**1047.1**
			2080	87.6	84.7	96.4	88.2	85.7	87.4	88	90.9	89.1	92.4	87.9	85.8	**1064.2**
		8.5	2030	85.4	82.7	94.2	86.1	84.2	85.3	85.9	89	87.3	90.5	86	83.9	**1040.6**
			2050	87.9	85.5	96	88.7	83.1	86.8	87.4	90.5	90.6	91.9	86.7	87.5	**1062.3**
			2080	91.6	88.5	98.6	90.3	85.9	89.3	89	92.2	92.8	96.5	91.1	89.1	**1094.9**
AEU15 Northern high hills	Rice-Rice-Fallow		Present	3.9	*	*	*	20.3	122.3	121.5	90	50.1	129.7	128.5	124.7	**791**
		4.5	2030	4	*	*	*	20.4	128.3	130.8	97.5	52.9	133.5	132	129.5	**828.9**
			2050	3.9	*	*	*	20.5	129.5	134.3	97.9	53.3	137.4	129.9	128	**834.7**
			2080	4	*	*	*	20.7	131	136	99.1	54.1	139.3	131.6	129.8	**845.6**
		8.5	2030	3.9	*	*	*	20.5	129.1	133.3	97.2	53	136.3	128.9	127.2	**829.4**
			2050	3.9	*	*	*	20.5	130.1	135.4	100.7	53.5	137.8	136	127.8	**845.7**
			2080	4.2	*	*	*	21.2	133.6	139.7	103.8	56	141.9	138.7	135.9	**875**
	Rubber		Present	110.9	117.8	138.5	125.9	98.3	105.6	102.9	105.9	105.6	108	100.6	102.2	**1322.3**
		4.5	2030	106.9	108.3	125.7	116.2	93.7	110.8	109.8	112.9	111.3	108.3	99.4	101.6	**1304.9**
			2050	107	109.6	125.9	116.1	93.7	111.7	112.7	113.6	111.3	111.5	98.7	101.2	**1312.9**
			2080	108.3	111.2	127.8	117.9	95.2	113	114	115.1	112.6	113	100.1	102.5	**1330.8**
		8.5	2030	106.3	108.8	125.5	115.9	94.8	111.4	111.8	112.7	110.4	110.8	98.2	100.7	**1307.4**
			2050	107.1	109.2	127.3	116.6	94	112.3	113.4	116.5	111.7	111	101.1	99.7	**1319.8**
			2080	111.9	114.2	130.5	120.1	96	115.3	116.7	120.1	117.4	114.6	103.7	105.8	**1366.2**

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Table168. Water requirement of major cropping systems of various AEUs in Thrissur district

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
			Water requirement (mm)													
AEU2 Northern coastal plain	Rice-Fallow-Fallow		Present	*	*	*	*	121.7	0	0	0	*	*	*	*	**121.7**
		4.5	2030	*	*	*	*	121.7	0	0	0	*	*	*	*	**121.7**
			2050	*	*	*	*	121.7	0	0	0	*	*	*	*	**121.7**
			2080	*	*	*	*	121.7	0	0	0	*	*	*	*	**121.7**
		8.5	2030	*	*	*	*	121.7	0	0	0	*	*	*	*	**121.7**
			2050	*	*	*	*	121.7	0	0	0	*	*	*	*	**121.7**
			2080	*	*	*	*	121.8	0	0	0	*	*	*	*	**121.8**
	Coconut		Present	90.5	93.1	92.7	27.2	0	0	0	0	0	0	3.1	76.1	**382.7**
		4.5	2030	78.4	77.9	91.7	53.2	0	0	0	0	80.2	0	51.6	54.9	**488.1**
			2050	57.6	81.4	79	79.4	44.8	2.7	0	0	24.8	55.3	0.5	41.4	**466.9**
			2080	87.9	81.4	73.1	68.3	0	0	0	0	37.3	0	31.7	51.4	**431.2**
		8.5	2030	77.9	83.8	80.9	45.7	0	0	0	0	80.3	0	51.3	53.7	**473.3**
			2050	79.1	84.4	81.2	27.5	0	0	0	0	22.2	0	30.2	51.9	**376.5**
			2080	91.2	84.5	85.7	63.2	0	0	0	0	0	0	54	44.5	**423.1**
AEU5 Pokkali lands	Rice-Rice-vegetable		Present	37.2	39.1	14.7	0	111.7	0	0	0.9	115.8	0	46.8	109.3	**475.5**
		4.5	2030	45.6	79.8	120.3	99.6	111.7	0	0	0.9	133.7	0.8	98.8	84.6	**775.8**
			2050	45.9	75.7	119.7	112.1	113.8	0	0	0.9	160	0	101.5	83.4	**813**
			2080	38	71.4	119.7	128.7	118.9	0	0	1	129.7	2.6	89.2	91.3	**790.5**
		8.5	2030	45.4	73.2	121.9	99.9	111.7	0	0	0.9	160.3	0	95.1	84.2	**792.6**
			2050	47.1	81.2	118.8	115.8	117.5	0	0	0.9	130.4	1.2	75.5	93.8	**782.2**
			2080	48.5	68.4	125.4	138.3	115.8	0	0	1	116.7	6.4	99.4	73.1	**793**
	Coconut		Present	75.1	46	0	0	0	0	0	0	0	0	9.3	69.3	**199.6**
		4.5	2030	85.9	83.1	82.6	49.9	0	0	0	0	26	0	53.4	45	**425.9**
			2050	84	77.3	80.7	62.6	0	0	0	0	79.9	0	55.4	41.9	**481.8**
			2080	67.7	73.3	80.4	78.7	0	0	0	0	11.1	0	42.4	49.4	**402.9**
		8.5	2030	84.2	75.6	83.7	51.7	0	0	0	0	80	0	49.4	43.2	**467.8**
			2050	88	82.9	79.3	65.8	0	0	0	0	12.3	0	29.8	51.3	**409.6**
			2080	90.3	68.5	83.6	86.5	0	0	0	0	0	0	51.8	31.1	**411.7**

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				Water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU6 Kole lands	Rice-Fallow-Fallow		Present	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
		4.5	2030	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
			2050	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
			2080	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
		8.5	2030	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
			2050	*	*	*	*	94.7	0	0	0	*	*	*	*	**94.7**
			2080	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
	Coconut + pepper + banana		Present	86.1	80.5	87.3	18.7	0	0	0	0	0	0	6	72.6	**351.2**
		4.5	2030	51.4	79.8	78.7	82.9	25.6	0	0	0	25.5	54.8	7.2	55.8	**461.7**
			2050	78.4	83.9	80.9	73.3	0	0	0	0	79.6	0	29.9	43.7	**469.7**
			2080	88.5	81	79.2	81.2	0	0	0	0	16.7	0	52	39	**437.4**
		8.5	2030	79.5	84	80.5	47.3	0	0	0	0	81.6	0	33.4	45.2	**451.3**
			2050	79.5	84.6	83.2	34.2	0	0	0	0	6.8	0	32.4	43.9	**364.4**
			2080	91	87.6	85.3	64.6	0	0	0	0	0	0	52	38.6	**419**
AEU10 North central laterites	Rice-Rice-Fallow		Present	3.9	*	*	*	125.7	0	0	0.9	119.8	0.9	64.2	103.5	**418.9**
		4.5	2030	3.9	*	*	*	115.7	0	0	0.9	171.5	3.6	111.1	92.6	**499.3**
			2050	4	*	*	*	115.7	0	0	0.9	169.7	3.2	90.6	110.5	**494.6**
			2080	4	*	*	*	115.7	0	0	1	170.4	3.5	78.9	86.4	**459.9**
		8.5	2030	4	*	*	*	115.7	0	0	0.9	169.2	2.9	90.3	110.4	**493.4**
			2050	4	*	*	*	115.7	0	0	0.9	163.1	5	87.9	110.7	**487.3**
			2080	4.1	*	*	*	115.7	0	0	1	162.8	9.7	119.3	118.3	**530.9**
	Coconut		Present	88.7	90.2	107.2	75.5	0	0	0	0	0	0	21.6	63.5	**446**
		4.5	2030	86.4	79.9	80.1	84.3	0	0	0	0	87.1	0	65.3	51.6	**534.9**
			2050	88.1	84.2	87.7	71.1	0	0	0	0	86.5	0	45.1	68.5	**531.2**
			2080	89.2	76.6	90.6	23.4	0	0	0	0	87.6	0	32.9	43.8	**444**
		8.5	2030	87.2	83.5	84.2	69.8	0	0	0	0	85.8	0	45.1	68.6	**524.3**
			2050	87	84.1	85.6	75.5	0	0	0	0	77.3	0	44.1	69.6	**523.1**
			2080	90.6	87.1	89.7	84.9	0	0	0	0	75.3	0	71.9	74.4	**574**

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Water requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU14 Southern high hills	Rice-Rice-Fallow		Present	3.9	*	*	*	129.7	0	0	0.9	133.8	0	5.8	90.5	**364.6**
		4.5	2030	3.8	*	*	*	129.6	0	0	0.9	176.7	0	93.3	110.4	**514.7**
			2050	3.8	*	*	*	129.7	0	0	0.9	143.6	3.4	99.6	69.3	**450.3**
			2080	3.9	*	*	*	129.7	0	0	0.9	150.7	2.8	101	66.6	**455.6**
		8.5	2030	3.8	*	*	*	129.6	0	0	0.9	176.9	0	109.4	113	**533.6**
			2050	4	*	*	*	129.7	0	0	0.9	151.4	2.3	98.9	73.1	**460.3**
			2080	4.1	*	*	*	129.7	0	0	1	134.9	7.7	120.3	65.8	**463.5**
	Coconut + Banana		Present	88.4	71.1	54.8	40.5	0	0	0	0	0	0	0	50.3	**305.2**
		4.5	2030	85	79.7	65.1	61.9	0	0	0	0	78.2	0	47.8	70.5	**487.9**
			2050	66.1	76.7	80.6	64.4	0	0	0	0	5.7	0	53.8	29.1	**376.4**
			2080	84.8	71.9	72.8	68.6	0	0	0	0	19.8	0	54.4	26	**398.1**
		8.5	2030	83.6	69.9	72	69.1	0	0	0	0	78.2	0	63.8	73.1	**509.7**
			2050	86.4	82.7	64.7	50.3	0	0	0	0	20.4	0	53.2	30.7	**388.5**
			2080	91.5	86.6	70.3	77	0	0	0	0	0	0	73	23.1	**421.4**
AEU15 Northern high hills	Rice-Rice-Fallow		Present	3.9	*	*	*	90.7	0	0	0.9	92.6	0	22.6	95.9	**306.6**
		4.5	2030	4	*	*	*	90.7	0	0	0.9	136.6	0.7	108.7	90	**431.6**
			2050	3.9	*	*	*	90.7	0	0	0.9	110.9	7.1	111	115.2	**439.7**
			2080	4	*	*	*	90.7	0	0	0.9	130.6	6.5	113.2	115.9	**461.8**
		8.5	2030	3.9	*	*	*	90.7	0	0	0.9	125.2	2.1	108	115.8	**446.6**
			2050	3.9	*	*	*	90.7	0	0	1	130.1	6	118.3	113.7	**463.7**
			2080	4.2	*	*	*	90.8	0	0	1	105.2	4.9	98.5	76.5	**381.1**
	Rubber		Present	102.3	105.1	120.7	33.2	3.7	0	0	0	0	0	5.4	73.6	**444**
		4.5	2030	103	101.1	113.3	82.5	0	0	0	0	102.2	0	76.1	62.1	**640.3**
			2050	98.1	99.1	113.8	101.2	0	0	0	0	43.1	0	79.9	88.4	**623.7**
			2080	106.7	102.4	110.9	94.6	0	0	0	0	87.7	0	81.6	88.6	**672.8**
		8.5	2030	98.8	108.7	108.2	75.2	0	0	0	0	77.7	0	77.2	89.4	**635.2**
			2050	99.2	98.7	100	81.5	1.6	0	0	0	86.9	0	83.4	85.6	**636.9**
			2080	111.7	106.8	113.1	109	0.7	0	0	0	23.7	0	63.4	46.5	**575.2**

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4.4.3. Water requirements of major cropping systems of various AEUs in Palakkad district and impact of climate change

Crop evapotranspiration of major cropping systems of various AEUs in Palakkad district were studied and presented in table169.

In AEU10 Rice-Rice-Fallow and coconut based are the major cropping systems. In Rice-Rice-Fallow cropping system the evapotranspiration during first and second crop season shows an increasing trend in projected climate as per RCP 4.5 and 8.5. In future climate there will be an increased amount of annual crop evapotranspiration compared to the present climate. In coconut based cropping system the crop evapotranspiration were calculated for a year. The projected values of annual crop evapotranspiration will be higher than the present condition.

Considering AEU13, the major cropping systems practiced in this unit are Rice-Banana-Fallow and Rubber. In Rice-Banana-Fallow cropping system the first season is cultivated with rice and the planting date is on June 1st week. On November 2nd week, Banana is planted as second crop. For the completion of this cropping system it takes two years. In this cropping system during virippu season the crop evapotranspiration shows an increasing trend in projected climate as per RCP 4.5 and 8.5 compared to the present condition. In the case of banana the projected crop evapotranspiration shows an increasing trend. As per RCP 8.5 in 2030 the crop evapotranspiration value will become lower than the present condition. In rubber based cropping systems the future values of crop evapotranspiration will be higher than the present condition. Cardamom and coffee are the major cropping systems carried out in AEU14. Coffee and cardamom are perennial crops so the crop evapotranspiration is calculated for a year. In both cropping systems the crop evapotranspiration shows an increasing trend in projected climate based on RCP 4.5 and 8.5 compared to the existing situation.

In the case of AEU15, Rice-Rice-Fallow and Rubber based are the major cropping system performed in this unit. In Rice-Rice-Fallow cropping system the future climate as per RCP 4.5 and 8.5 shows an increasing pattern in crop evapotranspiration from the present condition. In rubber based cropping system also the crop evapotranspiration shows an increasing trend in projected climate. Rice-Banana-Fallow and Coconut+ Banana are the major cropping systems followed in AEU18. Considering Rice-Banana-Fallow system, during virippu season the projected crop evapotranspiration will higher than the current condition. In the case of banana also the crop evapotranspiration shows an increasing trend in projected climate compared to the present condition. In coconut+ banana cropping system the projected climate shows higher crop evapotranspiration during future climate compared to the current condition. Considering AE19, the major cropping systems practiced in this unit are coconut+ banana and coconut+ green manure. As per RCP 4.5 and 8.5 the projected climate shows an increasing trend in crop evapotranspiration in the case of both cropping systems from the present condition.

In AEU22 and AEU23 the major cropping systems practiced in these units are Rice-Rice-Fallow. In Rice-Rice-Fallow cropping system in both units shows an increasing trend in crop evapotranspiration during projected climate as per RCP 4.5 and 8.5 from the current condition. Considering the rubber based cropping system in AEU22, the amount of crop evapotranspiration during projected climate will be lesser than the present condition. In AEU23, the coconut based cropping system shows an increasing trend in the projected values of crop evapotranspiration as per RCP 4.5 and 8.5. Based on RCP 4.5 and 8.5, only 2030 show a value which will be less than the present condition.

Water requirement of major cropping systems of various AEUs in Palakkad district were studied and presented in table170.

Considering AEU10, the major cropping systems in this unit are Rice-Rice-Fallow and coconut based. In Rice-Rice-Fallow cropping system, in projected climate as per RCP 4.5 annually the amount of water needed for irrigation will be higher than the present condition. In projected climate September, October and November shows high increase in water requirement compared to the present condition. In coconut based cropping system the projected climate shows an increased water requirement compared to the current condition. The periods were irrigation required will increase during future climate. During September in projected climate there will be a drastic increase in irrigation requirement.

In AEU13, Rice-Banana-Fallow and rubber are the major cropping systems. In this cropping system during virippu season the water requirement doesn't show any variation in projected climate as per RCP 4.5 and 8.5 compared to the current climate. In the case of banana the projected water requirement shows a higher value than the present climate. The numbers of periods were irrigation required shows an increase in projected climate compared to the current condition. There will be a drastic increase in water requirement during September and November. In rubber based cropping system the water requirement shows a high increase in projected climate compared to the present condition. There will be an increase in the periods were irrigation required. In future climate September and November shows a severe increase in irrigation requirement. Considering AEU14, the major cropping systems practiced in this unit are cardamom and coffee. In both cropping systems the future climate shows an increased water requirement compared to the existing condition. The periods were irrigation should be given also show an increase in projected climate. As per RCP 4.5 and 8.5 in projected climate there will be a drastic increase in water requirement during May, September and November.

In view of AEU15, Rice-Rice-Fallow and rubber are the major cropping systems in this unit. In Rice-Rice-Fallow cropping system as per RCP 4.5 and 8.5 the future climate shows an increase in water requirement during 2030 and it decreases in 2050 which will be less than the present and then it increases again in 2080. The periods were irrigation required also increases during projected climate. In rubber based cropping pattern, the water requirement shows a small decrease in 2050 during projected climate as per RCP 4.5 and 8.5. There will be an increase in water requirement and the numbers of periods were irrigation required during projected climate compared to the present condition. Also in future climate September shows a drastic increase in irrigation requirement.

Considering AEU18, Rice-Banana-Fallow and coconut+ banana are the major cropping systems practiced in this unit. In Rice-Banana-Fallow cropping system during viripu season the projected water requirement shows a decrease from the present value. The water requirement will become zero during July in projected climate compared to the current condition. In the case of banana the water requirement during projected climate will be higher than the present condition and there will not have much variation in the irrigation required periods. In coconut+ banana based cropping system the projected climate shows a great increase in water requirement compared to the present condition. The periods were irrigation required will increase in projected climate and also September should be irrigated compared to the present condition. In AEU19 the major cropping systems are coconut+ banana and coconut+ green manure based. In both cropping systems the projected climate shows an increased value of water requirement compared to the present condition. Periods were irrigation required will increase during the projected climate and irrigation should be given in September in contrast with the current condition.

In view of AEU22, the major cropping systems practiced are Rice-Rice-Fallow and rubber based. In Rice-Rice-Fallow cropping system the water requirement during projected climate will show a high increase compared to the current condition. The numbers of periods were irrigation required will decrease in projected climate. Water requirement will become zero in June and July during projected climate based on RCP 4.5 and 8.5 in contrast with the present condition. In rubber based cropping system there will be an extreme increase in water requirement during projected climate. About three times increase in water requirement will happen in future climate compared to the present condition. In projected climate the periods of irrigation required will increase and there will be a drastic increase in water requirement during September and November. Considering AEU23, Rice-Rice-Fallow and coconut are the major cropping systems followed in this unit. In both cropping systems the projected climate will show an increased water requirement compared to the present condition. In Rice-Rice-Fallow cropping system the number of periods were irrigation required will decrease in projected climate whereas in coconut based cropping system it will increase. In projected climate there will be a drastic increase in water requirement during September and November. The maximum amount of irrigation is needed for the rubber based cropping system in AEU22 and AEU13.

Table169. Crop evapotranspiration of major cropping systems of various AEUs in Palakkad district

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
				Crop evapotranspiration ET_c (mm)												
AEU10 North central laterites	Rice-Rice-Fallow		Present	3.9	*	*	*	21.5	131	129.4	94.9	50.9	128.9	125.5	125.4	**811.4**
		4.5	2030	4.1	*	*	*	22.6	139.2	142.1	105.9	55.2	141.1	137.7	135.3	**883.2**
			2050	4.2	*	*	*	22.8	142.6	142.5	105	56.5	140.5	137.4	138.3	**889.8**
			2080	4.3	*	*	*	23.1	144.5	144.3	106.5	57.2	142.3	138.9	140	**901.1**
		8.5	2030	4.2	*	*	*	22.5	141.7	141.5	104.3	56.1	139.4	136.3	137.1	**883.1**
			2050	4.2	*	*	*	22.8	143.9	146.4	105.7	57	144.7	135.2	136.6	**896.5**
			2080	4.4	*	*	*	23.5	147.1	150.6	111	59.2	148.1	143.1	143.6	**930.6**
	Coconut		Present	86.5	84.1	110.4	101.5	87.6	89.3	85.7	86.9	86.2	87.6	81.3	84.4	**1071.5**
		4.5	2030	90.1	83.5	101.1	95.1	94	94.8	93.5	96	93.3	96	90.1	91.5	**1118.8**
			2050	92.1	84.4	103.8	96	95.1	97.2	94.3	95.9	95.9	95.6	90	93.4	**1133.9**
			2080	93.3	84.9	105	97.3	96.6	98.4	95.5	97.3	97.3	96.8	91	94.6	**1147.9**
		8.5	2030	91.2	83.6	102.9	95.1	94.4	96.4	93.6	95.2	95.3	94.7	89.3	92.6	**1124.4**
			2050	91.4	84.2	101	94.9	96.5	98.1	96.8	96.8	96.2	98.5	89.6	92.8	**1136.8**
			2080	95.5	87.5	104.5	98	95.7	100.2	99.1	101.2	100.6	100.7	93.8	96.9	**1173.5**
AEU13 Northern foothills	Rice-Banana-Fallow		Present	*	*	*	*	21.7	120	121.4	83.3	*	*	*	*	**346.5**
		4.5	2030	*	*	*	*	21.3	128.8	132.3	93.2	*	*	*	*	**375.7**
			2050	*	*	*	*	21.4	129.6	135.5	93.7	*	*	*	*	**380.1**
			2080	*	*	*	*	21.8	131.2	137.1	94.8	*	*	*	*	**384.9**
		8.5	2030	*	*	*	*	21.3	129	134.7	92.9	*	*	*	*	**377.9**
			2050	*	*	*	*	21.7	130.2	136.5	96.1	*	*	*	*	**384.3**
			2080	*	*	*	*	22.2	133.3	139.8	98.7	*	*	*	*	**394.2**
	Banana		Present	101.9	138.4	181	165.9	150.5	114.5	108.1	98.9	69.5	55.6	51.1	61	**1296.4**
		4.5	2030	104.1	132.4	163.1	152.7	143.9	120.7	116	110	76.3	58	53.9	65.8	**1296.9**
			2050	104.3	134.2	163.7	153.4	144.2	121.3	118.7	110.5	76	59.8	53.7	65.5	**1305.3**
			2080	105.6	136.1	166	155.5	146.2	122.8	120	111.9	77	60.6	54.3	66.4	**1322.4**
		8.5	2030	103.1	133.1	162.2	152.1	142.7	120.6	117.8	109.2	75.4	59.3	53.2	65	**1293.7**
			2050	105.7	135.2	166	154.2	144.9	121.8	119.4	113.1	76.8	59.8	55.4	65.2	**1317.5**
			2080	110.2	140.1	171.5	158.8	149	124	121.7	115.9	80.1	62.6	56.6	68.3	**1358.8**

Crop evapotranspiration ET_c (mm)

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU13 Northern foothills	Rubber		Present	109	118.4	153.9	141.1	108.6	103.6	102.8	99.6	102.8	102.1	91.4	94.8	**1328.1**
		4.5	2030	109.9	112.1	136.2	127.6	101.7	111.2	110.2	108.3	110.3	104.9	94.2	99.7	**1326.3**
			2050	110.1	113.7	136.1	127.5	101.3	111.8	112.9	109.1	110.2	108.2	93.8	99.4	**1334**
			2080	111.6	115.2	138	129.2	102.8	113.2	114.2	110.4	111.5	109.5	95	100.6	**1351.2**
		8.5	2030	109.2	112.7	135.1	126.5	100.5	112.2	112.3	108.1	109.3	107.2	93.1	98.7	**1323.9**
			2050	110.4	113.5	137.7	127.8	101.6	112.4	113.6	111.6	110.7	107.5	95.8	97.9	**1340.5**
			2080	115.8	118.4	142.4	131.9	104.8	115	116.3	114.5	115.9	112.6	98.2	102.7	**1388.6**
AEU14 Southern high hills	Cardamom		Present	90.1	94.8	119.7	117.6	93.3	89.8	83.9	86.7	87.5	87.6	79.6	86.1	**1116.8**
		4.5	2030	100.9	102	119.7	113	90.4	92.2	89.4	93.1	91.2	91.3	83.9	91.2	**1158.2**
			2050	99	103.2	123.9	115.8	92.8	93.3	91	93.6	92.7	91.1	84	91	**1171.5**
			2080	100.3	104.6	125.5	117.4	94.1	94.6	92.1	95	94.2	92.6	85.3	92.4	**1188.1**
		8.5	2030	101.2	102.3	120	113.2	90.5	92.4	89.6	93.3	91.4	91.5	84.2	91.4	**1161.1**
			2050	99.7	101.7	125	119.2	95.1	96.1	92.2	95.4	93.1	92.5	83.7	90.8	**1184.6**
			2080	103.2	103.9	125.4	119.1	99.6	102.5	97.9	100.4	97.3	95.9	86.9	94.6	**1226.6**
	Coffee		Present	96.1	100.2	126.2	123.9	97.2	94.3	88	91.3	93	93.6	85.1	91.7	**1180.6**
		4.5	2030	109	108.5	126	118.9	110.2	92.8	90.1	94	80.7	99.1	92.4	99.9	**1221.7**
			2050	107.6	110.2	130.7	122.1	113.8	94.1	91.6	94.3	82.1	99.3	92.9	100.4	**1239**
			2080	109	111.6	132.5	123.8	115.4	95.4	92.8	95.7	83.3	100.9	94.1	101.7	**1256.4**
		8.5	2030	109.3	108.8	126.3	119.1	110.3	93	90.3	94.3	81	99.4	92.7	100.2	**1224.5**
			2050	109.4	109.3	132.7	126.4	116.9	97.1	92.8	96.2	82.6	101.3	93.1	100.7	**1258.4**
			2080	112.3	111.3	133.1	126.7	121.8	102.9	98.5	101.4	86.3	105	96.6	104.6	**1300.6**
AEU15 Northern high hills	Rice-Rice-Fallow		Present	3.4	*	*	*	21.6	123.3	131.2	93.8	51.9	125.6	114.4	107.6	**772.8**
		4.5	2030	3.7	*	*	*	20.7	124.3	133	95.5	50.8	123.8	118.2	115.1	**785.1**
			2050	3.7	*	*	*	21.5	128.6	136.5	96.9	51.5	125.4	119.1	114.6	**797.8**
			2080	3.8	*	*	*	21.3	128.5	135.5	98.2	51.7	125.6	118.7	117.2	**800.5**
		8.5	2030	3.7	*	*	*	21	126.4	132.8	96	50.8	124.8	116.3	114.4	**786.2**
			2050	3.8	*	*	*	21.8	132.6	139.4	99.8	52.1	127.7	119.4	116.9	**813.5**
			2080	3.9	*	*	*	22.1	134.5	143.2	105.5	56.1	135.6	126.6	121.3	**848.8**

Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern high hills	Rubber		Present	104.1	110.7	142.5	132.5	126.5	100.5	101.4	98.1	91.3	108.2	94.8	93.8	**1304.2**
		4.5	2030	103.5	109.5	135.4	124.2	100.4	107.3	110.2	109	107.6	101.8	89.7	91.5	**1290.6**
			2050	110.3	112.1	133.8	127.1	122.7	102.4	103.9	101.8	91.1	107.9	98	99.6	**1310.9**
			2080	113.4	114.4	141.7	130	122.7	103.5	104.5	103.3	91.5	108.1	98.3	101.9	**1333.5**
		8.5	2030	110.8	111.5	135.7	126.7	120.3	101.4	102.3	101.1	89.5	107.5	96.4	99.4	**1302.5**
			2050	111.3	111.4	133.1	123.8	121.9	105.1	106.6	105.1	92.3	110	98.6	101.2	**1320.3**
			2080	117.4	116.5	137	127.1	121.9	104.8	108.1	109.7	99.3	116.8	104.7	105.5	**1368.6**
AEU18 Attappady hills	Rice-Banana-Fallow		Present	*	*	*	*	20.9	133	126	91	*	*	*	*	**370.9**
		4.5	2030	*	*	*	*	21.2	139.1	136.4	98.8	*	*	*	*	**395.5**
			2050	*	*	*	*	21.9	144.5	142.7	101.9	*	*	*	*	**411**
			2080	*	*	*	*	22.3	143.9	143	101.2	*	*	*	*	**410.3**
		8.5	2030	*	*	*	*	21.6	140.9	140	98.9	*	*	*	*	**401.5**
			2050	*	*	*	*	21.8	143.8	147.4	107	*	*	*	*	**419.9**
			2080	*	*	*	*	22.7	149.1	147.9	106.1	*	*	*	*	**426**
	Banana		Present	84.6	110.1	154.1	149.8	143	127.3	112.5	108.1	72.9	75.6	52.2	56.3	**1246.5**
		4.5	2030	92.3	116.3	159	151.3	142.8	131.7	120.9	116.7	77.2	71.3	53.5	60.5	**1293.5**
			2050	92.6	117.3	158.6	151.6	146.8	137.4	126.1	120.3	79	72.5	54.2	61.1	**1317.5**
			2080	93.5	118.7	156.8	154.7	148.8	136	125.5	119.5	79.8	72.8	54.5	61.4	**1322**
		8.5	2030	91.4	116.7	153.3	151.2	145.1	132.9	122.8	116.7	78.1	71.1	55	60	**1294.3**
			2050	93.9	117.2	153.6	148.6	143.6	134.1	128.4	124.9	82.1	74.1	55.2	61.6	**1317.3**
			2080	97.5	122.1	165.8	159	152	140.5	130.1	124.9	84.2	77.9	60	67.1	**1381.1**
	Coconut + Banana		Present	73.3	74.9	103.1	99.7	84.2	90.6	83.4	83.9	85.4	113.4	78	72.5	**1042.4**
		4.5	2030	78.1	76.5	102.7	98.5	84.7	94.8	89.9	90.1	89.7	106.8	79.6	76.5	**1067.9**
			2050	77.3	75.7	100.4	98.7	87.7	98.5	93.3	92.4	91.6	108.6	80.8	76.8	**1081.8**
			2080	77.8	76.4	99.1	100	88.5	97.9	93.4	92.3	92.8	109.1	80.8	77.1	**1085.2**
		8.5	2030	75.7	74.8	96.4	97.6	86.4	96	91.6	90.3	90.7	106.7	81.8	75.2	**1063.2**
			2050	78.5	76	97.7	94.7	84.2	97.9	96.2	96.3	94.9	111.3	82	77.3	**1087**
			2080	82.8	80.8	107.5	103.1	89.5	101.6	97.5	97.3	98.3	116.7	89.4	85.2	**1149.7**

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AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Crop evapotranspiration ET_c (mm)																
AEU19 Attappady dry hills	Coconut + Banana		Present	65.9	67.8	85.7	84	69.1	67.5	63.1	65.3	66.8	67.4	58.9	63.1	**824.6**
		4.5	2030	70.1	69.6	83.1	78.2	66.4	68.9	67.9	70.2	71.9	72	62.2	66.2	**846.7**
			2050	70.8	70	85.5	82.2	69.3	70.8	68.4	70.5	71	70.7	64.3	69.6	**863.1**
			2080	71.7	71.1	86.8	83.5	70.5	71.7	69.5	71.4	71.9	71.8	65.4	70.7	**876**
		8.5	2030	70.5	69.6	83	80.2	69	74.2	72.8	73.7	72.8	71.6	63.2	66.6	**867.2**
			2050	73.7	71.9	85.6	81.8	70.3	74	72.1	76.3	76.7	74.8	65.6	69.1	**891.9**
			2080	77.2	76.1	92.7	88.9	75.2	76.9	74.6	76.9	77.3	77.2	70.1	76.2	**939.3**
	Coconut+ Green manure		Present	65.9	67.8	85.7	84	69.1	67.5	63.1	65.3	66.8	67.4	58.9	63.1	**824.6**
		4.5	2030	70.1	69.6	83.1	78.2	66.4	68.9	67.9	70.2	71.9	72	62.2	66.2	**846.7**
			2050	70.8	70	85.5	82.2	69.3	70.8	68.4	70.5	71	70.7	64.3	69.6	**863.1**
			2080	71.7	71.1	86.8	83.5	70.5	71.7	69.5	71.4	71.9	71.8	65.4	70.7	**876**
		8.5	2030	70.5	69.6	83	80.2	69	74.2	72.8	73.7	72.8	71.6	63.2	66.6	**867.2**
			2050	73.7	71.9	85.6	81.8	70.3	74	72.1	76.3	76.7	74.8	65.6	69.1	**891.9**
			2080	77.2	76.1	92.7	88.9	75.2	76.9	74.6	76.9	77.3	77.2	70.1	76.2	**939.3**
AEU22 Palakkad central plains	Rice-Rice-Fallow		Present	4.6	*	*	*	27.1	166.3	157.8	110	58.2	152.6	150.8	144.9	**972.3**
		4.5	2030	4.6	*	*	*	26.9	167.9	162	115.6	60.6	153.3	149.3	147.4	**987.6**
			2050	4.6	*	*	*	25.6	166.2	165.8	116.2	60.9	157.9	150	146.7	**993.9**
			2080	4.6	*	*	*	26	168.6	168.1	117.8	61.7	159.8	151.9	149	**1007.5**
		8.5	2030	4.6	*	*	*	25.9	168.3	162.7	115.8	60.7	153.4	150.5	148.1	**990**
			2050	4.5	*	*	*	25.8	167.1	167.4	119.5	61.2	158.3	156.4	146.7	**1006.9**
			2080	4.8	*	*	*	26.6	171.3	171.4	122.6	64.2	165.5	158.7	153.6	**1038.7**
	Rubber		Present	133.2	138.1	177.5	172.5	140.5	143.5	130.5	125.2	123.5	130.4	121.1	122.3	**1658.3**
		4.5	2030	124.3	124	153.3	147.8	127.8	144.9	135.1	132.3	127.8	125.5	114	117.3	**1574.2**
			2050	132.1	128.4	150.8	144.8	141.6	130.1	125.1	120.3	106.2	136.1	125.2	128.3	**1568.9**
			2080	134.1	130.5	153.1	147.3	143.8	132.2	127	122.2	107.7	137.7	126.7	130.2	**1592.6**
		8.5	2030	132.7	127.9	151.8	145.7	144.5	132.9	123.9	121.1	106.8	132.2	124.7	129.1	**1573.4**
			2050	133.8	129.2	152.8	145.6	142.3	130.5	126.2	123.9	107.2	136.2	129.1	128	**1584.9**
			2080	140	134.2	157.6	149.7	146.2	133.3	128.7	126.7	112.1	142.5	131.8	133.7	**1636.7**

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Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU23 Palakkad eastern plains	Rice-Rice-Fallow		Present	4.6	*	*	*	22.4	130	125.7	91.3	51.7	131.7	136.2	141.9	**835.5**
		4.5	2030	4.6	*	*	*	22.2	136.6	139.9	99.8	54.9	139.6	138.2	145.2	**881**
			2050	4.6	*	*	*	22.3	137.5	141.4	102.4	55	139.4	144.1	144.8	**891.5**
			2080	4.6	*	*	*	22.6	139.1	143.1	103.6	55.7	141.2	146	147.1	**903**
		8.5	2030	4.5	*	*	*	22.2	136.2	140.2	101.6	54.6	138.4	143	143.7	**884.4**
			2050	4.8	*	*	*	22.5	137.6	141.7	102.8	56.3	142.3	142.9	148.1	**889**
			2080	5	*	*	*	23.4	143.1	145	105.3	57.3	145.5	148.7	154.7	**928**
	Coconut		Present	105.7	103.6	121.1	113.2	102	88.5	83.9	84.7	87.4	89.5	88.2	95.6	**1163.3**
		4.5	2030	108.6	105.3	118	106.8	98	82.6	81.4	80.6	89.3	94.9	90.6	100.6	**1156.7**
			2050	103.2	95.6	107.2	99.9	97.6	93.7	92.6	92.7	93.2	94.8	93.5	97.9	**1161.7**
			2080	104.4	96.5	108.2	99.8	98.4	94.7	93.7	93.8	94.3	95.9	94.7	99.2	**1173.9**
		8.5	2030	102.3	94.9	106.6	99.3	96.9	92.8	91.9	92	92.5	94	92.8	97	**1152.7**
			2050	106.1	98.1	109.4	101.7	98	93.7	92.6	92.8	95.2	96.7	93.1	99.9	**1177.2**
			2080	112.8	105	115.4	107.1	99.7	97.5	95.2	95.3	97	99	96.8	104.4	**1225.1**

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Table170. Water requirement of major cropping systems of various AEUs in Palakkad district

				Water requirement(mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU10 North central laterites	Rice-Rice-Fallow		Present	3.9	*	*	*	95.5	0	0	0.9	99	0.3	61.6	104.4	**365.6**
		4.5	2030	4.1	*	*	*	95.6	0	0	1	150.6	10.7	121.9	100.7	**484.6**
			2050	4.2	*	*	*	95.6	0	0	1	150.9	10.8	114.8	96.5	**473.8**
			2080	4.3	*	*	*	95.6	0	0	1	153.7	7.6	83.5	93.4	**439.1**
		8.5	2030	4.2	*	*	*	95.6	0	0	1	152.6	6.7	94.8	116.5	**471.4**
			2050	4.2	*	*	*	95.6	0	0	1	146.8	9.1	92.5	116.6	**465.8**
			2080	4.4	*	*	*	95.7	0	0	1.1	123.6	9.8	124.5	125.3	**484.4**
	Coconut		Present	86.3	84.1	110.3	78.7	0	0	0	0	0	0	19.9	63.6	**442.9**
		4.5	2030	90	83.3	94.5	53.4	0	0	0	0	89.3	0	74.1	57.1	**541.5**
			2050	92	79.6	95.5	87.3	0	0	0	0	90.8	0	67.4	51.7	**564.2**
			2080	93.2	73.1	92.8	70.5	0	0	0	0	94.1	0	35.5	47.9	**507.1**
		8.5	2030	91.1	83.5	92.8	85.9	0	0	0	0	92.3	0	47.7	72	**565.3**
			2050	91.3	78.5	93.9	90.9	0	0	0	0	85.9	0	46.9	72.8	**560.1**
			2080	95.3	87.4	93.9	88.6	0	0	0	0	36.3	0	75.3	78.5	**555.2**
AEU13 Northern foothills	Rice-Banana-Fallow		Present	*	*	*	*	95.5	0	0	0	*	*	*	*	**95.5**
		4.5	2030	*	*	*	*	95.5	0	0	0	*	*	*	*	**95.5**
			2050	*	*	*	*	95.5	0	0	0	*	*	*	*	**95.5**
			2080	*	*	*	*	95.5	0	0	0	*	*	*	*	**95.5**
		8.5	2030	*	*	*	*	95.5	0	0	0	*	*	*	*	**95.5**
			2050	*	*	*	*	95.5	0	0	0	*	*	*	*	**95.5**
			2080	*	*	*	*	95.6	0	0	0	*	*	*	*	**95.6**
	Banana		Present	100.1	127.3	149.3	72.2	28.9	0	0	0	0	0	0	43.2	**521**
		4.5	2030	104	132.2	129.7	132.8	15.8	0	0	0	73.5	0	18.8	44.6	**651.4**
			2050	104.2	134.1	153.6	143.2	11.1	0	0	0	67.2	0	8.6	27.9	**649.9**
			2080	105.5	136	151.3	122.9	7.7	0	0	0	69.6	0	7.1	20.2	**620.3**
		8.5	2030	103	132.9	142.7	129	8.8	0	0	0	66.7	0	8.6	27.1	**618.8**
			2050	105.5	135.1	128.1	120.5	8.5	0	0	0	69.5	0	17.6	13.9	**598.7**
			2080	110.1	140	144.2	150.7	12.1	0	0	0	26.3	0	17.7	13	**614.1**

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
				Water requirement(mm)												
AEU13 Northern foothills	Rubber		Present	107.1	107.2	122.3	47.4	9.9	0	0	0	0	0	0	77	**471**
		4.5	2030	109.8	111.9	102.9	107.6	7.3	0	0	0	107.5	0	54.7	78.5	**680.4**
			2050	110	113.6	126.1	117.4	3	0	0	0	101.4	0	41.1	61.8	**674.2**
			2080	111.5	115	123.3	96.6	0	0	0	0	104.2	0	39.9	54.5	**644.9**
		8.5	2030	109.1	112.6	115.5	103.4	0.7	0	0	0	100.6	0	40.9	60.7	**643.6**
			2050	110.3	113.3	99.8	94.2	0.3	0	0	0	103.4	0	54.6	46.5	**622.3**
			2080	115.7	118.3	115.2	123.8	3.6	0	0	0	60.8	0	56.1	45.1	**638.7**
AEU14 Southern high hills	Cardamom		Present	89	73.4	66.7	59.8	0	0	0	0	0	0	0	51.8	**340.7**
		4.5	2030	71.4	97	94.4	85.7	5.9	0	0	0	90.1	0	45.4	17.4	**507.2**
			2050	79.8	86.3	88.8	86.1	5.7	0	0	0	82.8	0	42.8	16.5	**488.8**
			2080	80.3	89.1	97.9	87.7	0	0	0	0	83.8	0	41.6	13.8	**494.1**
		8.5	2030	85.7	97	103	79	2.8	0	0	0	56.8	0	0.5	9.5	**434.3**
			2050	81.8	96.4	108.1	83.5	6.8	0	0	0	28.8	0	0	9.3	**414.7**
			2080	85.6	75.4	85.9	59.6	22.6	0	0	0	69.7	0	50.6	19.5	**468.6**
	Coffee		Present	94.9	78.9	73.1	66	0	0	0	0	0	0	0	57.3	**370.3**
		4.5	2030	79.5	103.7	100.7	91.6	8.9	0	0	0	79.8	0	53.9	26.2	**544**
			2050	88.5	93.4	95.7	92.6	8.9	0	2	2	74.9	0	51.5	25.8	**531.4**
			2080	89	96.2	104.7	94.1	5.6	0	0	0	75.7	0	50.4	21.6	**537.4**
		8.5	2030	93.9	103.4	109.3	84.8	6.8	0	0	0	55.6	0	6.2	12.6	**472.3**
			2050	91.4	103.9	115.8	90.7	9.7	0	0	0	31.9	0	1.1	12.8	**457.4**
			2080	94.9	82.8	93.5	67.1	30.6	0	0	0	66	0	60.2	29.5	**524.9**
AEU15 Northern high hills	Rice-Rice-Fallow		Present	3.4	*	*	*	95.5	0	0	0.9	99.1	0	11	78.8	**288.7**
		4.5	2030	3.7	*	*	*	95.5	0	0	0.9	125.2	1.6	106	88.9	**421.8**
			2050	3.7	*	*	*	95.5	0	0	0.9	114.1	0	9.3	64.1	**287.6**
			2080	3.8	*	*	*	95.5	0	0	0.9	113.9	0	11.1	92.8	**318**
		8.5	2030	3.7	*	*	*	95.5	0	0	0.9	122.1	2.9	93.1	83.9	**402.1**
			2050	3.8	*	*	*	95.5	0	0	0.9	114.7	0	3.1	67	**285**
			2080	3.9	*	*	*	95.6	0	0	1	122.7	7.5	44.9	76.3	**351.9**

Water requirement(mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern high hills	Rubber		Present	95.5	98	124.6	39.8	10.8	0	0	0	0	0	3.1	65.1	**437**
		4.5	2030	103.5	102.3	117.8	121.7	2.4	0	0	0	68	0	77.6	65.3	**658.5**
			2050	99.2	95.9	118.2	104.6	42.8	0	0	0	34.7	0	1	49.2	**545.4**
			2080	110.8	99.2	123.8	75.5	33.2	0	0	0	34.3	0	3.8	77.4	**558.1**
		8.5	2030	110.7	101.8	111.6	126.1	0.3	0	0	0	56	0	73.2	68.9	**648.5**
			2050	100.5	95.1	116.9	91.2	25.3	0	0	0	35.1	0	0	51.4	**515.4**
			2080	99	104.2	124.5	112.4	19.6	0	0	0	52.7	0	22.8	60.5	**595.6**
AEU18 Attappady hills	Rice-Banana-Fallow		Present	*	*	*	*	95.5	51.7	16.7	0	*	*	*	*	**163.9**
		4.5	2030	*	*	*	*	95.5	6.3	0	0	*	*	*	*	**101.8**
			2050	*	*	*	*	95.6	10.1	0	0	*	*	*	*	**105.6**
			2080	*	*	*	*	95.6	3.1	0	0	*	*	*	*	**98.6**
		8.5	2030	*	*	*	*	95.5	4.2	0	0	*	*	*	*	**99.7**
			2050	*	*	*	*	95.6	6.5	0	0	*	*	*	*	**102.1**
			2080	*	*	*	*	95.6	6.6	0	0	*	*	*	*	**102.3**
	Banana		Present	64.2	74.5	61.9	45.7	54.2	45.9	4.8	0	0	0	0	28.9	**380.1**
		4.5	2030	84.9	99.3	150.1	135.1	88	4.2	0	0	15.5	0	0	13.4	**590.5**
			2050	81.9	112.8	144	119.9	57.4	5.8	0	0	16	0	0	32.8	**570.6**
			2080	81.1	101.5	143.9	142.5	69.4	0.7	0	0	19.7	0	0	20.4	**579.2**
		8.5	2030	81	99.9	138.1	129.7	77	1.8	0	0	16.1	0	0	14.1	**557.7**
			2050	83.2	112.7	138.8	131.8	59.3	3.5	0	1.1	14.5	0	0	33.6	**578.5**
			2080	86.4	122	152.5	128.4	82.8	4.1	0	0	12.6	0	5.8	38	**632.6**
	Coconut + Banana		Present	52.8	39.3	10.7	0	6.6	9.3	0	0	0	0	0	45	**163.7**
		4.5	2030	70.7	59.6	93.8	82.3	31.8	0	0	0	22.4	0	0	23.3	**383.9**
			2050	66.4	71.3	85.7	67.1	9.8	0	0	0	22.7	0	0	48.6	**371.6**
			2080	65.5	59.3	86.1	87.8	16.2	0	0	0	28.4	0	0	32.3	**375.6**
		8.5	2030	65.3	58	81.1	76.1	22.6	0	0	0	22.6	0	0	23.6	**349.3**
			2050	67.6	71.5	82.9	63	7.5	0	0	0	26	0	0	49.3	**367.8**
			2080	71.7	80.7	94.3	72.5	24.5	0	0	0	20.6	0	28.4	56.1	**448.2**

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Water requirement(mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU19 Attappady dry hills	Coconut + Banana		Present	55.4	50.7	36	5.7	10.6	8	0	0	0	0	3.3	48.9	**218.6**
		4.5	2030	57.8	63.7	56.7	9.6	0	0	0	0	25.9	0	34	53.9	**301.6**
			2050	49.4	57.4	66.8	33.7	5.5	0	0	0	13.5	0	0	7.1	**233.4**
			2080	49.5	58.8	67.7	34.3	6	0	0	0	14.3	0	0	6.8	**237.4**
		8.5	2030	63.5	49.8	67.7	43.7	2.3	0	0	0	50.6	0	45.6	53.6	**376.8**
			2050	52.3	59.3	66.9	33.4	5.5	0	0	0	17.2	0	0	7.2	**241.8**
			2080	66.9	56.6	64.8	29.5	13.1	0	0	0	25.8	0	45.8	67.9	**370.4**
	Coconut+ Green manure		Present	55.4	50.7	36	5.7	10.6	8	0	0	0	0	3.3	48.9	**218.6**
		4.5	2030	57.8	63.7	56.7	9.6	0	0	0	0	25.9	0	34	53.9	**301.6**
			2050	49.4	57.4	66.8	33.7	5.5	0	0	0	13.5	0	0	7.1	**233.4**
			2080	49.5	58.8	67.7	34.3	6	0	0	0	14.3	0	0	6.8	**237.4**
		8.5	2030	63.5	49.8	67.7	43.7	2.3	0	0	0	50.6	0	45.6	53.6	**376.8**
			2050	52.3	59.3	66.9	33.4	5.5	0	0	0	17.2	0	0	7.2	**241.8**
			2080	66.9	56.6	64.8	29.5	13.1	0	0	0	25.8	0	45.8	67.9	**370.4**
AEU22 Palakkad central plains	Rice-Rice-Fallow		Present	4.6	*	*	*	95.9	20.2	4.5	1	105.1	17.6	32.6	40.6	**322.1**
		4.5	2030	4.6	*	*	*	95.6	0	0	1.1	157.7	20.7	111.6	123.7	**515**
			2050	4.6	*	*	*	95.8	0	0	1.1	152	21.6	110.5	127.2	**512.8**
			2080	4.6	*	*	*	95.9	0	0	1.1	154.2	20.8	98.4	103.8	**478.8**
		8.5	2030	4.6	*	*	*	95.9	0	0	1.1	157.9	20	111.2	129.6	**520.3**
			2050	4.5	*	*	*	95.8	0	0	1.1	153.9	20.8	116.9	126.8	**519.8**
			2080	4.8	*	*	*	95.9	0	0	1.1	152.5	23.3	119.2	104.6	**501.4**
	Rubber		Present	22.6	37.1	83.8	51.7	23.7	1.8	0	0	0	2	3	18.1	**243.6**
		4.5	2030	116.3	123.8	144.8	145.3	21.5	0	0	5.4	125	1.8	76.4	93.7	**853.9**
			2050	127.9	128.3	140.3	109.6	6	0	0	0	99.7	6.7	85.7	108.6	**812.8**
			2080	132.9	130.4	140.8	91.8	6.1	0	0	0	102.1	5.8	73.1	85	**768.1**
		8.5	2030	132.1	127.8	135	142.2	15.4	0	0	1.7	104.8	5.6	85.5	110.6	**860.6**
			2050	129.9	129.1	145.3	121.5	9.5	0	0	0.5	101.8	5.9	89.6	108.1	**841**
			2080	139.9	134.1	139.4	130.7	28.1	0	0	0	102.1	7.6	92.3	84.8	**858.8**

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Water requirement(mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU23 Palakkad eastern plains	Rice-Rice-Fallow		Present	4.6	*	*	*	95.6	1.3	0	0.9	107.5	11.9	49.4	126.2	**397.4**
		4.5	2030	4.6	*	*	*	95.6	0	0	0.9	150.1	21.4	91.3	105.6	**469.5**
			2050	4.6	*	*	*	95.6	0	0	1	154	24	115.4	88.4	**483**
			2080	4.6	*	*	*	95.6	0	0	1	154.7	24.3	116.5	85.9	**482.6**
		8.5	2030	4.5	*	*	*	95.6	0	0	1	153.8	23.5	114.4	86.4	**479.2**
			2050	4.8	*	*	*	95.6	0	0	1	155.5	25.2	114.2	91.6	**487.9**
			2080	5	*	*	*	95.6	0	0	1	156.8	14.6	142.8	94.2	**510**
	Coconut		Present	104.7	90.1	99.3	59.7	23.9	0	0	0	0	0	7.5	79.9	**465.1**
		4.5	2030	108.5	105.2	102.9	93.9	0	0	0	0	85.1	0	43.9	61	**600.4**
			2050	88.9	95.4	94.7	88.1	4.1	0	0	0	92.8	0	64.9	41.3	**570.3**
			2080	99	96.4	91.2	93.8	8.6	0	0	0	93.8	0	65.2	37.9	**586.1**
		8.5	2030	102.2	94.8	93.9	88.1	4.4	0	0	0	92.2	0	64.2	39.7	**579**
			2050	105.9	98	93.4	86.8	1	0	0	0	94.7	0	64.4	43.2	**587.5**
			2080	112.7	104.9	89.8	97.4	0	0	0	0	96.7	0	90.9	43.8	**636.2**

4.4.4. Water requirements of major cropping systems of various AEUs in Malappuram district and impact of climate change

Crop evapotranspiration of major cropping systems of various AEUs in Malappuram district were studied and presented in table171.

In AEU2, Rice-Rice-Fallow and banana based are the major cropping system practiced in this unit. In Rice-Rice-Fallow cropping system the projected climate shows an increasing trend in the crop evapotranspiration. In banana based cropping system as per RCP4.5 and 8.5 the amount of crop evapotranspiration will be less in projected climate compared to the present condition.

Considering AEU6 the major cropping systems followed in this unit are Rice-Fallow and coconut based. In Rice-fallow cropping system the first season is cultivated with rice and second season is leaving as fallow. The amount of crop evapotranspiration in future climate will be higher than that of the present condition. In coconut based cropping system compared to the present climate the crop evapotranspiration will be increasing during projected climate as per RCP 4.5 and 8.5.

Rice-Rice-Fallow and Coconut+ Pepper+ Banana are the major cropping systems practiced in AEU11. In Rice-Rice-Fallow cropping system, as per RCP 4.5 and 8.5 in projected climate the crop evapotranspiration shows an increasing trend from the present condition. In Coconut+ Pepper+ Banana based cropping system, Banana and Pepper are intercropped with coconut. In this coconut and pepper are perennials and banana is taken as annual crop. The planting of banana is done on second week of September. The crop evapotranspiration for a year were calculated. In projected climate as per RCP 4.5 and 8.5 the crop evapotranspiration will be less than the present condition.

Considering AEU13, Rice-Rice-Fallow and rubber are the major cropping systems practiced in this unit. In Rice-Rice-Fallow cropping system the amount of crop evapotranspiration occurring during the first and second crop season in future climate will be higher than that of the present condition. In the case of rubber based cropping system comparing with the present condition the crop evapotranspiration will be less during the future climate. Annual crop evapotranspiration in 2080 as per 8.5 show an amount which will be higher than the present condition.

Rice-Rice-Fallow and rubber based are the major cropping system followed in AEU15. In Rice-Rice-Fallow cropping system as per RCP 4.5 and 8.5 in projected climate the crop evapotranspiration shows an increasing trend from the present condition. In rubber based cropping system as per RCP 4.5 and 8.5 the projected climate shows a decreasing trend in crop evapotranspiration compared to the present condition.

Water requirement of major cropping systems of various AEUs in Malappuram district were studied and presented in table172.

The irrigation requirements of major cropping systems of various AEUs in Malappuram district were studied and represented in table. Considering AEU2, in Rice-Rice-Fallow cropping system the water requirement shows an increasing trend during projected climate as per RCP 4.5 and 8.5. In projected climate during October and November the water requirement shows a drastic increase compared to the present condition. In banana based cropping system the future climate shows an increasing trend in projected climate whereas in 2030s it will decrease compared to the current condition. The period of irrigation required will increase in projected climate.

In the case of AEU6, the water requirement for the Rice-Fallow cropping system doesn't show much variation in projected climate based on RCP4.5 and 8.5. In coconut based cropping system the future climate shows an increased water requirement compared to the present condition. Compared to the present condition the periods were irrigation required will increase during future climate.

Considering AEU11, in Rice-Rice-Fallow cropping system as per RCP 4.5 and 8.5 compared to the present condition the water requirement will be higher in projected climate. In the case of Coconut+ Pepper+ Banana based cropping system the water requirement in projected climate will be higher as compared to the current condition. The periods were irrigation required will also increases during projected climate.

Rice-Rice-Fallow cropping system practiced in AEU13 the amount of irrigation water required will be higher in projected climate than the current condition. The variations in water requirement will happen mostly during the mundakan season. In rubber based cropping system the projected climate shows an increasing pattern in water requirement as per RCP 4.5 and 8.5. The periods were irrigation required will increase during projected climate. Compared to the present climate there will be a drastic increase in annual water requirement during projected climate.

Considering AEU15, in Rice-Rice-Fallow cropping system as per RCP 4.5 and 8.5 annually the amount of water requirement will be higher in projected climate compared to the current condition. In projected climate October and November shows a drastic increase in water requirement from the present situation. As in the case of rubber based cropping system during projected climate there will be a drastic increase in annual water requirement compared to the current climate as per RCP 4.5 and 8.5. The periods were irrigation required will increase during projected climate compared to the existing condition. Comparing the AEUs the maximum amount of irrigation water is required for the rubber based cropping system in AEU13 and AEU15.

Table171. Crop evapotranspiration of major cropping systems of various AEUs in Malappuram district

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
				Crop Evapotranspiration ET_c (mm)												
AEU2 Northern coastal plain	Rice-Rice-Fallow		Present	4.8	*	*	*	23.7	140.5	138.7	104.7	55.9	146.2	148.9	151.7	**915.1**
		4.5	2030	4.5	*	*	*	22.4	141	147.1	106.6	57.8	151.1	146.6	146.8	**923.9**
			2050	4.5	*	*	*	23.1	142.6	147.1	111.1	57.4	150.9	150.2	148.4	**935.3**
			2080	4.6	*	*	*	23.4	144.3	148.9	112.5	58.1	153	152.2	150.5	**947.5**
		8.5	2030	4.5	*	*	*	22.5	142.2	147.5	106.8	57.9	151.7	152.1	149.1	**934.3**
			2050	4.6	*	*	*	23.3	144	148.4	112.4	58	152.7	152.1	150.4	**945.9**
			2080	4.7	*	*	*	24	150.7	154.6	113.6	60.7	158.6	151.6	154	**972.5**
	Banana		Present	122.2	150.8	184.6	178.5	165.4	131.5	119.9	85.6	81.1	66.1	63.5	78.1	**1427.3**
		4.5	2030	115	137.4	164.9	158.7	146.7	125.7	122.8	86.3	82.8	68.5	64.8	77.8	**1351.4**
			2050	115.9	138.3	166	160.5	151.1	127.3	123.1	88.7	82.7	68.4	65.9	78.5	**1366.4**
			2080	117.5	140.2	168.2	162.7	153.4	128.7	124.6	89.9	83.8	69.3	66.8	79.6	**1384.7**
		8.5	2030	115.4	137.8	165.3	159.1	147.4	126.7	123.4	86.6	82.9	68.8	66.5	78.4	**1358.3**
			2050	117.2	140	167.8	162.2	152.9	128.4	124.2	89.7	83.7	69.3	66.8	79.5	**1381.7**
			2080	121	144.1	170.9	164.9	156	133.8	129.4	91.4	87	72	67.4	82	**1419.9**
AEU6 Kole lands	Rice-Fallow		Present	*	*	*	*	23.6	140.3	138	103.6	*	*	*	*	**405.6**
		4.5	2030	*	*	*	*	22.4	141.5	147	106.1	*	*	*	*	**417.1**
			2050	*	*	*	*	23.1	142.5	146.7	110.2	*	*	*	*	**422.5**
			2080	*	*	*	*	23.4	144.2	148.6	111.5	*	*	*	*	**427.9**
		8.5	2030	*	*	*	*	23	141.4	145.6	109.6	*	*	*	*	**419.6**
			2050	*	*	*	*	23.3	146.5	147.2	109.5	*	*	*	*	**426.7**
			2080	*	*	*	*	24	150.1	154.3	114.9	*	*	*	*	**443.2**
	Coconut		Present	108.6	106.3	125.9	116.6	103.9	83.3	79.6	83.6	90.4	99.3	95.4	102.1	**1195.4**
		4.5	2030	107.9	103.5	120.2	110.2	97.5	82.8	83.2	83.9	92.1	103.1	97.5	103.6	**1185.3**
			2050	108.3	104	120.7	110.9	99.6	82.9	82.8	86.4	92.1	103	99.3	104.7	**1194.5**
			2080	110	105	122.2	112.5	101	84.1	84	87.6	93.3	104.4	100.7	106.1	**1211.1**
		8.5	2030	107.6	103	121.2	110.6	99.2	82.6	82.5	86.2	91.7	102.3	98.6	105.1	**1190.4**
			2050	110.6	104.8	121.1	111.2	99.9	84.6	82.7	86.7	95.3	102.6	99.2	106.6	**1205.4**
			2080	113.9	108.4	125.5	114.2	102.5	87.1	87.1	90.2	96.8	107.5	103.6	107.8	**1244.3**

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AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
				Crop Evapotranspiration ET_c (mm)												
AEU11 Northern laterites	Rice-Rice-Fallow		Present	4.8	*	*	*	23.7	140.5	138.9	104.8	55.9	145.9	148.8	151.5	**914.8**
		4.5	2030	4.4	*	*	*	22.7	140	145.1	109.7	56.4	148.3	148	146.3	**920.9**
			2050	4.6	*	*	*	22.9	143.9	145.2	108.8	58.1	149.9	148	149.5	**930.9**
			2080	4.6	*	*	*	23.2	145.6	147.4	110.4	58.6	149.5	149.4	151.5	**940.2**
		8.5	2030	4.5	*	*	*	22.7	142.8	144.2	108	58.1	146.8	146.3	148.2	**921.6**
			2050	4.6	*	*	*	23.2	145.7	147.1	110.4	58.6	149.5	149.4	151.5	**940**
			2080	4.6	*	*	*	23.7	149.3	154	115.1	60	156.3	155.5	151.4	**969.9**
	Coconut + pepper + banana		Present	107.2	104.3	125	120.9	109.5	95.7	91.7	95.3	94.1	99.1	95.1	101.4	**1239.4**
		4.5	2030	98	89.6	103.7	100.4	94.2	95.3	95.7	99.7	95.1	100.8	97	99.3	**1168.9**
			2050	99.9	90.4	104.4	101.1	95.5	98	96.4	99.8	98.1	101.9	97.3	101.2	**1184**
			2080	101.1	90.8	105.4	102.1	96.6	99.2	97.7	101	99.3	101.7	98.2	102.6	**1195.5**
		8.5	2030	99.1	89.6	103.5	100.1	94.8	97.3	95.7	98.9	98.6	99.7	96.1	100.3	**1173.6**
			2050	101	91.2	105.1	101.6	96.4	99.2	97.6	100.9	99.1	101.7	98.2	102.4	**1194.6**
			2080	102.7	92.4	106.2	101.7	98.5	101.6	102.2	105.4	101.3	106.3	102.3	103	**1223.4**
AEU13 Northern foothills	Rice-Rice-Fallow		Present	4.8	*	*	*	23.7	140.6	139	104.8	55.9	145.9	148.6	151.2	**914.5**
		4.5	2030	4.5	*	*	*	22.8	143.5	148.3	109	57.8	150.6	144.2	146.9	**927.6**
			2050	4.6	*	*	*	23	145.2	150	110.2	58.4	152.3	145.8	148.4	**937.9**
			2080	4.6	*	*	*	23.3	146.9	151.9	111.9	59.2	154.3	146.2	149.9	**948.2**
		8.5	2030	4.6	*	*	*	22.9	146.2	149.3	109.4	58	151.1	144.8	149.7	**936**
			2050	4.5	*	*	*	23.2	145.7	151.3	113.4	58.7	152.5	152.4	148.3	**950**
			2080	4.9	*	*	*	24	149.2	154.8	116	61.5	159.7	155	155.8	**980.9**
	Rubber		Present	134.7	130.2	155	150	140.3	116	108.9	110.4	97.5	125.4	120.4	128.2	**1517.1**
		4.5	2030	129.5	120.1	136.5	131.8	125.5	111.4	111.3	112.6	100.5	129.9	120.9	128.9	**1458.7**
			2050	130.8	121.3	138	133.1	126.6	112.3	112.4	113.6	101.5	131.3	122.3	130.4	**1473.5**
			2080	132.9	123.1	139.9	134.9	128.3	113.9	114	115.5	102.9	133	123.1	131.9	**1493.2**
		8.5	2030	130.3	120.5	136.8	132.1	125.7	113.4	112.1	112.9	100.7	130.2	121.3	130.8	**1466.8**
			2050	132.4	121.8	139.2	133.2	126.7	112.3	113	116.9	102.2	131.3	126.4	130	**1485.3**
			2080	139	126.8	143.9	137.6	130.5	114.6	115.1	119.1	107.1	137.6	129.3	136.1	**1536.9**

				Crop Evapotranspiration ET_c (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern high hills	Rice-Rice-Fallow		Present	4.7	*	*	*	23.7	140.8	139	104.8	55.8	145.6	148.3	150.9	**913.6**
		4.5	2030	4.5	*	*	*	22.9	143.9	150.3	112.6	57.9	150.6	150.9	147	**940.6**
			2050	4.7	*	*	*	23.1	145.2	151	113.6	59.1	151.8	150.8	152.9	**952.2**
			2080	4.7	*	*	*	23.3	147.1	153.4	115.2	60	154	153.4	155	**966.1**
		8.5	2030	4.5	*	*	*	23	144.4	150.4	112.7	58	151.1	151.5	147.4	**943**
			2050	4.7	*	*	*	23.3	146.8	153.1	115	59.9	153.6	152.7	154.5	**963.6**
			2080	5	*	*	*	24.3	151	156.7	116.3	61.4	159.9	159.1	159.3	**993**
	Rubber		Present	134.5	130.1	154.9	150	140.4	116	108.9	110.4	97.4	125.3	120.2	127.9	**1516.1**
		4.5	2030	131.1	121.1	138.8	132.9	126.7	112.3	113.2	116.9	101.2	126.7	124.6	128.2	**1476.4**
			2050	133.1	122.9	139.4	134.4	127.4	113.4	113.9	118.2	103.8	130.7	124.7	132.5	**1494.3**
			2080	134.9	124.3	141.3	136.2	128.8	115.2	115.8	120.1	105.4	132.5	126.2	134	**1514.6**
		8.5	2030	131.4	121.4	139.2	133.4	127.2	112.6	113.2	116.9	101.4	130	125	128.7	**1480.6**
			2050	134.6	124.4	141.1	136.1	128.6	114.5	115.4	119.6	105.1	132.3	126.3	133.9	**1511.8**
			2080	143.4	131	147.6	140.2	132.7	116.4	116.7	119.8	107.2	137.8	132.1	139.1	**1563.9**

Table172. Water requirement of major cropping systems of various AEUs in Malappuram district

				Water Requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU2 Northern coastal plain	Rice-Rice-Fallow		Present	4.8	*	*	*	127.9	0	0	1	132.5	3.9	46.1	133.2	**449.4**
		4.5	2030	4.5	*	*	*	127.9	0	0	1	134.9	12.4	118.7	108.6	**508**
			2050	4.5	*	*	*	127.9	0	0	1	134.1	14	140.8	122.4	**544.7**
			2080	4.6	*	*	*	127.9	0	0	1.1	141.5	14.3	137.8	141.5	**568.7**
		8.5	2030	4.5	*	*	*	127.9	0	0	1	134.6	10.8	106.4	110.3	**495.5**
			2050	4.6	*	*	*	127.9	0	0	1.1	153.5	14.2	137.7	141.9	**580.9**
			2080	4.7	*	*	*	128	0	0	1.1	139.3	10.7	93.4	117.3	**494.5**
	Banana		Present	120	144.8	162.2	106.7	20.2	0	0	3.9	0	0	0	59.6	**617.4**
		4.5	2030	111.9	137.2	152.1	121.3	9.3	0	0	3.9	0	0	36.8	39.5	**612**
			2050	112.1	138.1	160.3	149.8	8.3	0	0	4	0	0	56.5	52.5	**681.6**
			2080	88.7	140	136.9	127.3	11.3	0	0	4.1	0	0	52.4	70.5	**631.2**
		8.5	2030	113.9	137.7	151.5	101.9	5.3	0	0	3.9	0	0	22.6	39.6	**576.4**
			2050	115.6	139.9	153.6	154.2	12.5	0	0	4.3	17.7	0	52.4	71	**721.2**
			2080	120.8	144	152.7	149.9	10.1	0	0	4.1	0	0	14.5	45.3	**641.4**
AEU6 Kole lands	Rice-Fallow		Present	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
		4.5	2030	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
			2050	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
			2080	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
		8.5	2030	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
			2050	*	*	*	*	94.8	0	0	0	*	*	*	*	**94.8**
			2080	*	*	*	*	94.9	0	0	0	*	*	*	*	**94.9**
	Coconut		Present	105.5	94.6	105.4	33.9	0	0	0	0	0	0	11.3	90.1	**440.7**
		4.5	2030	107.8	103.4	105.6	35.2	0	0	0	0	0	0	65.3	49	**466.2**
			2050	106.7	103.8	109.6	86.2	0	0	0	0	22.4	0	84.8	96.3	**609.7**
			2080	108.3	104.9	101.5	53.5	0	0	0	0	25.4	0	86.5	97.9	**578.1**
		8.5	2030	105.7	102.8	109	83.7	0	0	0	0	84.9	0	83.1	96.1	**665.3**
			2050	109	104.7	106.9	101.9	0	0	0	0	26.6	0	78.5	92.2	**619.7**
			2080	106.3	108.3	116.2	98.6	0	0	0	0	0	0	84.5	93.6	**607.5**

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Water Requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU11 Northern laterites	Rice-Rice-Fallow		Present	4.8	*	*	*	94.8	0	0	1	96.9	2.8	36.7	121.2	**358.2**
		4.5	2030	4.4	*	*	*	94.8	0	0	1	152.7	12.8	113.2	108.3	**487.2**
			2050	4.6	*	*	*	94.8	0	0	1	152.1	11	111.9	110	**485.4**
			2080	4.6	*	*	*	94.8	0	0	1.1	152.1	10.8	124.1	107.5	**495**
		8.5	2030	4.5	*	*	*	94.8	0	0	1	152	9.4	110.3	108.5	**480.5**
			2050	4.6	*	*	*	94.8	0	0	1.1	152	10.5	111.9	111.1	**486**
			2080	4.6	*	*	*	94.9	0	0	1.1	136.6	8.5	117	102	**464.7**
	Coconut + pepper + banana		Present	103.8	99.3	101.2	37.3	0	0	0	0	0	0	2.5	71.1	**415.2**
		4.5	2030	97.8	89.5	92	59.8	0	0	0	0	94.5	0	62.2	61.4	**557.1**
			2050	99.8	90.3	86.4	71	0	0	0	0	95.2	0	61.2	61.8	**565.5**
			2080	99.8	90.7	86.3	61.1	0	0	0	0	95.8	0	73	58.5	**565.2**
		8.5	2030	98.9	89.4	87.2	89.9	0	0	0	0	95.5	0	60.2	60.6	**581.7**
			2050	100.9	91.1	88.2	76.4	0	0	0	0	95.6	0	60.6	62.1	**574.7**
			2080	102.6	92.2	90.6	74.6	0	0	0	0	70	0	63.9	53.5	**547.4**
AEU13 Northern foothills	Rice-Rice-Fallow		Present	4.8	*	*	*	94.8	0	0	1	96.9	1.2	30.4	133.5	**362.6**
		4.5	2030	4.5	*	*	*	94.8	0	0	1	148.1	12	120.4	114.3	**495.1**
			2050	4.6	*	*	*	94.8	0	0	1	137.9	20.1	109.1	129.6	**497.1**
			2080	4.6	*	*	*	94.8	0	0	1.1	138.3	19.9	107.4	136.1	**502.2**
		8.5	2030	4.6	*	*	*	94.8	0	0	1	148.1	17.2	113.6	114.6	**493.9**
			2050	4.5	*	*	*	94.8	0	0	1.1	137.8	21.6	130.6	107.5	**497.9**
			2080	4.9	*	*	*	94.9	0	0	1.1	137.2	15.7	122.9	107.4	**484.1**
	Rubber		Present	132.9	119.1	123.3	56.3	18.7	0	0	0	0	0	10.3	110.4	**571.2**
		4.5	2030	128.8	120	130.3	47.4	0	0	0	0	95.6	0	97.1	96.2	**715.3**
			2050	122.9	121.2	124	116.2	3.7	0	0	0	81.8	5.9	85.5	111.4	**772.9**
			2080	132.8	123	121	118.6	3.2	0	0	0	82.5	5.5	84.2	118.1	**789.2**
		8.5	2030	121.7	120.4	131.3	115.1	2.2	0	0	0	95.9	3	90.2	95.7	**775.3**
			2050	129.3	121.6	129.6	98.6	2.7	0	0	0	81.7	7.1	104.5	89	**764.4**
			2080	138.8	126.7	126	130.5	14.1	0	0	0	81.6	2.5	97.2	87.7	**805.2**

270

				Water Requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern high hills	Rice-Rice-Fallow		Present	4.7	*	*	*	107.7	0	0	1	111.5	4.6	42.4	122.2	**394.1**
		4.5	2030	4.5	*	*	*	107.6	0	0	1.1	162.5	14.5	117.2	123.7	**531.1**
			2050	4.7	*	*	*	107.6	0	0	1.1	160.7	14.4	115.3	131.7	**535.5**
			2080	4.7	*	*	*	107.7	0	0	1.1	163.3	15.2	114.5	100	**506.5**
		8.5	2030	4.5	*	*	*	107.6	0	0	1.1	162.7	14.5	116.1	126.7	**533.2**
			2050	4.7	*	*	*	107.7	0	0	1.1	160.9	15.7	116.4	133.7	**540.2**
			2080	5	*	*	*	107.7	0	0	1.1	115.6	16.3	140.5	84.6	**470.8**
	Rubber		Present	125.9	117.4	137.2	57.4	22.8	0	0	0	0	0	15.6	99.2	**575.4**
		4.5	2030	131	121	131.8	93.3	0	0	0	0	96	0.7	90.8	104.9	**769.5**
			2050	129.1	122.7	135.4	105.9	3.2	0	0	0	95.8	0.5	89.1	111.3	**793.1**
			2080	127.4	124.1	128.5	95.3	1.4	0	0	0	99.1	0.5	87.4	78.9	**742.9**
		8.5	2030	127.5	121.3	132.9	53.2	0	0	0	0	96.2	0.7	89.7	107.9	**729.5**
			2050	130.7	124.2	131.9	115.9	1.8	0	0	0	96.2	1.2	89.9	113.1	**805**
			2080	143.3	130.9	133	136.4	10.6	0	0	0	0	8.1	113.5	64.3	**740.2**

4.5. Crop Weather Calendar of Rice based cropping system

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Rain (mm)	0	2.6	171	35	17	75	156	230	84	19	44	357	263	236	271	140	9.2	266	245	87	33	6.4
Present	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
Present					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation
Present													Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Sowing
Rain (mm)	16	27	36	124	66	142	220	204	176	381	256	247	223	262	192	203	69	45	13	0.3	0	198
2030	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
2030					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation
2030													Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Sowing

STD WEEK	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb
	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7
Rain (mm)	24	29	174	74	98	110	0	18	1.3	0.4	0	2.2	0	0	0	0	0.1	0	0	0	0
Present	Harvesting	Harvesting	Harvesting	Harvesting			Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Grain formation	Grain formation	Grain formation	Grain formation	Grain formation			
Present	Grain formation		Transplanting	Transplanting	Transplanting	Transplanting	Transplanting				Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
Present	Sowing	Sowing	Sowing	Sowing																	
Rain (mm)	0	190	40	22	5.2	11	0	0	3.6	27	2.3	32	3	0	0	0	0	3	0	0	0
2030	Harvesting	Harvesting	Harvesting	Harvesting			Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Grain formation	Grain formation	Grain formation	Grain formation	Grain formation			
2030	Grain formation		Transplanting	Transplanting	Transplanting	Transplanting	Transplanting				Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
2030	Sowing	Sowing	Sowing	Sowing																	

Fig.6. Crop weather calendar of Northern coastal plain (AEU2) in Malappuram district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
Rain (mm)	0	2.6	171	35	17	75	156	230	84	19	44	357	263	236	271	140	9.2	266	245	87	33	6.4
Present	Sowing	Sowing	Sowing	Sowing	Sowing				Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth									
Present					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting		Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
Present															Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation		Sowing
Rain (mm)	33	7.5	0	71	130	196	316	379	182	371	398	217	191	320	177	116	112	49	29	7.3	0	0
2030	Sowing	Sowing	Sowing	Sowing	Sowing				Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth									
2030					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting		Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
2030															Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation		Sowing

STD WEEK	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb
	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7
Rain (mm)	24	29	174	74	98	110	0	18	1.3	0.4	0	2.2	0	0	0	0	0.1	0	0	0	0
Present							Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Grain formation	Grain formation	Grain formation	Grain formation	Grain formation			
Present	Harvesting		Transplanting	Transplanting	Transplanting	Transplanting	Transplanting				Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
Present	Sowing	Sowing	Sowing	Sowing																	
Rain (mm)	0	182	123	49	7.9	19	6	0	19	22	3.3	8.5	23	0	0	0	0	7.9	0	0	7.7
2030							Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Grain formation	Grain formation	Grain formation	Grain formation	Grain formation			
2030	Harvesting		Transplanting	Transplanting	Transplanting	Transplanting	Transplanting				Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
2030	Sowing	Sowing	Sowing	Sowing																	

Fig.7. Crop weather calendar of Northern coastal plain (AEU2) in Thrissur district

STD WEEK	02 Apr - 08 Apr	09 Apr - 15 Apr	16 Apr - 22 Apr	23 Apr - 29 Apr	30 Apr - 06 Ma	07 May - 13	14 May - 20	21 May - 27	28 May - 03	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Rain (mm)	187	234	239	149	110	87	84	22	63	5	175	96	299	164	102	161	98	396	47	15	32	30	10	0	0	5	59	0	0
Present				Sowing									Vegetative Growth									Harvesting							
									Transplanting											Grain formation									
															Flowering														
Rain (mm)	1.2	0	0.4	24	61	10	74	316	257	117	136	307	386	261	259	200	290	239	114	63	68	0	9.7	0	0	0	208	130	0.5
2030								Sowing								Vegetative Growth										Harvesting			
											Transplanting											Grain formation							
																			Flowering										

Fig.8. Crop weather calendar of Pokkali lands (AEU5) in Ernakulam district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7
Rain (mm)	149	110	87	84	22	63	5	175	96	299	164	102	161	98	396	47	15	32	30	10	0	0	5	59	0	0	0	0	0	0	0	20	0	0	0	0	0	0	2	15	1	0	2
Present			Sowing								Vegetative Growth																				Vegetative Growth							Grain formation					
								Transplanting						Flowering						Harvesting							Transplanting								Flowering					Harvesting		
																	Grain formation							Sowing																			
Rain (mm)	39.8	100	88.7	30.5	129	343	185	226	390	550	404	198	181	337	210	151	159	70.3	0	9.1	0	59.9	0	173	123	50.7	8.6	21.2	6.6	0	16.9	19.2	3	8.6	25.6	0	0	0	0	1	2.6	0	0
2030			Sowing								Vegetative Growth																				Vegetative Growth							Grain formation					
								Transplanting						Flowering						Harvesting							Transplanting								Flowering					Harvesting		
																	Grain formation							Sowing																			

Fig.9. Crop weather calendar of Pokkali lands (AEU5) in Thrissur district

<table>
<tr><td rowspan="2">STD WEEK</td><td>15 Oct - 21 Oct</td><td>22 Oct - 28 Oct</td><td>29 Oct - 04 Nov</td><td>05 Nov - 11 Nov</td><td>12 Nov - 18 Nov</td><td>19 Nov - 25 Nov</td><td>26 Nov - 02 Dec</td><td>03 Dec - 09 Dec</td><td>10 Dec - 16 Dec</td><td>17 Dec - 23 Dec</td><td>24 Dec - 31 Dec</td><td>01 Jan - 07 Jan</td><td>08 Jan - 14 Jan</td><td>15 Jan - 21 Jan</td><td>22 Jan - 28 Jan</td><td>29 Jan - 04 Feb</td><td>05 Feb - 11 Feb</td><td>12 Feb - 18 Feb</td><td>19 Feb - 25 Feb</td><td>26 Feb - 04 Mar</td><td>05 Mar - 11 Mar</td><td>12 Mar - 18 Mar</td><td>19 Mar - 25 Mar</td></tr>
<tr><td>42</td><td>43</td><td>44</td><td>45</td><td>46</td><td>47</td><td>48</td><td>49</td><td>50</td><td>51</td><td>52</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td></tr>
<tr><td>Rain (mm)</td><td>120</td><td>95.8</td><td>17.6</td><td>0</td><td>94.8</td><td>4.6</td><td>0</td><td>0</td><td>21.2</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td rowspan="3">Present</td><td colspan="5">Sowing</td><td colspan="3"></td><td colspan="5">Vegetative Growth</td><td colspan="10"></td></tr>
<tr><td colspan="4"></td><td colspan="6">Transplanting</td><td></td><td colspan="5">Flowering</td><td></td><td colspan="6">Harvesting</td></tr>
<tr><td colspan="14"></td><td colspan="6">Grain formation</td><td colspan="3"></td></tr>
<tr><td>Rain (mm)</td><td>49.3</td><td>8</td><td>19.3</td><td>6</td><td>0</td><td>18.5</td><td>21.7</td><td>3.2</td><td>8.4</td><td>22.7</td><td>0</td><td>0</td><td>0</td><td>0</td><td>7.8</td><td>0</td><td>0</td><td>7.6</td><td>0</td><td>5.1</td><td>0</td><td>1.3</td><td>0</td></tr>
<tr><td rowspan="3">2030</td><td colspan="5">Sowing</td><td colspan="3"></td><td colspan="5">Vegetative Growth</td><td colspan="10"></td></tr>
<tr><td colspan="4"></td><td colspan="6">Transplanting</td><td></td><td colspan="5">Flowering</td><td></td><td colspan="6">Harvesting</td></tr>
<tr><td colspan="14"></td><td colspan="6">Grain formation</td><td colspan="3"></td></tr>
</table>

Fig.10. Crop weather calendar of Kole lands (AEU6) in Thrissur district

<table>
<tr><td rowspan="2">STD WEEK</td><td>15 Oct - 21 Oct</td><td>22 Oct - 28 Oct</td><td>29 Oct - 04 Nov</td><td>05 Nov - 11 Nov</td><td>12 Nov - 18 Nov</td><td>19 Nov - 25 Nov</td><td>26 Nov - 02 Dec</td><td>03 Dec - 09 Dec</td><td>10 Dec - 16 Dec</td><td>17 Dec - 23 Dec</td><td>24 Dec - 31 Dec</td><td>01 Jan - 07 Jan</td><td>08 Jan - 14 Jan</td><td>15 Jan - 21 Jan</td><td>22 Jan - 28 Jan</td><td>29 Jan - 04 Feb</td><td>05 Feb - 11 Feb</td><td>12 Feb - 18 Feb</td><td>19 Feb - 25 Feb</td><td>26 Feb - 04 Mar</td><td>05 Mar - 11 Mar</td><td>12 Mar - 18 Mar</td><td>19 Mar - 25 Mar</td></tr>
<tr><td>42</td><td>43</td><td>44</td><td>45</td><td>46</td><td>47</td><td>48</td><td>49</td><td>50</td><td>51</td><td>52</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td></tr>
<tr><td>Rain (mm)</td><td>120</td><td>96</td><td>18</td><td>0</td><td>95</td><td>4.6</td><td>0</td><td>0</td><td>21</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td rowspan="3">Present</td><td colspan="5">Sowing</td><td colspan="3"></td><td colspan="5">Vegetative Growth</td><td colspan="10"></td></tr>
<tr><td colspan="4"></td><td colspan="6">Transplanting</td><td></td><td colspan="5">Flowering</td><td></td><td colspan="6">Harvesting</td></tr>
<tr><td colspan="14"></td><td colspan="6">Grain formation</td><td colspan="3"></td></tr>
<tr><td>Rain (mm)</td><td>22</td><td>5.3</td><td>11</td><td>0</td><td>0</td><td>3.6</td><td>31</td><td>25</td><td>29</td><td>2.8</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>8.8</td><td>0</td><td>6.1</td><td>0</td></tr>
<tr><td rowspan="3">2030</td><td colspan="5">Sowing</td><td colspan="3"></td><td colspan="5">Vegetative Growth</td><td colspan="10"></td></tr>
<tr><td colspan="4"></td><td colspan="6">Transplanting</td><td></td><td colspan="5">Flowering</td><td></td><td colspan="6">Harvesting</td></tr>
<tr><td colspan="14"></td><td colspan="6">Grain formation</td><td colspan="3"></td></tr>
</table>

Fig.11. Crop weather calendar of Kole lands (AEU6) in Malappuram district

STD WEEK		Rain (mm) Present	Rain (mm) 2030
23 Apr - 29 Apr	17	0	23.1
30 Apr - 06 May	18	1.2	18.3
07 May - 13 May	19	202	0
14 May - 20 May	20	0	83.9
21 May - 27 May	21	25.3	196
28 May - 03 Jun	22	128	137
04 Jun - 10 Jun	23	86.7	274
11 Jun - 17 Jun	24	185	126
18 Jun - 24 Jun	25	124	179
25 Jun - 01 Jul	26	29.2	387
02 Jul - 08 Jul	27	14.5	360
09 Jul - 15 Jul	28	247	208
16 Jul - 22 Jul	29	93.3	61.5
23 Jul - 29 Jul	30	244	368
30 Jul - 05 Aug	31	339	197
06 Aug - 12 Aug	32	140	120
13 Aug - 19 Aug	33	11.6	98
20 Aug - 26 Aug	34	138	38.3
27 Aug - 02 Sep	35	185	20.6
03 Sep - 09 Sep	36	61.4	3.9
10 Sep - 16 Sep	37	6.3	0
17 Sep - 23 Sep	38	0	0
24 Sep - 30 Sep	39	70.8	0
01 Oct - 07 Oct	40	47.5	99.8
08 Oct - 14 Oct	41	83.7	80.9
15 Oct - 21 Oct	42	136	41.4
22 Oct - 28 Oct	43	30.8	1.3
29 Oct - 04 Nov	44	58.9	12.9
05 Nov - 11 Nov	45	2.1	1.6
12 Nov - 18 Nov	46	10.3	0
19 Nov - 25 Nov	47	6.2	5.6
26 Nov - 02 Dec	48	0	19.8
03 Dec - 09 Dec	49	0	3.3
10 Dec - 16 Dec	50	21.5	6.1
17 Dec - 23 Dec	51	0	16.6
24 Dec - 31 Dec	52	0	0
01 Jan - 07 Jan	1	0	0
08 Jan - 14 Jan	2	0	0
15 Jan - 21 Jan	3	0	0
22 Jan - 28 Jan	4	0	0
29 Jan - 04 Feb	5	0	0
05 Feb - 11 Feb	6	0	0
12 Feb - 18 Feb	7	0	0

Present: Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting, Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting

2030: Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting, Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting

Fig.12. Crop weather calendar of North central laterites (AEU10) in Palakkad district

STD WEEK		Rain (mm) Present	Rain (mm) 2030
23 Apr - 29 Apr	17	0	1.6
30 Apr - 06 May	18	1.2	27
07 May - 13 May	19	202	0
14 May - 20 May	20	0	56
21 May - 27 May	21	25	200
28 May - 03 Jun	22	128	62
04 Jun - 10 Jun	23	87	237
11 Jun - 17 Jun	24	185	139
18 Jun - 24 Jun	25	124	262
25 Jun - 01 Jul	26	29	310
02 Jul - 08 Jul	27	15	276
09 Jul - 15 Jul	28	247	165
16 Jul - 22 Jul	29	93	155
23 Jul - 29 Jul	30	244	289
30 Jul - 05 Aug	31	339	178
06 Aug - 12 Aug	32	140	126
13 Aug - 19 Aug	33	12	182
20 Aug - 26 Aug	34	138	49
27 Aug - 02 Sep	35	185	14
03 Sep - 09 Sep	36	61	0.3
10 Sep - 16 Sep	37	6.3	0
17 Sep - 23 Sep	38	0	0
24 Sep - 30 Sep	39	71	0
01 Oct - 07 Oct	40	48	170
08 Oct - 14 Oct	41	84	58
15 Oct - 21 Oct	42	136	22
22 Oct - 28 Oct	43	31	5.4
29 Oct - 04 Nov	44	59	8.6
05 Nov - 11 Nov	45	2.1	2.6
12 Nov - 18 Nov	46	10	0
19 Nov - 25 Nov	47	6.2	3.4
26 Nov - 02 Dec	48	0	22
03 Dec - 09 Dec	49	0	4.3
10 Dec - 16 Dec	50	22	6.9
17 Dec - 23 Dec	51	0	21
24 Dec - 31 Dec	52	0	0
01 Jan - 07 Jan	1	0	0
08 Jan - 14 Jan	2	0	0
15 Jan - 21 Jan	3	0	0
22 Jan - 28 Jan	4	0	0
29 Jan - 04 Feb	5	0	0
05 Feb - 11 Feb	6	0	0
12 Feb - 18 Feb	7	0	0.1
19 Feb - 25 Feb	8	0	3.5
26 Feb - 04 Mar	9	0	10
05 Mar - 11 Mar	10	0	0

Present: Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting, Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting

2030: Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting, Sowing, Transplanting, Vegetative Growth, Flowering, Grain formation, Harvesting

Fig.13. Crop weather calendar of North central laterites (AEU10) in Thrissur district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul -08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**
Rain (mm)	2.6	14.5	0	31.8	79.9	75.8	41.9	225	172	190	258	111	160	131	206	22.2	16	3.2	77	104	221	133	3.6	15.9	6	76
Present	Sowing	Sowing	Sowing	Sowing	Sowing				Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth													
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting		Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting			
															Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation						
Rain (mm)	3.5	28.4	0	28	88.1	72.9	86.1	204	232	236	287	162	218	312	184	137	140	35.8	13.4	0.7	0	0	0	113	88.4	38.1
2030				Sowing	Sowing	Sowing	Sowing	Sowing				Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth										
								Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting		Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
																		Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation			

Fig.14. Crop weather calendar of Northern foothills (AEU13) in Palakkad district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul -08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Rain (mm)	2.6	14.5	0	31.8	79.9	75.8	41.9	225	172	190	258	111	160	131	206	22.2	16	3.2	77	104	221	133	3.6	15.9	6	76	195	3.6	0	6.2	22.6	51.2	0	0	0	0	0	0	0	0	0	0	2.1
Present	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting			Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Grain formation	Grain formation	Grain formation	Grain formation	Grain formation			
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation		Transplanting	Transplanting	Transplanting	Transplanting	Transplanting				Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
													Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Sowing	Sowing	Sowing	Sowing	Sowing																	
Rain (mm)	48.1	90.2	2.7	66.4	105	61.6	135	210	356	125	428	202	226	237	248	155	121	99.5	16.5	0.3	0	0	0	52.9	201	35	5.6	8.6	2.7	0	0	16.8	8.9	6	16.4	0	0	0	0	0.6	0	0	0
2030	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting			Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Grain formation	Grain formation	Grain formation	Grain formation	Grain formation			
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation		Transplanting	Transplanting	Transplanting	Transplanting	Transplanting				Flowering	Flowering	Flowering	Flowering	Flowering		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
													Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Sowing	Sowing	Sowing	Sowing	Sowing																	

Fig.15. Crop weather calendar of Northern foothills (AEU13) in Malappuram district

STD WEEK	02 Apr - 08 Apr	09 Apr - 15 Apr	16 Apr - 22 Apr	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb	19 Feb - 25 Feb
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8
Rain (mm)	35	9	12	8	83	162	0	4	35	78	44	122	72	37	97	102	81	135	48	27	194	179	88	19	7	85	39	16	145	128	88	5	52	24	43	0	23	7.2	6	0	1	0	0	0	0	0	22
Present	Sowing, Vegetative Growth, Harvesting, Flowering / Transplanting, Grain formation, Vegetative Growth, Harvesting / Flowering, Transplanting, Grain formation / Sowing																																														
Rain (mm)	25	7.6	0	0.3	40	74	72	75	316	223	100	115	246	370	204	256	212	325	264	124	68	76	38	11	0	0	0	251	183	0.5	0.3	24	0	0	18	24	9.5	16	5.6	2.6	4.5	0	17	0.9	0.2	0	0.8
2030	Sowing, Vegetative Growth, Harvesting, Flowering / Transplanting, Grain formation, Vegetative Growth, Harvesting / Flowering, Transplanting, Grain formation / Sowing																																														

Fig.16. Crop weather calendar of Southern high hills (AEU14) in Ernakulam district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7
Rain (mm)	8	83	162	0	4	35	78.4	44	122	72.4	37	97	102	81	135	48	27	194	179	88	19	7	85	39	16	145	128	88	5	52	24	43.2	0	23.2	7.2	6	0	1	0	0	0	0	0
Present	Sowing, Vegetative Growth, Vegetative Growth, Grain formation / Transplanting, Flowering, Harvesting, Transplanting, Flowering, Harvesting / Grain formation, Sowing																																										
Rain (mm)	23.6	57.3	25.4	103	187	115	215	103	256	352	188	209	242	198	305	234	140	98.9	3.5	9	0	0	0	39.7	170	115	7.7	19.1	6.1	0	0	16.3	7.6	2.5	2.2	0.3	0	0	0	0.2	0	0.4	2.3
2030	Sowing, Vegetative Growth, Vegetative Growth, Grain formation / Transplanting, Flowering, Harvesting, Transplanting, Flowering, Harvesting / Grain formation, Sowing																																										

Fig.17. Crop weather calendar of Southern high hills (AEU14) in Thrissur district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Rain (mm)	15.2	9.8	54.9	17.1	53.7	47.5	214	48.4	66.2	53.8	88.8	92.7	21.8	5.1	49.1	137	99.9	316	182	7.1	50.3	34.9	90.5	33.3	14.5	0	29	18.3	0	0	10.1	9.2	0	0	0	15.1	0	0	0	0	0	9.1	0
Present			Sowing								Vegetative Growth																				Vegetative Growth							Grain formation					
								Transplanting						Flowering							Harvesting						Transplanting								Flowering						Harvesting		
																		Grain formation						Sowing																			
Rain (mm)	26.8	14.5	32.9	146	180	79	191	271	118	352	306	184	223	301	176	139	111	48.6	29.1	7.1	0	0	0	141	112	71.3	1.8	15.5	1.9	0	0	20.1	2.7	5.6	20.9	0	0	0	0	3.8	0	0	1
2030			Sowing								Vegetative Growth																				Vegetative Growth							Grain formation					
								Transplanting						Flowering							Harvesting						Transplanting								Flowering						Harvesting		
																		Grain formation						Sowing																			

Fig.18. Crop weather calendar of Northern high hills (AEU15) in Thrissur district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb	19 Feb - 25 Feb
	17	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Rain (mm)	15.2	9.8	54.9	17.1	53.7	47.5	214	48.4	66.2	53.8	88.8	92.7	21.8	5.1	49.1	137	99.9	316	182	7.1	50.3	34.9	90.5	33.3	14.5	0	29	18.3	0	0	10.1	9.2	0	0	0	15.1	0	0	0	0	0	9.1	0	19.8
Present			Sowing								Vegetative Growth																				Vegetative Growth							Grain formation						
								Transplanting						Flowering							Harvesting						Transplanting								Flowering						Harvesting			
																		Grain formation						Sowing																				
Rain (mm)	0	3.5	84	0.8	132	40	21.7	105	39.1	97.8	120	146	112	157	172	126	52.7	32.8	42.1	0	34	0	0	0	29.7	128	78.8	0.3	11.4	0.6	0	0	6.1	6.9	6.7	7.8	0	0	0	0	7.2	0	0	0
2030				Sowing								Vegetative Growth																				Vegetative Growth							Grain formation					
									Transplanting						Flowering							Harvesting						Transplanting								Flowering						Harvesting		
																			Grain formation						Sowing																			

Fig.19. Crop weather calendar of Northern high hills (AEU15) in Palakkad district

STD WEEK	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul -08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7
Rain (mm)	15.2	9.8	54.9	17.1	53.7	47.5	214	48.4	66.2	53.8	88.8	92.7	21.8	5.1	49.1	137	99.9	316	182	7.1	50.3	34.9	90.5	33.3	14.5	0	29	18.3	0	0	10.1	9.2	0	0	0	15.1	0	0	0	0	0	9.1	0
Present	Sowing									Vegetative Growth								Harvesting											Vegetative Growth							Grain formation							
Present					Transplanting										Grain formation										Transplanting								Flowering						Harvesting				
Present													Flowering									Sowing																					
Rain (mm)	21.8	27.1	44.7	57.5	226	48.3	155	224	184	164	476	226	141	197	273	172	98.5	66.1	11.4	2.3	0	0	0	26.2	141	77.9	5.3	14	4.7	0	0	18.1	9.8	3.5	7.5	2.4	0	0	0	0	0	0	0
2030	Sowing									Vegetative Growth								Harvesting											Vegetative Growth							Grain formation							
2030					Transplanting										Grain formation										Transplanting								Flowering						Harvesting				
2030													Flowering									Sowing																					

Fig.20. Crop weather calendar of Northern high hills (AEU15) in Malappuram district

The figures (Fig.6 to 20) show the present and expected changes in crop calendar of rice in Northern coastal plain (AEU2), Pokkali lands (AEU5), Kole lands (AEU6), North central laterites (AEU10), Northern foothills (AEU13), Southern high hills (AEU14) and Northern high hills (AEU15) of Ernakulam, Thrissur, Palakkad and Malappuram districts under projected climate.

As a general trend, the length of growing period in the major rice growing areas of different AEUs are getting shorter with slight differences among various agro-ecological units, implying a higher risk of operating under projected climate as per RCP 4.5. It can be also evident from the figures that the sowing date will be delayed by three weeks due to delay in summer showers. And this can be observed in AEU5 and AEU14 of Ernakulam district, AEU10 of Thrissur district and AEU13 of Palakkad district. In AEU15 of Palakkad district, the sowing date will be delayed by one week and in the case of remaining AEUs there will not be any shift in the sowing date. It can be also observed that the crops will have to suffer water stress during the grain filling stage and will be under heavy rains at the time of harvest in almost all AEUs of Ernakulam, Palakkad and Malappuram districts whereas in Thrissur district these will mostly affect the second crop growing season.

In general, there will be excess water available during rainy season (monsoon), even after fulfilling all the needs of user sectors and then will be shorter during non-monsoon seasons which may be reduced only through long-term storage structures. As more and larger scale storage structures have limitations due to the recent enforcement of environmental clearances, a realistic approach to fulfill this total water demand will be through scientific approaches of water management and soil and water conservation practices. First and foremost, water use efficiency needs to be improved by adopting scientific irrigation management practices in the area. This available surplus water conserved through scientific management during monsoon season can be utilized for fulfilling the scarcity during non-monsoon season.

This study showed that it may not be possible to bring the entire cultivable area under irrigation, and hence policy makers, planners in irrigation department, agriculture department officials and agricultural scientists should promote water saving methods/techniques. This includes adoption of micro irrigation techniques, crop varieties resistant to drought/water deficit, re-adjustment of cropping and nutrient application patterns, planting period adjustment (moving the planting window depending on the rainfall) and prioritization of areas/crops to be brought under irrigation and following the practice of deficit irrigation. Besides, sophisticated tillage operations (laser levelling) and traditional mulching techniques could also decrease water use by limiting soil evaporation and plant transpiration, and more area can be brought under irrigation. Hence, water saving techniques for agricultural sector, in combination with optimized water reallocation, are prerequisites for comprehensively addressing the worsening water shortage problems in Kerala, especially during summer season. The projection data also reveals that there will be an increase in high intensity rainfall of more than 50 mm per day. Being a highly undulating state this will leads to high soil erosion and nutrient loss and worsen the crop productivity.

A shift in the water surplus periods can be observed in Northern coastal plain (AEU2) of Thrissur and Malappuram district, Pokkali lands (AEU5) of Ernakulam and Thrissur districts, Southern and central foothills (AEU12) of Ernakulam district, Attappady hills (AEU18) and Palakkad central plain (AEU22) of Palakkad districts. This situation demands the need of changing or adjusting the existing crop calendar mainly because the distribution of rainfall is not likely to be spatially homogeneous across a given agro-ecological unit. At present, adjustments to the agricultural calendar do not seem consistent across locations.

Given climate change, farmers develop coping mechanisms such as adjusting some of their farming practices. They have to design their own agricultural calendar by relying on personal experience. Due to climate change, the duration of the cropping season is getting shorter in majority of the AEUs with slight differences among or within agro-ecological units. As a result, the risk for farmers to be operating under time inefficient calendar conditions becomes higher. These findings suggest that providing farmers with climate related information could help to ensuring rational and time-efficient management of the agricultural calendar. As well, research and extension institutions should help in designing clear agricultural calendars to be based on the driving forces of farmers' behavior towards the adjustment of their farming practices as a climate change response.

Creation of irrigation sources are very much needed even in a wet tropical region like Kerala, where irregularity in rainfall is the norm and the domestic production of food could hardly meet just one-sixth of the requirement of the population and achieved yield levels fall extremely short of the potential levels projected.

CHAPTER 5. SUMMARY

The negative impacts brought by climate change have become an important limiting factor for agricultural development. The risk of climate variability is reduced by the use of irrigation, irrigated farming systems are dependent on reliable water resources; therefore they may be exposed to changes in the spatial and temporal distribution of rainfall in a location. To stabilize the negative effects of climate change, researchers have generally emphasized incremental adaptation to existing cropping systems, such as the adjustment of planting window, suitable variety and improved agronomic practices. AEZ concept is a good decision making approach for variety of farming activities performed by the farmers and is a useful tool for the studying the impact of climate change.

The objectives of the study are:

1. To study rainfall variability and to determine water availability periods of Agro ecological units of Central Kerala under different climate change scenarios
2. To study the impact of projected climate change on cropping pattern, crop calendar and the possible changes in the water requirements of major cropping systems prevailed in the various Agro ecological Units of central Kerala

5.1. Method of analysis

CROPWAT model was used for the calculations of crop evapotranspiration, crop water requirements and irrigation requirements for the development of irrigation schedules under various management conditions and scheme water supply. Weather cock v.1.5 was used for converting the daily weather data into standard week, month and seasonal formats. It is also used to compute PET and Thornthwaite water balances.

5.2. Major finding of the study

- The monthly rainfall of various Agro ecological units of Central Kerala indicate a increased rainfall during the months June, July and August in Projected climate as per RCP 4.5 and 8.5

- A decline in rainfall can be observed during the months January, February, September and December in projected climate
- Annually, the number of rainy days indicates a decreasing trend in projected climate. In nut shell the wet months will be wetter and dry periods will be drier
- The south west monsoon and summer season shows an increasing trend in the number of rainy days and amount of rainfall in projected climate
- The projected climate indicate that there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend
- Most of the agro ecological units in central Kerala indicate a shortening in the length of growing period in projected climate as per RCP 4.5 and 8.5
- The AEUs such as Attappady hills (AEU18) and Attappady dry hills (AEU19) of Palakkad district indicate a increasing trend in the length of growing period during projected climate
- In projected climate the maximum amount of potential evapotranspiration can be observed during the months May, July and September whereas the minimum will be in January, November and December
- The yearly potential evapotranspiration shows an increasing trend in projected climate as per RCP 4.5 and 8.5
- The number of periods where deficit will happen indicate an increasing trend and also the annual amount of deficit shows an increasing pattern in projected climate
- As per the projections, maximum water deficit will happen during the March in most of the agro ecological units of central Kerala
- Annually the amount of water surplus indicate an increasing trend in projected climate based on RCP 4.5 and 8.5 except in Northern high hills (AEU15), Palakkad central plains (AEU22), Palakkad eastern plains (AEU23) of Palakkad district and Northern foothills (AEU13) of Malappuram district
- A shift in the water surplus periods can be observed in Northern coastal plain (AEU2) of Thrissur and Malappuram districts, Pokkali lands (AEU5) of Ernakulam and Thrissur districts, Southern and central foothills (AEU12) of Ernakulam district, Attappady hills (AEU18) of Palakkad district

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- Most of the AEUs in central Kerala indicate a reduced number of surplus periods in projected climate
- The crop evapotranspiration indicate a increasing trend in the rice based cropping system during the projected climate
- The cropping systems like coconut based and Rubber based show a decreasing trend in the crop evapotranspiration in projected climate whereas in coffee and cardamom based cropping system it indicate an increasing trend
- The water requirement indicate an increasing trend in most of the major cropping systems whereas in Rice-Fallow-Fallow cropping the irrigation requirement remains unchanged
- As a general trend, the length of growing period in the major rice growing areas of different AEUs are getting shorter with slight differences among various agro-ecological units, implying a higher risk of operating under projected climate as per RCP 4.5
- The crop calendar of rice based cropping system indicate a delay in sowing date due to delay in summer showers
- It can be observed that the crops will have to suffer water stress during the grain filling stage and will be under heavy rains at the time of harvest in projected climate as per RCP 4.5

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Impact of projected climate change on cropping pattern of different agro ecological units of central Kerala

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(2012-20-117)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the requirement for the degree of

BSc-MSc (integrated) Climate Change Adaptation

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2017

ABSTRACT

Agriculture faces hastily growing challenges because it must supply food to an increasing population under shifting climate conditions. To stabilize the negative effects of climate change, researchers have generally emphasized incremental adaptation to existing cropping systems, such as the adjustment of planting window, suitable variety and improved agronomic practices. Characterization of the ecosystems using the AEZ concept is a good decision making approach for variety of farming activities performed by the farmers and is a useful tool for the studying the impact of climate change. The objectives of this study are (1) To study rainfall variability and to determine water availability periods of Agro ecological units of Central Kerala under different climate change scenarios. (2) To study the impact of projected climate change on cropping pattern, crop calendar and the possible changes in the water requirements of major cropping systems prevailed in the various Agro ecological Units of central Kerala.

Daily rainfall data for the period 1991-2014 were collected from the India Meteorological Department, Thiruvananthapurm. The weather data from General Circulation Models based on RCP 4.5 and 8.5 were analyzed. Weather cock v.1.5 was used for converting the daily weather data into standard week, month and seasonal formats. The rainfall parameters or indices like seasonal and monthly rainfall, rainy days, high rainfall events, length of growing period were calculated. It is also used to compute PET and Thornthwaite water balances. CROPWAT model was used for the calculations of crop evapotranspiration, crop water requirements and irrigation requirements for the development of irrigation schedules under various management conditions and scheme water supply.

A decline in rainfall can be observed during the months January, February, September and December in projected climate as per RCP 4.5 and 8.5 whereas an increased rainfall during the months June, July and August. In nut shell the wet months will be wetter and dry periods will be drier. The south west monsoon and summer season shows an increasing trend in the number of rainy days and amount of rainfall in projected climate. The projected climate indicates that there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events show an increasing trend.

Most of the agro ecological units in central Kerala indicate a decreasing pattern in the length of growing period in projected climate as per RCP 4.5 and 8.5. In projected climate the maximum amount of potential evapotranspiration can be observed during the months May, July and September whereas the minimum will be in January, November and December. The number of periods were deficit will happen indicate an increasing trend and also the annual amount of deficit show an increasing pattern in projected climate. A shift in the water surplus periods can be observed during projected climate. Most of the AEUs in central Kerala indicate a reduced number of surplus periods in projected climate.

The crop evapotranspiration indicate an increasing trend in the rice based cropping system during the projected climate whereas in perennial crops it shows a decreasing trend. The water requirement indicates an increasing trend in most of the major cropping systems whereas in Rice-Fallow-Fallow cropping the irrigation requirement remains unchanged. As a general trend, the length of growing period in the major rice growing areas of different AEUs are getting shorter with slight differences among various agro-ecological units, implying a higher risk of operating under projected climate as per RCP 4.5. The crop calendar of rice based cropping system indicates a delay in sowing date due to delay in summer showers and the crops will have to suffer water stress during the grain filling stage and will be under heavy rains at the time of harvest in projected climate as per RCP 4.5.