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

by

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THESIS

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DECLARATION

I, Yasser E.K. (2012 – 20 – 122) hereby declare that this thesis entitled **"Impact of projected climate change on cropping pattern of agro ecological units of northern Kerala"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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ABBREVIATIONS

AR5	Assessment Report 5
BSH	Bright Sunshine Hours
CD	Critical Difference
CERES	Crop Estimation through Resource and Environment Synthesis
FAO	Food and Agriculture Organization
GCM	General Circulation Model
GDD	Growing Degree Days
IBSNAT	International Benchmark Sites Network for Agrotechnology Transfer
IPCC	Inter government panel on Climate Change
IRRI	International Rice Research Institute
KAU	Kerala Agricultural University
LAI	Leaf area index
NS	Non significant
PI	Panicle Initiation
RARS	Regional Agricultural Research Station
RH-I	Morning Relative humidity
RH-II	After noon Relative humidity
RMSE	Root Mean Square error
RCP	Representative Concentration Pathway
T_{max}	Maximum temperature
T_{min}	Minimum temperature

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Chapter 1. Introduction

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather within the context of longer-term average conditions. Climate change poses a challenge to agricultural production and its impacts vary depending on regional focus and on the type of production system. 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 sea level rise. Rising temperatures associated 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.

Climate, with its regional and temporal variability, is a key determinant of agricultural production. All agricultural production is correlated to the performance of cultivated species, which are bound to particular environmental conditions. As climatic conditions change, also production conditions are likely to change with possible positive or negative implications on agricultural production. While agriculture provides humanity with essential goods i.e., food, fodder and fiber, agricultural management also affects important ecosystem services such as the provision of clean water or soil protection. It is important to anticipate future changes in the agroecosystem to be able to respond adequately and maintain its functionality with regard to multiple ecosystem services. If climate change impacts on agroecosystem functioning are known, measures can be planned to adapt agricultural management in order to prevent the negative impacts of climate change and to exploit new, emerging potentials.

Recently, agro ecological zone (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 is considered to be extremely vulnerable 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 will 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 impact of climate change on regional water availability, changes in the cropping pattern and water requirement at agro ecological unit level of northern districts of 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 major cropping systems of southern 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 northern 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 northern Kerala.

Chapter 2. Review of literature

There is an enormous literature that analyzes the impacts that global warming will have on crop growth and production. Although authors offer diverse scenarios, the consensus is that the productivity of crops and livestock may decline because of rice in temperatures and drought-related stress, but these effects will vary among regions. Diverse and location-specific impacts on agricultural production are anticipated. Regions at middle to high latitudes, where global warming will extend the length of the potential growing season may not experience the yield decreases expected in tropical regions which are expected to be the worst affected from climate change, suffering significant agricultural production losses Many of these countries are also currently under severe economic and ecological stress. Climate change is expected to push the agricultural sectors in these countries into further hardship. Historical studies demonstrate that climate change has already had negative impacts on crop yields. Overall, productivity levels are expected to be lower than without climate change due to changes in temperatures, crop water requirements and water availability and quality.

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 northern Kerala is being reviewed.

2.1. CLIMATE CHANGE

A systematic variation with season and latitude in the concentration and isotopic abundance of atmospheric carbon dioxide has been found in the northern hemisphere. In Antarctica, a small but persistent increase in concentration has been found (Keeling, 1960).

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

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 (Vijaya Venkata 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).

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.

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.

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.

The crop production in low latitude developing countries would suffer more, and earlier, than in (mainly mid- to high latitude) developed countries, due to a combination of adverse agro-climatic, socio-economic, and technological conditions (Rosenzweig and Hillel 2008).

Manjunatha *et al.,* (2009) conducted a study, during the *kharif* season of 2005 in Karnataka, India, to determine the effect of different system of rice intensification on yield, water requirement and water use efficiency. Treatment combinations comprised: three methods of planting (M1, normal method; M2, recommended SRI method; and M3, modified SRI method) and five seedling ages (9, 12, 15, 18 and 21 days) laid out in split-plot design with three replications. Data on the effects of planting method and seedling age on the grain and straw yields of rice, water requirement and water use efficiency are tabulated. The grain yield of rice was significantly highest with M3 (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.

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.

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.

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 led 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.

2.2.1 Climate change impact on Indian agriculture

Direct effect of climate change in irrigated and well managed rice crops will always be positive in different agro climatic regions in India irrespective of the various uncertainties. Southern and western India, which are at present relatively cooler during the rice season compared to northern and eastern regions, are likely to show a greater sensitivity to climate change. In case climatic change has a negative effect on productivity effect on productivity varieties with greater temperature tolerance can easily mitigate the negative effects. There is an urgent need to document the temperature sensitivities of major crop varieties to changes in temperature (Aggarwal and Mall, 2002).

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 favourable 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

In agricultural systems, the level of existing biodiversity can make the difference between the system being stressed or resilient when confronting a biotic or abiotic perturbation. In all agroecosystems, a diversity of organisms is required for ecosystem function and to provide environmental services.

Most Indian workers have adopted the classification strategies based on techniques developed by Koeppen (1936), Thornthwaite (1931, 1948), Thornthwaite and Mather (1955), Papadakis (1970), 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. Both the studies have 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); Subrahmanyam (1957, 1963); Subrahmanyam and Sastry (1969); and Krishnan (1969).

Other workers such as Krishnan and Thanvi (1971); Subramaniam and Umadevi (1979); Subramaniam and Vinayak (1982); 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 Hargreave. Sarkar and Biswas (1988) worked out agro climatic classification for entire India.

The National Bureau of Soil Survey and Land use Planning (NBSS&LUP) has divided India into agro-ecological regions based on climatic and ecological conditions (Murthy and Panday 1978). The same organization has now updated and divided India into agro-ecological regions based on physiography, soil, climate and length of growing period (Sehgal *et al.*, 1990).

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 Bora (1976), Ram Mohan (1978), Vinayak (1991) and 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.

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).

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 moves 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 concepts 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.

Thornthwaite and Mather (1955) revised assumptions and methods of computations of the book keeping procedure.

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.

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).

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

Donker (1987) prepared a computer program (WTRBLN) to calculate water balance based on the basis of long-term average monthly precipitation, potential evapotranspiration and combined soil and vegetation characteristics, according to the method proposed by Thornthwaite and Mather. Three additions to the original method are implemented (1) direct runoff can be taken into account (2) reference potential evapotranspiration can be adjusted to crop potential evapotranspiration by the factors and (3) a successive approximation method can be selected by the user if the climate is so dry that the soil never reaches field capacity.

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.

Zahler (1991) determined moisture deficiencies for C. *arabia* in the Distrito Federal, Brazil, using 1931-1960 meteorological data. The water balance was calculated by Thornthwaite and Mather's method, considering a soil moisture retention of 125 mm.

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.

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 ; 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). Use of probabilities of monthly total rainfall for agronomic purpose has been reported by Manning (1956); Baliga and Sridharan (1968).

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.

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.

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.

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) 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.

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.

Deo and Amissal (1973) estimated potential evapotranspiration rates over a grass sward at Guelph, Canada using the methods of (a) Penman and (b) Thornthwaite. There was no difference between the two methods, if annual totals were considered, but when using monthly totals, estimates using (a) were higher than when using (b) from May to July; from July onwards estimates with (b) were higher than with (a).

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.

Franco (1983) presented simplifications of the Thornthwaite, Penman and Turc methods of calculating evapotranspiration. The method involved replacing daily values for some parameters by values for a hypothetical mean day value. Values for the parameters are given for N and S latitudes in the different months of the year.

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.

2.5. CLIMATE CHANGE AND WATER REQUIREMENT

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.

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).

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.

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.

Kite and Droogers (2000) as part of an inter comparison study on estimating ET used different methods such as field measurements, satellite data and model predictions. Six of the most commonly used reference ET methods were applied in this comparison. Jensen *et al.,* (1990) reported a major study where they analyzed the performances of 20 different methods for estimating the ET under different climatic conditions. The impact of climate change on crop evapotranspiration therefore becomes important for water management and agricultural sustainability (Mo *et al.*, 2013).

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.

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).

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.

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, every 1°C increase in night time temperature led to a 10 per cent reduction in yield.

Shakhawat *et al.,* (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

George and Krishnan (1969) attempted for assessing the water availability periods based on climatic and soil conditions.

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.

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.

Budhar and Gopalaswamy (1992) presented annual, seasonal, monthly and weekly rainfall data and suitable cropping systems for the Uthangarai taluk 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.

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.

The combustion of fuel, biomass burning, production of synthetic chemicals and deforestation are enhancing the greenhouse effect by changing the chemical composition of the atmosphere. The greenhouse gases are found to be increasing at the rate of one per cent for methane, 0.4-0.5 per cent for carbon dioxide and 0.2-0.3 per cent for nitrous oxide At this rate the concentration of carbon dioxide will exceed 370 ppm by the year 2030 (Baker, 1989).

The beneficial effects of increased temperature can be negated as the incidence. Photosynthetically Active Radiation (PAR) is likely to decline by one per cent (Hume and Cattle 1990).

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 with CO_2 fertilization effect had shown a reduction of 135 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

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).

Climate change impacts research is usually performed by using GCMs to provide climate change scenarios Global Climate Models, also referred to as General Circulation Models (GCMs), are appliances clear up the basic equations of mass, momentum and thermodynamics to have a description of the condition of the weather, and provide much of the meteorological variables, for example wind speed, relative humidity, rainfall, temperature and solar radiation (Helfer *et.al.* 2012).

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 northern Kerala. Agro-Ecological Units Maps of Kerala shows the location of weather stations in the State (Fig. 1).

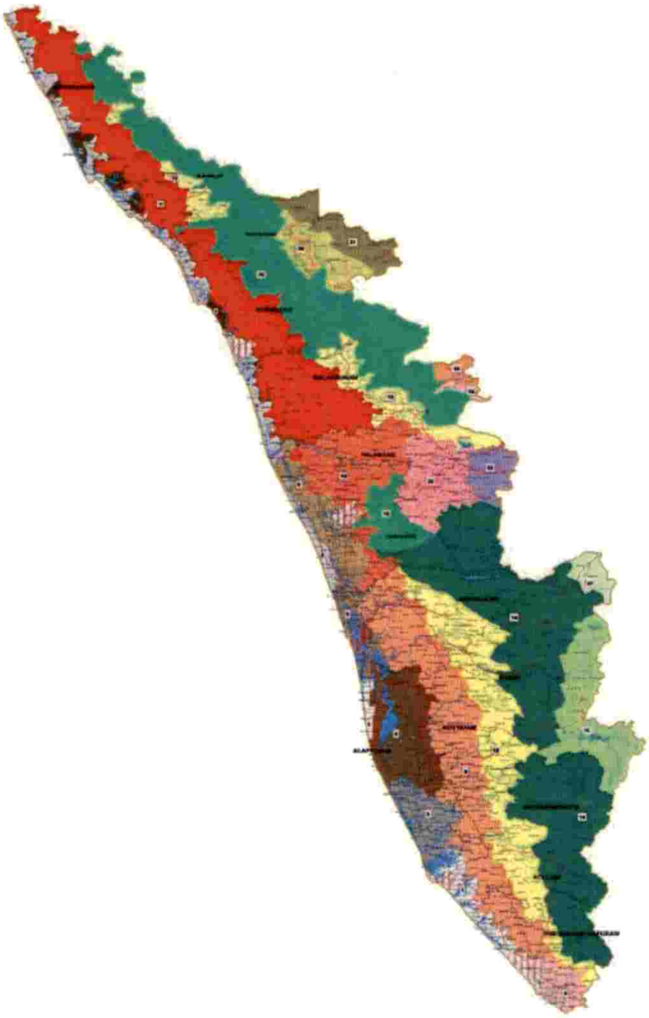

Fig. 1. Agro-Ecologi`cal Units Maps of Kerala

3.1. COLLECTION OF DATA

3.1.1 Meteorological data

Daily rainfall data for the period 1991-2014 were collected from 25 stations of Kerala state from the Indian 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	KANNUR	Kannur	11°58'N	75°33'E
02		Tahaliparamba	11°50'N	75°20'E
03		Thalasserry	11°45'N	75°32'E
04		Irikkur	12°03'N	75°23'E
05	KASARAGOD	Kasaragod	12°12'N	75°06'E
06		Hosdurg	12°31'N	74°59'E
07		Kudulu	12°30'N	75°00'E
08	KOZHIKODE	Kozhikode	11°15'N	75°47'E
09		Vadagara	11°25'N	75°40'E
10		Quilandy	11°35'N	75°30'E
11	WAYANAD	Mananthavady	11°41'N	76°16'E
12		Vythiri	11°50'N	76°00'E
13		Kuppady	11°33'N	76°02'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 National Bureau of Soil Survey and Land Use Planning (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. Potential Evapotranspiration (PET)

The potential 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,

ETo = 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.

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. Monthly 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 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 (Unadjusted *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* – *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 f 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 ≥ 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 were 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 V.8

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 (ETo) 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 (ETc). The FAO Penman-Monteith method suggested by Verhoef and Feddes (1991) to estimate ETo is given as

ETo	- 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 convert the daily weather data into standard week, month and seasonal formats. It is 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.

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

RCP	Description
RCP 2.6	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.

RCP 4.5	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.
RCP 6.0	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.
RCP 8.5	It is characterized by increasing GHG emissions over time representative of scenarios in the literature leading to high GHG concentration levels.

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.

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 southern 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 northern Kerala" are presented in this chapter. The variations in rainfall pattern and water balance due to fluxes 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 analysed. 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. Kannur, Kasaragod, Kozhikode, Wayanad comprises northern Kerala.

4.1.1. Rainfall analysis of various AEUs of Kozhikode district

The Kozhikode district has been divided into four agro-ecological units (fig. 3) such as Northern coastal plain (AEU2), Kaipad lands (AEU7), Northern laterites (AEU11), Northern high hills (AEU15) and these cover an area of 24,186 ha. (10.31%), 4929 ha. (2.10%), 116,035 ha. (49.45%) and 75,186 ha. (32.04%) respectively.

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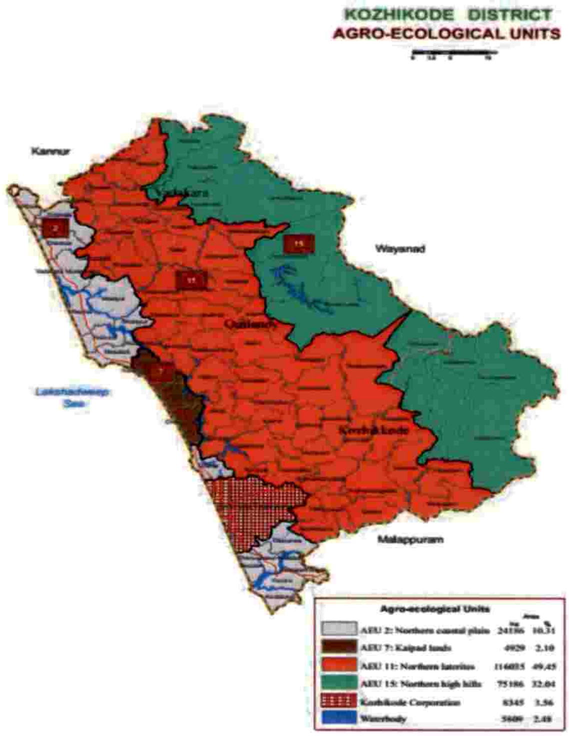

Fig.3 Agro-Ecological Units Map of Kozhikode District

4.1.1.1. Rainfall analysis of Northern coastal plain (AEU 2) and climate change impacts in Kozhikode district

Major cropping system in the unit is coconut based and it is practiced in nearly 53 per cent of the cultivable area and followed in all the panchayats in the unit. Banana based cropping system (12.86% of cultivable area), Rice based cropping system (7.87% of cultivable area), and Arecanut based cropping systems (3.46% of cultivable area) and Rubber based cropping systems (1.31% of cultivable area) are also seen here.

Among the rice-based cropping systems, Rice-Rice-Fallow system predominates and is practiced in 70.59 per cent of panchayats and occupies 32.13 per cent of rice area in the unit. This is followed by Rice-Rice-Vegetable cropping system representing 30.6 per cent of the rice area in the unit. Among coconut-based systems coconut monocropping is adopted all the panchayats and occupies 45.64 per cent of the coconut area of the unit.

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4.1.1.1.1. Rainfall and Rainy days of Northern coastal plain (AEU2) in Kozhikode 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 3.

Table 3. Monthly rainfall distribution of Northern coastal plain (AEU2) and the projected climate in Kozhikode district

Monthly Rainfall (mm)	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0.1	0	0	0
February	0.4	0	0	0	0	0	0
March	5.1	12.4	5.3	12.8	5.9	2.9	20.3
April	50.2	53.4	90.8	97.6	63.7	87	18.2
May	415.4	312.4	472.4	395.5	352.5	462.6	456.6
June	1361.9	1334	1285	1530.1	1146.4	1486.7	998.7
July	1725	1457.7	1485.9	1500.9	1463.1	1476.3	1460.7
August	484.1	522.8	486.8	557.2	520.8	581.5	660.8
September	159.8	194	145.1	207	198.9	207.7	12.5
October	332.4	245	279.7	317.4	308.3	311.9	373.6
November	34.7	44.2	23.7	31.4	31.3	29.5	56.6
December	29.8	71.4	33.2	13	14	16.1	43.5
Total	**4598.8**	**4247.3**	**4307.9**	**4663**	**4104.9**	**4662.2**	**4101.5**

In the present condition June and July are the wettest months, having a rainfall of 1361.9 mm and 1725 mm. January and February are the months having lowest rainfall of 0 mm and 0.4 mm. As per projected climate based on RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during June and July. And the lowest rainfall gets during January and February. As in the case of annual rainfall, the projected climate shows a decreasing trend from the present condition from 2030 to 2050 in RCP 4.5 and in RCP 8.5 the values show an increase from 2030 to 2050 and again decreases in 2080.

The monthly rainy days of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were analysed and represented in table 4.

Table 4. Monthly rainy days of Northern coastal plain (AEU2) and the projected climate in Kozhikode district

Monthly Rainy days	2016	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	1	3	1	2	1	0	3
April	6	3	6	4	5	5	2
May	14	13	16	15	16	16	13
June	26	28	26	26	28	26	25
July	29	30	30	30	30	30	30
August	13	15	14	16	15	16	17
September	6	4	6	4	4	4	2
October	11	11	12	11	11	11	10
November	4	4	4	3	4	3	4
December	5	5	2	2	2	3	5
Total	**115**	**116**	**117**	**113**	**116**	**114**	**111**

In the current condition, June and July have the most extreme number of rainy days and it is around 29 days. Also, the most reduced rainy days are in January and February. According to RCP 4.5 and 8.5, the greatest number of rainy days will be happening in June and July and the base will be in January and February. The greatest rainy days will be 30 days and the base will be 0 days. The projected climate demonstrates an expanding pattern in the yearly rainy days of northern coastal plain from 2030 to 2050 (RCP 4.5). The yearly rainy days of projected climate will be more when contrasted with the current condition except in 2050 and 2080 of RCP 8.5.

The seasonal rainy days of northern coastal plain (AEU2) for the existing condition and projected climate were examined and given in table 5.

Table 5. Seasonal rainy days of Northern coastal plain (AEU2) and the projected climate in Kozhikode 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	0	0.4	21	470.7	74	3730.8	20	396.9
4.5	2030	0	0	19	378.2	77	3508.5	20	360.6
	2050	0	0	23	568.5	76	3402.8	18	336.6
	2080	0	0.1	21	505.9	76	3795.2	16	361.8
8.5	2030	0	0	22	422.1	77	3329.2	17	353.6
	2050	0	0	21	552.5	76	3752.2	17	357.5
	2080	0	0	18	495.1	74	3132.7	19	473.7

At present, the greatest number of rainy days happens in south west rainstorm time (74 days) trailed by summer season (21 days), north east (20 days) and winter season (0 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in South West rainstorm taken after by summer season. The base number of rainy days and precipitation will be in winter. The projected climate demonstrates a strengthened precipitation in South West when contrasted with the earlier years.

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4.1.1.1.2. High rainfall events of northern coastal plain (AEU2) in Kozhikode district

For the present condition and projected climate, the high rainfall events of northern coastal plain (AEU2) were studied and given in table 6.

Table 6. High rainfall events of Northern coastal plain (AEU2) and the projected climate in Kozhikode district

Year	Season	RCP 4.5 (Days) 10 <25	25 <50	50 <75	75 <100	>= 100	RCP 8.5 (Days) 10 <25	25 <50	50 <75	75 <100	>= 100
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	2	3	1	0	7	3	2	0	0
	SW monsoon	19	19	6	13	9	22	18	6	14	9
	NE monsoon	5	2	1	0	1	5	2	1	0	1
	Total	**32**	**23**	**10**	**14**	**10**	**34**	**23**	**9**	**14**	**10**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	1	0	0	7	4	2	0	0
	SW monsoon	15	25	15	5	7	17	26	15	4	5
	NE monsoon	8	1	0	0	1	5	3	0	1	0
	Total	**31**	**31**	**16**	**5**	**8**	**29**	**33**	**17**	**5**	**5**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	6	0	2	0	7	4	1	1	1
	SW monsoon	14	26	16	4	5	15	23	17	5	6
	NE monsoon	6	4	1	0	0	5	3	0	1	0
	Total	**27**	**36**	**17**	**6**	**5**	**27**	**30**	**18**	**7**	**7**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	3	3	5	0	0	3	2	0	2	1
	SW monsoon	18	15	20	5	8	13	27	12	4	6
	NE monsoon	5	3	0	0	1	8	2	0	0	2
	Total	**26**	**21**	**25**	**5**	**9**	**24**	**31**	**12**	**6**	**9**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm and 25 to 50 mm. 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 there will be a decreasing trend in the number of rainfall events during low rainfall in south west monsoon from 2030 to 2050. In the case of heavy rainfall, the number of rainfall events shows a fluctuating trend.

4.1.1.2. Rainfall analysis of Kaipad lands (AEU7) and climate change impacts in Kozhikode district

Rice based, coconut based and arecanut based cropping systems are commonly undertaken by the farming community of this unit. Dominant cropping system pursued by the farmers in the unit is coconut based, which is practiced in 53.5 per cent of the cultivable area. Rice based cropping system and banana-based cropping system also contribute to a major portion of cultivable area (nearly 8 %). Arecanut based and rubber-based cropping systems are also seen in few areas.

Rice-Rice-Vegetable system accounts to almost 49.89 per cent of rice area in the unit. This is followed by Rice-Fallow cropping system that occupies 26.77 per cent of rice area in the unit. Among coconut-based systems coconut monocropping occupies nearly 41.52 per cent of the coconut area.

4.1.1.2.1. Rainfall and Rainy days of Kaipad lands (AEU7) in Kozhikode district

The monthly rainfall distribution of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were analysed and presented in table 7.

Table 7. Monthly rainfall distribution of Kaipad lands (AEU7) and the projected climate in Kozhikode district

Monthly Rainfall (mm)	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	7.9	1.3	27.4	2	3.8	0.2
February	0	0	0	0	0	0	0
March	16.6	5.9	16.6	15	11	9	23.5
April	86.7	24.5	30.7	27.6	17.7	15	21.5
May	461.4	457.2	353.9	281.1	301.1	588.2	490.8
June	1162.9	1223.7	1445.3	1366.3	1614.5	1347.7	1084
July	1618.9	1821.8	1446.2	1386.2	1497.8	1358	1506.2
August	509.7	562.3	550.5	567.4	557.6	620.9	634.1
September	219.6	227.7	1.7	1.8	7.8	5.3	44.8
October	254.5	321.4	309.3	180.3	318.6	201	226.9
November	41.5	29	28.6	13.3	30.6	42.9	53.9
December	34.8	19.4	10.8	45.5	11.3	14.5	35.8
Total	**4406.6**	**4700.8**	**4194.9**	**3911.9**	**4370**	**4206.3**	**4121.7**

In the existing condition June and July are the wettest months, having a rainfall of 1162.9 mm and 1618.9 mm. January and February are the months having lowest rainfall of 0 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 lowest rainfall gets during February. Compared to the present condition the rainfall of projected climate will be decreasing during April and September. As per RCP 4.5 and 8.5 the total rainfall shows a decreasing trend.

The monthly rainy days of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 8.

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Table 8. Monthly rainy days of Kaipad lands (AEU7) and the projected climate in Kozhikode district

Monthly Rainy days	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	1	0	2	0	1	0
February	0	0	0	0	0	0	0
March	2	1	3	3	2	1	4
April	6	4	4	2	3	2	2
May	13	14	16	12	16	15	15
June	28	28	26	29	28	27	26
July	30	30	30	29	26	29	29
August	15	15	16	16	16	16	17
September	5	5	0	0	1	1	3
October	11	11	11	8	11	8	7
November	4	3	3	3	3	3	4
December	3	4	1	3	1	2	4
Total	**117**	**116**	**110**	**107**	**107**	**105**	**111**

In the current condition, June and July have the maximum number of rainy days and it is about 28 to 30 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and the minimum will be 0 day in February. As per RCP 4.5 the projected climate shows a decreasing trend in the annual rainy days of Kaipad lands, as per 8.5 from 2030 to 2050 rainy days are decreasing and it will be increasing in 2080. 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 Kaipad lands (AEU7) were examined and given in table 9.

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Table 9. Seasonal rainy days of Kaipad lands (AEU7) and the projected climate in Kozhikode 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	0	0	21	564.7	78	3511.1	18	330.8
4.5	2030	1	7.9	19	487.6	78	3835.5	18	369.8
	2050	0	1.3	23	401.2	72	3443.7	15	348.7
	2080	2	27.4	17	323.7	74	3321.7	14	239.1
8.5	2030	0	2	21	329.8	71	3677.7	15	360.5
	2050	1	3.8	18	612.2	73	3331.9	13	258.4
	2080	0	0.2	21	535.8	75	3269.1	15	316.6

Presently, the maximum number of rainy days occurs during south west monsoon time (78 days) followed by summer season (21 days), north east monsoon (18 days) and winter season (0 days). According to projected climate the highest number of rainy days will be in South West monsoon followed by summer season and north east monsoon. There will be a decreasing trend in seasonal rainfall during south west monsoon time from 2030 to 2050 and increases in 2080. As in the case of summer season the seasonal rainfall shows an increasing trend from 2030 to 2050 and decreases in 2080 as per RCP 4.5 and as per RCP 8.5 there is a decrease from 2030 to 2050 and increases in 2080. But in north east monsoon season the rainfall will be decreasing as per RCP 4.5 and in RCP 8.5 it shows a decrease from 2030 to 2050 and increases in 2080. Comparing the present condition to the projected climate there will be a slight variation in rainfall during north east and winter season but in the case of south west shows a decreasing trend and in summer season the rainfall shows an increasing trend.

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4.1.1.2.2. High rainfall events of Kaipad lands (AEU7) in Kozhikode district

High rainfall events for the present condition and projected climate of Kaipad lands (AEU7) were analysed and represented in table 10.

Table 10. High rainfall events of Kaipad lands (AEU 7) and the projected climate in Kozhikode district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	5	4	0	0	6	4	2	0	0
	SW monsoon	15	23	16	5	7	13	25	15	9	5
	NE monsoon	6	1	0	0	1	6	1	0	0	1
	Total	**27**	**29**	**20**	**5**	**8**	**25**	**30**	**17**	**9**	**6**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	3	2	0	1	5	1	2	0	0
	SW monsoon	13	27	10	10	8	11	25	8	7	9
	NE monsoon	5	3	0	0	1	5	3	0	0	1
	Total	**23**	**33**	**12**	**10**	**10**	**21**	**29**	**10**	**7**	**10**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	2	3	3	0	0	6	3	0	4	0
	SW monsoon	13	24	14	5	7	16	21	16	4	6
	NE monsoon	5	3	0	0	1	5	1	0	0	1
	Total	**20**	**30**	**17**	**5**	**8**	**27**	**25**	**16**	**8**	**7**
2080	Winter	2	0	0	0	0	0	0	0	0	0
	Summer	6	2	0	0	1	5	3	0	2	1
	SW monsoon	16	22	13	6	6	15	28	10	3	8
	NE monsoon	5	2	1	0	0	8	1	0	0	1
	Total	**29**	**26**	**14**	**6**	**7**	**28**	**32**	**10**	**5**	**10**

In the present condition the greater number of rainfall events occur during low rainfall and a smaller number of events during high rainfall. According to the projected climate based on RCP 4.5 and 8.5, in 2030 there will be a decrease in the number of rainfall events during low rainfall which is in the range of 10 to 50 mm. As per RCP 4.5 from 2050 to 2080 the number of rainfall events shows an increasing trend. But as per RCP 8.5 there will be a decrease in the number of rainfall events from 2050 to 2080.

4.1.1.3. Rainfall analysis of Northern laterites (AEU11) and climate change impacts in Kozhikode districts

The major cropping system in the unit is coconut-based covering 56 per cent of cultivable area in the unit. Though rice-based cropping system is practiced in majority (97.96%) of the panchayats, the area covered is meager (2.80 % of the cultivable area in the unit). Arecanut based cropping system covers 6.63 per cent, while rubber-based cropping system occupies 5.90 per cent of the cultivable area in the unit. Banana based cropping system covers 3.99 per cent of the cultivable area in the unit. Among rice-based cropping systems, Rice-Rice-Fallow system dominates accounting for 26.27 per cent of rice area in the unit. This is followed by Rice-Fallow system covering 21.42 per cent of rice area in the unit.

4.1.1.3.1. Rainfall and Rainy days of Northern laterites (AEU11) in Kozhikode 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 11.

Table 11. Monthly rainfall distribution of Northern laterites (AEU11) and the projected climate in Kozhikode district

Monthly Rainfall (mm)	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	5.2	2	24.3	1.9	0.1	0
February	0	0	0	0	0	0	0
March	9.2	14.5	23.4	36.9	10.4	26.9	25.2
April	47.4	29.7	10.7	22.6	40.3	23.5	36.6
May	320.9	325.2	378.8	262	406.5	345.2	429.1
June	1084.7	1179.6	1338.4	1078.7	1193.8	1451.5	954.4
July	1441.6	1321.4	1495.9	1405	1276.1	1339.3	1630
August	510.5	528.1	624.5	605.5	525.4	603.6	623
September	207.4	0.4	10	4.5	0.4	4.6	40.2
October	257.9	208.6	213.3	206.8	302.6	211.5	236.6
November	32.2	34.1	36.9	35.2	35.9	42.6	38.9
December	41.1	37	41.2	45.7	39.4	14.9	49.7
Total	**3952.9**	**3683.8**	**4175.1**	**3727.2**	**3832.7**	**4063.7**	**4063.7**

In the existing condition June and July are the wettest months, having a rainfall of 1084.7 mm and 1441.6 mm. January and February are the months having lowest rainfall of 0 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 gets during January and February. Comparing the projected climate and present condition, the rainfall distribution shows a drastic decrease in the month September. As per RCP 4.5 the total rainfall shows an increasing trend from 2030 to 2050 and decreasing in 2080. But according to RCP 8.5 the total rainfall shows an increase from 2030 to 2080. In projected climate the amount of annual rainfall will be higher than that of 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 12.

Table 12. Monthly rainy days of Northern laterites (AEU11) and the projected climate in Kozhikode district

Monthly Rainy days	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	1	0	2	0	0	0
February	0	0	0	0	0	0	0
March	2	3	2	5	1	4	5
April	5	4	2	1	3	1	1
May	13	17	16	13	15	16	12
June	26	28	26	28	28	26	25
July	30	26	26	29	26	29	28
August	16	16	16	16	16	16	17
September	4	0	2	1	0	1	3
October	11	7	7	7	9	8	7
November	3	3	3	3	3	3	3
December	4	3	3	3	3	2	5
Total	**114**	**108**	**103**	**108**	**104**	**106**	**106**

In the current condition, June and July have the maximum number of rainy days and it is about 26 to 30 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 29 days 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 northern laterites from 2030 to 2050 and it will be increasing in 2080. 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 laterites (AEU11) were examined and presented in table 13.

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Table 13. Seasonal rainy days of Northern laterites (AEU 11) and the projected climate in Kozhikode 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	0	0	20	377.5	76	3244.2	18	331.2
4.5	2030	1	5.2	24	369.4	70	3029.5	13	279.7
	2050	0	2	20	412.9	70	3468.8	13	291.4
	2080	2	24.3	19	321.5	74	3093.7	13	287.7
8.5	2030	0	1.9	19	457.2	70	2995.7	15	377.9
	2050	0	0.1	21	395.6	72	3399	13	269
	2080	0	0	18	490.9	73	3247.6	15	325.2

Presently, the maximum number of rainy days occurs during south west monsoon time (76 days) followed by summer (20 days), north east (18 days) and winter season (0 days). According to projected climate the highest number of rainy days will be in South West monsoon followed by summer season. There will be an increasing trend in seasonal rainfall during south west monsoon time. The number of rainy days occur in summer will be higher than that of north east. The minimum number of rainy days will be in winter. And in projected climate there will be an increase in rainfall during winter season compared to the present condition as per RCP 4.5.

4.1.1.3.2. Heavy rainfall events of northern laterites (AEU11) in Kozhikode 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 14.

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Table 14. Heavy rainfall events of Northern laterites (AEU 11) and the projected climate in Kozhikode district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	6	3	3	0	0
	SW monsoon	19	21	16	6	4	15	21	14	5	6
	NE monsoon	6	1	0	0	1	6	1	0	0	1
	Total	**29**	**26**	**18**	**6**	**5**	**27**	**25**	**17**	**5**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	5	0	0	0	4	4	2	1	0
	SW monsoon	12	22	11	6	6	15	21	11	5	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**25**	**28**	**11**	**6**	**7**	**25**	**28**	**13**	**6**	**7**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	2	3	0	0	6	2	3	0	0
	SW monsoon	9	24	9	9	7	13	19	15	5	8
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**27**	**12**	**9**	**8**	**24**	**22**	**18**	**5**	**9**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	7	2	0	1	0	5	2	1	1	1
	SW monsoon	14	23	12	6	5	17	23	13	3	7
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**28**	**26**	**12**	**7**	**6**	**29**	**27**	**14**	**4**	**9**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm and 25 to 50 mm. 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 there will be a decrease in the number of rainfall events during low rainfall south west monsoon in 2030 (RCP 4.5).

4.1.1.4. Rainfall analysis of northern high hills (AEU15) and climate change impacts in Kozhikode districts

The most dominant cropping system practiced in this unit is coconut based which occupies 43.16 per cent of cultivable area in the unit followed by rubber-based systems (26 % cultivable area). Another dominant cropping system is arecanut based cropping system. Banana based, rice based, coffee based and pepper-based cropping systems are also practiced in certain areas. Among the rice-based cropping systems, Fallow-Rice-fallow cropping system is widely practiced in 69.23 per cent of rice area in the unit. Rice-fallow-fallow system covers 9.89 per cent of rice area in the unit. Coconut monocropping is the major cropping system occupying about 26 per cent of coconut growing area of the unit.

4.1.1.4.1. Rainfall and Rainy days of northern high hills (AEU15) in Kozhikode 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 given in table 15.

Table 15. Monthly rainfall distribution of Northern high hills (AEU 15) and the projected climate in Kozhikode district

Monthly Rainfall (mm)	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	5.6	1.9	13.3	2.8	0.1	0
February	0	0	0	0	0	0	0
March	9.5	14.9	16.4	16.3	17.9	13.8	5.4
April	48.6	29.8	11.1	10.3	9.4	3.6	20.8
May	321.7	330.5	318.1	381.2	482.5	356.8	224.1
June	1038.2	1124.1	1247.5	1091.8	1058.2	1084	1125.1
July	1447.2	1328.4	1493.3	1377	1243.9	1427.7	1421.6
August	516.5	535.1	636.3	619.2	596.7	617.8	636
September	213.4	0.4	3.6	4.5	3	4.5	40.9
October	265.1	214.5	219.3	213.6	308.5	218.5	241.9
November	31.6	33.6	36.4	34.8	35.1	42	38.4
December	41	37	41.1	45.4	40.9	15	49.4
Total	**3932.8**	**3653.9**	**4025**	**3807.4**	**3798.9**	**3783.8**	**3803.6**

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In the present condition June and July are the wettest months; having a rainfall of 1038.2 mm and 1447.2 mm. January and February are the months having lowest rainfall of 0 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 is observed during January and February. According to RCP 4.5 the total rainfall shows an increase from 2030 to 2050 and it decreases in 2080. But as per RCP 8.5 the total rainfall shows a decreasing trend from 2030 to 2050 and it increases in 2080. In projected climate there will be a drastic decrease in rainfall distribution during April and September from the present state.

The monthly rainy days of northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were analysed and given in table 16.

Table 16. Monthly rainy days of northern high hills (AEU 15) and the projected climate in Kozhikode district

Monthly Rainy days	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	1	0	2	1	0	0
February	0	0	0	0	0	0	0
March	2	3	4	3	3	2	0
April	5	4	2	2	2	1	1
May	13	17	17	13	15	15	11
June	26	28	25	28	26	26	27
July	30	26	26	29	26	29	28
August	16	16	16	16	16	16	17
September	4	0	0	1	1	1	3
October	11	7	7	7	9	8	7
November	3	3	3	3	3	3	3
December	4	3	3	3	3	2	5
Total	**114**	**108**	**103**	**107**	**105**	**103**	**102**

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At the present condition, June and July have the maximum number of rainy days and it is about 30 days. And the lowest is in January and February. As per RCP 4.5 and 8.5, the maximum number of rainy days will be occurring during June and July and the minimum will be in January and February. The maximum rainy days will be 29 days and the minimum will be 0 to 1 day. The projected climate shows a decreasing trend in the annual rainy days of northern high hills (AEU15). The annual rainy days of projected climate will be less as compared to the present condition.

The seasonal rainy days of northern high hills (AEU15) for the existing condition and projected climate were examined and represented in table 17.

Table 17. Seasonal rainy days of northern high hills (AEU 15) and the projected climate in Kozhikode 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	0	0	20	379.8	76	3215.3	18	337.7
4.5	2030	1	5.6	24	375.2	70	2988	13	285.1
	2050	0	1.9	23	345.6	67	3380.7	13	296.8
	2080	2	13.3	18	407.8	74	3092.5	13	293.8
8.5	2030	1	2.8	20	509.8	69	2901.8	15	384.5
	2050	0	0.1	18	374.2	72	3134	13	275.5
	2080	0	0	12	250.3	75	3223.6	15	329.7

Currently, the maximum number of rainy days occurs during south west monsoon time (76 days) followed by summer (20 days), north east (18 days) and winter season (0 days). According to projected climate the maximum number of rainy days will be occurring in south west monsoon followed by summer season. The highest amount of rainfall will be getting in southwest followed by summer

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season. The minimum number of rainy days will be in winter. The projected climate shows an intensified rainfall in South West and there will be less rainfall in north east monsoon as compare to the present condition.

4.1.1.4.2. High rainfall events of northern high hills (AEU15) in Kozhikode district

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

Table 18. High rainfall events of northern high hills (AEU15) and the projected climate in Kozhikode district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

In the present condition, the more number of rainfall events occur during low rainfall and less number of events during high rainfall. According to the projected present and projected climate there will be a slight variation in the number of rainfall events climate based on RCP 4.5 and 8.5, in 2050 there will be a decrease in the number of rainfall events during low rainfall which is in the range of 10 to 50 mm but during high rainfall the number of rainfall events will be increasing. As per RCP 4.5 from 2050 to 2080 the number of rainfall events shows an increasing trend. Comparing the present and projected climate there will be a slight variation in the number of rainfall events.

4.1.2. Rainfall analysis of various AEUs of Wayanad district

The Wayanad district has divided into three agro-ecological units (fig. 4) such as Northern high hills (AEU15), Wayanad central plateau (AEU20) and Wayanad eastern plateau (AEU21) and these cover an area of 67,031 ha. (31.48%), 74,471 ha. (34.97%) and 70,325 ha. (33.02%) respectively.

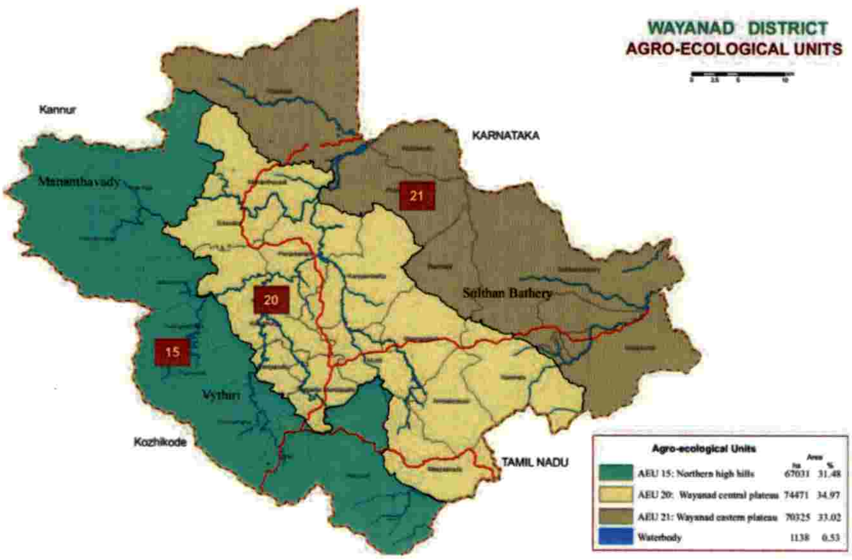

Fig.4 Agro-Ecological Units Map of Wayanad District

4.1.2.1. Rainfall analysis of Northern high hills (AEU15) and climate change impacts in Wayanad district

Major cropping system in the unit is coffee based which is practiced in nearly 48 per cent of the cultivable area. This is followed by banana-based cropping system and arecanut based cropping system. Rice based and coconut-based cropping systems are also followed in all panchayats in this unit. Rice based cropping system occupies the lowest percentage of cultivable area in this unit. Among rice-based systems, rice-rice system is practiced in all the panchayats and occupies nearly 45.83 per cent of the total rice area in the unit. Rice- fallow system is also a major rice-based system. It is practiced in 40.34 per cent of the rice area in the unit.

4.1.2.1.1. Rainfall and Rainy days of Northern high hills (AEU15) in Wayanad 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 19.

Table 19. Monthly rainfall distribution of Northern high hills (AEU15) and the projected climate in Wayanad district

Monthly Rainfall (mm)	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0.6	0	0.4	0
February	7.5	5.3	5.8	0	6	0	2.2
March	57.6	79.9	56.5	12.3	54.2	11.9	17.9
April	2.5	23.8	4.7	66	14.2	22.4	19.2
May	317.9	259.5	234.9	277.7	299.4	343.7	253
June	894	929.2	977.6	835.5	988.3	781.3	802.1
July	1522.8	1521.6	1601	1361.8	1501.7	1407	1590.7
August	542.4	639.7	641.4	606.2	581.7	601.3	739.5
September	51.3	52.3	10.6	6.8	53	6.9	40.2
October	233.7	244.1	261	84.4	238	83.2	97.9
November	15.7	24.4	44.3	27.1	19.3	27.5	15.8
December	72.6	81.3	65.5	63.5	75.1	58.7	67.9
Total	**3718**	**3861.1**	**3903.3**	**3341.9**	**3830.9**	**3344.3**	**3646.4**

In the present condition June and July are the wettest months, having a rainfall of 894 mm and 1522.8 mm. January and February are the months having lowest rainfall of 0 mm and 7.5 mm. As per projected climate based on RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during June and

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July. And the lowest rainfall gets during January and February. Compared to the present condition the projected climate shows a drastic decrease in rainfall distribution during the month of September. As in the case of annual rainfall, the projected climate shows an increasing trend from the present condition. According to RCP 4.5 the total rainfall shows an increase from 2030 to 2050 and it decreases in 2080. As per RCP 8.5 the total rainfall shows a decreasing trend from 2030 to 2050 and increases in 2080.

The monthly rainy days of northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were analysed and represented in table 20.

Table 20. Monthly rainy days of Northern high hills (AEU15) and the projected climate in Wayanad district

Monthly Rainy days	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	2	1	1	0	1	0	0
March	8	10	11	2	9	2	5
April	0	2	0	4	2	3	3
May	14	12	13	15	12	16	13
June	26	27	26	26	26	28	26
July	29	28	29	29	28	29	29
August	12	15	15	19	13	19	21
September	1	1	1	1	1	1	4
October	12	10	10	5	12	5	6
November	2	3	3	3	2	3	2
December	8	11	9	5	9	5	7
Total	**114**	**120**	**118**	**109**	**115**	**111**	**116**

In the current condition, June and July have the most extreme number of rainy days and it is around 29 days. Also, the most reduced is in January and February. According to RCP 4.5 and 8.5, the greatest number of rainy days will be happening in June and July and the base will be in January and February. The greatest rainy days will be 29 days and the base will be 0 to 1 day. There is a decrease in the annual rainy days from 2030 to 2050 and an increase in 2080 as per RCP 4.5 and 8.5. The yearly rainy days of projected climate will be more when contrasted with the current condition in 2030, 2050 (RCP 4.5) and 2030, 2050 and 2080 (RCP 8.5).

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The seasonal rainy days of northern high hills (AEU15) for the existing condition and projected climate were examined and given in table 21.

Table 21. Seasonal rainy days of Northern high hills (AEU15) and the projected climate in Wayanad 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	7.5	22	378	68	3010.5	22	322
4.5	2030	1	5.3	24	363.2	71	3142.8	24	349.8
	2050	1	5.8	24	296.1	71	3230.6	22	370.8
	2080	0	0.6	21	356	75	2810.3	13	175
8.5	2030	1	6	23	367.8	68	3124.7	23	332.4
	2050	0	0.4	21	378	77	2796.5	13	169.4
	2080	0	2.2	21	290.1	80	3172.5	15	181.6

At present, the greatest number of rainy days happens in south west monsoon time (68 days) trailed by summer (22 days), north east (22 days) and winter season (2 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in South West monsoon taken after by summer season. The base number of rainy days and precipitation will be in winter. There will be an increase in precipitation in summer when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West when contrasted with the earlier years.

4.1.2.1.2. High rainfall events of northern high hills (AEU15) in Wayanad district

For the present condition and projected climate, the high rainfall events of northern high hills (AEU15) were studied and given in table 22.

Table 22. High rainfall events of Northern high hills (AEU15) and the projected climate in Wayanad district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm and 25 to 50 mm. 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 there will be an increasing trend in the number of rainfall events during low rainfall. In the case of heavy rainfall, the number of rainfall events shows an increasing trend.

4.1.2.2. Rainfall analysis of Wayanad central plateau (AEU20) and climate change impacts in Wayanad district

Major cropping system in the unit is coffee based which is practiced in nearly 46 per cent of the cultivable area. Rice based cropping system has second position followed by banana-based cropping system. Arecanut based and coconut-based cropping systems are also practiced here. Among rice-based cropping systems, rice-fallow system dominates and occupies 48.10 per cent of rice area in the unit.

4.1.2.2.1. Rainfall and Rainy days of Wayanad central plateau (AEU20) in Wayanad district

The monthly rainfall distribution of Wayanad central plateau (AEU20) for the present and projected climate (RCP 4.5 and 8.5) were analysed and presented in table 23.

Table 23. Monthly rainfall distribution of Wayanad central plateau (AEU20) and the projected climate in Wayanad district

Monthly Rainfall (mm)	2016	4.5			8.5		
		2030	2050	2080	2030	2050	2080
January	0	0.5	8.5	2.8	8.5	8.8	0
February	0	0	0	0	0	0	3.6
March	16.6	12.5	12.1	10.5	10.8	11.3	25.9
April	10.5	17.6	27.4	33.5	22.9	60.5	40.9
May	302.6	278	264.4	331.6	316.9	309.8	219
June	537.2	607.6	548	460.2	594.7	510.4	632.6
July	1074.5	1083.8	1165.9	1251	1115.2	1303.4	1252.5
August	420	534.7	535.5	521.4	526.1	539.1	642.8
September	36	30.6	29.5	31.7	30.7	32.2	14.7
October	161.9	161.5	165.5	183.4	163.7	181	250.3
November	21.9	41.8	44.4	41.2	44.4	26.9	19.4
December	36.6	28.2	30.1	35.2	30.2	48	62.5
Total	**2617.8**	**2796.8**	**2831.3**	**2902.5**	**2864.1**	**3031.4**	**3164.2**

In the existing condition June and July are the wettest months, having a rainfall of 537.2 mm and 1074.5 mm. January and February are the months having lowest rainfall of 0 mm. Based on RCP 4.5 and 8.5, there will be a probability of

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getting maximum rainfall during June and July in the projected climate. And the lowest rainfall gets during January and February. Compared to the present condition the rainfall of projected climate will be decreasing during March. As per RCP 4.5 the total rainfall shows an increasing trend. According to RCP 8.5 the total rainfall shows a drastic increase from 2030 to 2080.

The monthly rainy days of Northern central plateau (AEU20) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 24.

Table 24. Monthly rainy days of Northern central plateau (AEU20) and the projected climate in Wayanad district

Monthly Rainy days	2016	4.5			8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	1	1	1	1	0
February	0	0	0	0	0	0	1
March	3	2	2	1	2	2	3
April	2	1	3	2	4	3	4
May	12	14	14	12	15	15	11
June	25	22	24	24	26	23	25
July	30	30	30	30	29	30	29
August	18	19	19	18	19	19	18
September	1	1	1	1	1	1	2
October	6	7	7	7	7	7	7
November	3	3	3	4	3	3	2
December	4	3	3	4	3	4	5
Total	**104**	**102**	**107**	**104**	**110**	**108**	**107**

In the current condition, June and July have the maximum number of rainy days and it is about 25 to 30 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and the minimum will be 0 days in February. As per RCP 4.5 the projected climate shows an increasing trend in the annual rainy days of northern central plateau from 2030 to 2050 and it will be decreasing in 2080 and as per RCP 8.5 the annual rainy days show a decreasing trend from 2030 to 2080. The annual rainy days of projected climate will be less as compared to the present condition in RCP 4.5 and more in RCP 8.5.

For the current condition and projected climate, the seasonal rainy days of northern central plateau (AEU20) were examined and given in table 25.

Table 25. Seasonal rainy days of Northern central plateau (AEU20) and the projected climate in Wayanad 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	0	0	17	329.7	74	2067.7	13	220.4
4.5	2030	0	0.5	17	308.1	72	2256.7	13	231.5
	2050	1	8.5	19	303.9	74	2278.9	13	240
	2080	1	2.8	15	375.6	73	2264.3	15	259.8
8.5	2030	1	8.5	21	350.6	75	2266.7	13	238.3
	2050	1	8.8	20	381.6	73	2385.1	14	255.9
	2080	1	3.6	18	285.8	74	2542.6	14	332.2

Presently, the maximum number of rainy days occurs during south west monsoon time (74 days) followed by summer season (17 days), north east monsoon (13 days) and winter season (0 days). According to projected climate the highest number of rainy days will get in South West monsoon followed by summer season and north east. There is a fluctuating trend in seasonal rainfall during south west monsoon time. As in the case of summer season the seasonal rainfall shows an increasing trend from 2030 to 2050 and decreases in 2080 as per RCP 4.5 and as per 8.5 there is a decreasing trend in rainy days from 2030 to 2080. But in north east monsoon season the rainfall will be increasing as per RCP 4.5 and RCP 8.5. Comparing the present condition to the projected climate there will be a slight variation in rainfall during north east and winter season but in the case of south west and summer season the rainfall shows an increasing trend.

4.1.2.2.2. High rainfall events of northern central plateau (AEU20) in Wayanad district

High rainfall events for the present condition and projected climate of northern central plateau (AEU20) were analysed and represented in table 26.

Table 26. High rainfall events of Northern central plateau (AEU 20) and the projected climate in Wayanad district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

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In the present condition the more number of rainfall events occur during low rainfall and less number of events during high rainfall. There is a decrease in low rainfall (south west monsoon) in 2030 when compared to present condition.

4.1.2.3. Rainfall analysis of Wayanad eastern plateau (AEU21) and climate change impacts in Wayanad districts

The major cropping system in the unit is coffee based, which is practiced in 42.83 of the cultivable area. Coconut based cropping system has the second position 15 % of cultivable area in the unit) followed by rice-based cropping system (8 % of cultivable area in the unit). Other cropping systems such as arecanut based, rubber based and banana-based cropping systems are also practiced here.

4.1.2.3.1. Rainfall and Rainy days of Wayanad eastern plateau (AEU21) in Wayanad district

The monthly rainfall distribution of Wayanad eastern plateau (AEU21) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 27.

Table 27. Monthly rainfall distribution of Wayanad eastern plateau (AEU21) and the projected climate in Wayanad district

Monthly Rainfall (mm)	2016	4.5			8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	8.5	3	8.5	8.7	0
February	0	0	0	0	0	0	3.6
March	5.1	16.3	11.5	4.2	10.7	8.4	25.4
April	7.7	17.5	59.2	33.5	12	29.5	40.6
May	461.4	231.4	306.2	217.1	266.1	356.3	215.9
June	941.6	483.9	597.9	548.5	608.1	480	613.1
July	1255.1	1078.9	1150	1194.3	1145	1203.7	1179.1
August	497	494.6	501.1	512.5	489.1	530.3	606.9
September	6.8	32.2	31.8	57.1	32.7	58.1	15
October	153.3	149.4	179.6	145.4	177.6	143.6	248.5
November	17	41.4	38.7	17.3	38.6	15.4	19.2
December	28.7	28.4	33.3	46.1	33.4	44.9	62.3
Total	**3373.7**	**2574**	**2917.8**	**2779**	**2821.8**	**2878.9**	**3029.6**

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In the present condition June and July are the wettest months, having a rainfall of 941.6 mm and 1255.1 mm. January and February are the months having lowest rainfall of 0 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 will be during January and February. Comparing the projected climate and present condition, the rainfall distribution shows a drastic increase in the month of April and September. As per RCP 4.5 the total rainfall shows an increasing trend from 2030 to 2050 and decreasing in 2080. But according to RCP 8.5 the total rainfall shows an increase from 2030 to 2080. In projected climate the amount of annual rainfall is lesser than that of the present condition.

The monthly rainy days of Wayanad eastern plateau (AEU21) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 28.

Table 28. Monthly rainy days of Wayanad (AEU21) and the projected climate in Wayanad district

Monthly Rainy days	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	1	1	1	1	0
February	0	0	0	0	0	0	1
March	1	3	2	0	2	1	3
April	1	2	3	2	2	3	4
May	22	13	16	13	13	15	11
June	24	22	24	24	23	24	25
July	27	30	30	30	30	30	29
August	15	17	18	18	17	19	17
September	1	1	1	1	1	1	2
October	8	6	7	7	7	7	7
November	2	3	4	3	4	2	2
December	3	3	3	5	3	6	5
Total	**104**	**100**	**109**	**104**	**103**	**109**	**106**

In the current condition, June and July have the maximum number of rainy days and it is about 24 to 27 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and there will be no rainy days in February. As per RCP 4.5 the projected climate shows an increasing trend in the annual rainy days of Wayanad eastern plateau from 2030 to 2050 and it will be decreasing in 2080 and in RCP 8.5 the rainy days show an increasing trend from 2030 to 2080. The annual rainy days of projected climate will be less as compared to the present condition except 2050 (RCP 4.5) and 2050 and 2080 (RCP 8.5).

For the current condition and projected climate, the seasonal rainy days of Wayanad eastern plateau (AEU21) were examined and presented in table 29.

At present condition the maximum number of rainy days occurs during south west monsoon time (67 days) followed by summer season (24 days), north west monsoon (13 days) and winter season (0 days). According to projected climate the highest number of rainy days will be in South West monsoon followed by summer season.

Table 29. Seasonal rainy days of Wayanad eastern plateau (AEU 21) and the projected climate in Wayanad 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	0	0	24	474.2	67	2700.5	13	199
4.5	2030	0	0	18	265.2	70	2089.6	12	219.2
	2050	1	8.5	21	376.9	73	2280.8	14	251.6
	2080	1	3	15	254.8	73	2312.4	15	208.8
8.5	2030	1	8.5	17	288.8	71	2274.9	14	249.6
	2050	1	8.7	19	394.2	74	2272.1	15	203.9
	2080	1	3.6	18	281.9	73	2414.1	14	330

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There will be an increasing trend in seasonal rainfall during south west monsoon time. The number of rainy days occur in summer will be higher than that of north east. The minimum number of rainy days will be occurring during winter. And in projected climate there will be a drastic increase in rainfall during winter season compared to the present condition.

4.1.2.3.2. Heavy rainfall events of Wayanad eastern plateau (AEU21) in Wayanad district

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

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm and 25 to 50 mm. 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 there will be an increasing trend in the number of rainfall events during low rainfall. In projected climate the number of rainfall events during low rainfall shows a noticeable increase from the present condition.

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Table 30. Heavy rainfall events of Wayanad eastern plateau (AEU 21) and the projected climate in Wayanad district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

4.1.3. Rainfall analysis of various AEUs of Kannur district

The Kannur district is divided into five ecological (fig. 1) such as Northern coastal plain (AEU 2), Kaipad land (AEU 7), Northern laterites (AEU 11), Northern foothills (AEU 13), Northern high hills (AEU 15) and these cover an area of 27,273 ha. (9.18 %), 9661 ha. (3.25 %), 109,906 ha. (36.99 %), 45,077 ha. (14.16 %) and 100,124 ha. (33.70 %) respectively.

Fig.5. Agro-Ecological Units Map of Kannur District

4.1.3.1. Rainfall analysis of Northern coastal plain (AEU2) and climate change impacts in Kannur district

Rice based and coconut-based farming systems are practiced most widely. Among rice-based systems, rice-rice-vegetable cropping system dominates. Rice-fallow system and rice-rice-fallow cropping system ranks next. Rice-pulses based cropping system is also practiced here. Coconut based cropping system is the dominant cropping system. This is followed by rice-based cropping system and arecanut based cropping system. Banana based cropping system and rubber-based cropping system are also prevalent in this unit. Monocropping of coconut is practiced in majority of the panchayats in the AEU. Intercropping coconut gardens with pepper and banana is the next main system in this AEU, while coconut+ pepper+ mango+ banana system ranks next.

4.1.3.1.1 Rainfall and Rainy days of Northern coastal plain (AEU2) in Kannur 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 31.

Table 31. Monthly rainfall distribution of Northern coastal plain (AEU2) and the projected climate in Kannur district

Monthly Rainfall (mm)	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	2.5	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0.4	15.1	0	0	7.8
April	46	89	11.2	31.9	32.5	2	3.9
May	433.2	251.6	413.3	439.8	356.9	333.8	355.3
June	1431.1	1756.8	1542.1	1137.6	1225.5	1291.9	1209.2
July	1280.7	1446.2	1458.7	1448.8	1440.2	1465.3	1396.2
August	488.8	501.3	571.8	614.6	550.4	635.3	585.7
September	129.7	124	160.5	187.7	169.9	188.5	1.3
October	300	291.6	212.2	292.5	219	291.7	226.5
November	27.3	24.1	33.1	26.2	34.1	24.1	31.4
December	28.1	23.5	36.7	22	36.1	15.9	41.1
Total	**4164.9**	**4508.1**	**4440**	**4218.7**	**4064.6**	**4248.5**	**3858.4**

In the existent condition June and July are the wettest months, having a rainfall of 1431.1 mm and 1280.7 mm. January and November are the months having lowest rainfall of 0 mm and 27.3 mm. As per projected climate based on RCP 4.5 and 8.5, there will be a chance of getting maximum rainfall during June and July. And the lowest rainfall is observed during January and February. Compared to the present condition the projected climate indicates a drastic decrease in the rainfall distribution during the months of April and June. As in the case of annual rainfall, the projected climate shows an irrelevant variation from the present condition. According to RCP 4.5 the total rainfall expresses a slight increase from

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2030 to 2050 and it decreases in 2080. According to RCP 8.5 the total rainfall shows a cumulative trend from 2030 to 2050 and decline in 2080.

The monthly rainy days of northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were analysed and represented in table 32.

In the present-day condition, June and July have the most extreme number of rainy days and it is around 30 days. Also, the most reduced is in January, February and March. As per RCP 4.5 and 8.5, the highest number of rainy days will be occurring in June and July and the base will be in January and February. The greatest rainy days will be 30 days and the lesser will be 0 to 1 day. The projected climate exhibits an expanding pattern in the yearly rainy days of Northern Coastal Plain. The annual rainy days of projected climate will be fewer when compared with the current condition.

Table 32. Monthly rainy days of Northern coastal plain (AEU2) and the projected climate in Kannur district

Monthly Rainy days	2016	4.5			8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	1	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	2	0	0	1
April	3	3	1	4	3	0	1
May	16	10	13	15	14	12	14
June	25	25	26	29	25	29	27
July	29	30	30	30	30	30	28
August	14	14	16	16	16	17	16
September	5	5	4	4	4	4	0
October	11	11	10	11	10	11	9
November	4	4	4	3	4	3	3
December	5	4	3	3	3	3	3
Total	**112**	**106**	**107**	**118**	**109**	**109**	**102**

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The seasonal rainy days of northern coastal plain (AEU 2) for the existing condition and projected climate were examined and given in table 33.

Table 33. Seasonal rainy days of Northern coastal plain (AEU2) and the projected climate in Kannur 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	0	0	19	479.2	73	3330.3	20	355.4
4.5	2030	0	0	13	340.6	74	3828.3	19	339.2
	2050	0	0	14	424.9	76	3733.1	17	282
	2080	1	2.5	21	486.8	79	3388.7	17	340.7
8.5	2030	0	0	17	389.4	75	3386	17	289.2
	2050	0	0	12	335.8	80	3581	17	331.7
	2080	0	0	16	367	71	3192.4	15	299

At present-day, the maximum number of rainy days happens in south west thunderstorm time (73 days) followed by North East (20 days), summer season (19 days) and winter season (0 days). As per projected climate the highest number of rainy days and high measure of precipitation will be in South West monsoon followed by North East. The lesser number of rainy days and precipitation will be in the winter and summer season. There will be a great decrease in the precipitation of summer and winter season when compared with the current condition. The projected climate shows a build-up in the precipitation of South West season and a decline in the North East season when compared with the previous years.

4.1.3.1.2. High rainfall events of northern coastal plain (AEU2) in Kannur district

For the present condition and projected climate, the high rainfall events of northern coastal plain (AEU2) were studied and given in table 34.

Table 34. High rainfall events of Northern coastal plain (AEU2) and the projected climate in Kannur district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

The number of rainfall events occurring in the present condition is more in the range of 10 to 25 mm and 25 to 50 mm. However, in the case of heavy rainfall which is in the range 50 to more than 100 mm the number of rainfall events is not as much of light showers. Correlated, the present and the projected climate shows a decreasing trend in the number of rainfall events during low rainfall. In the case of heavy rainfall, the number of rainfall events shows an increasing trend.

4.1.3.2. Rainfall analysis of Kaipad land (AEU7) and climate change impacts in Kannur district

Coconut based cropping system is the major cropping system practiced in all the panchayats of this unit. About 57 per cent of the cultivable area in AEU is under this cropping system. Coconut based cropping system is followed by rice-based cropping system. Around 88 per cent of the panchayats in this AEU are following rice based and coconut-based systems. Rice based cropping system constitutes 9.7 per cent of total cultivable area in the unit. Arecanut, rubber, banana and cashew-based cropping systems are also seen in this unit. In rice-based cropping systems, rice-fallow system is predominant. About 75 per cent of the panchayats are following this system constituting about 58 per cent of the rice growing area and 5.6 per cent of the cultivable area in this AEU.

4.1.3.2.1. Rainfall and Rainy days of Kaipad land (AEU7) in Kannur district

The monthly rainfall distribution of Kaipad land (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were analysed and presented in table 35.

Table 35. Monthly rainfall distribution of Kaipad land (AEU7) and the projected climate in Kannur district

Monthly Rainfall (mm)	2016	4.5			8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	2.7	4.2	1.8	0.1	0
February	0	0	0	0	0	0	0
March	0	0	0	8.8	0	0	4.7
April	82.7	55	32.6	31	15.8	13.5	13.7
May	187.1	161.6	210	482	384	291.4	309.1
June	1314.9	1313.1	1296.8	1110.1	1305	1296.3	1167.2
July	1462.2	1471.7	1483.5	1478	1467.2	1497.6	1455.2
August	497.8	511.2	584.4	625.7	564.6	663.5	656.5
September	130.2	126.1	164.6	188.4	172.1	189.1	4.3
October	301.3	296.4	218.9	297	223.7	297.4	214.3
November	22.4	22.3	31.5	24.7	32.5	22.8	47.4
December	14.7	14.3	37.9	22.3	37.4	14.6	43.9
Total	**4013.3**	**3971.7**	**4062.9**	**4272.2**	**4204.1**	**4286.3**	**3916.3**

In the prevailing situation June and July are the wettest months, having a rainfall of 1314.9 mm and 1462.2 mm. January and February are the months having lowest rainfall of 0 mm. On the basis of RCP 4.5 and 8.5, there is a chance of getting maximum rainfall during June and July in the projected climate. And the lowest rainfall gets during January and February. Related to the present condition the

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rainfall of projected climate will be declining during April and October but in the case of May there will be an intensification in the rainfall. According to RCP 4.5 the total rainfall shows an intensification trend. Then according to RCP 8.5 the total rainfall shows a slight increase from 2030 to 2050 and decline in 2080.

The monthly rainy days of Kaipad land (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were considered and represented in table 36.

Table 36. Monthly rainy days of Kaipad land (AEU7) and the projected climate in Kannur district

Monthly Rainy days	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	1	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	2	0	0	1
April	4	3	3	5	2	2	3
May	11	12	11	17	13	12	13
June	27	25	25	28	27	25	27
July	30	30	30	30	30	30	29
August	14	14	16	16	16	17	16
September	5	5	4	4	4	4	1
October	11	11	10	11	10	11	8
November	3	4	4	3	4	3	4
December	2	2	3	3	3	2	3
Total	**107**	**106**	**107**	**119**	**109**	**106**	**105**

In the present situation, June and July have the maximum number of rainy days and it is about 27 to 30 days. Also, the lesser is in January and February. As per RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and the minimum will be 0 day in February. Consequently, in RCP 4.5 the projected climate shows a cumulative trend in the annual rainy days of Kaipad Land. But according to RCP 8.5 there is a decrease in annual rainfall. The annual rainy days of projected climate will show a reduction as compared to the current condition, except RCP 4.5 2080.

For the current condition and projected climate, the seasonal rainy days of Kaipad land (AEU7) were examined and given in table 37.

Table 37. Seasonal rainy days of Kaipad land (AEU7) and the projected climate in Kannur 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	0	0	15	269.8	76	3405.1	16	338.4
4.5	2030	0	0	15	216.6	74	3422.1	17	333
	2050	1	2.7	14	242.6	75	3529.3	17	288.3
	2080	0	4.2	24	521.8	78	3402.2	17	344
8.5	2030	0	1.8	15	399.8	77	3508.9	17	293.6
	2050	0	0.1	14	304.9	76	3646.5	16	334.8
	2080	0	0	17	327.5	73	3283.2	15	305.6

In the present-day condition, the maximum number of rainy days occurs in south west monsoon (76 days) followed by North East (16 days), summer season (15 days) and winter season (0 days). As per projected climate the highest number of rainy days will be in South West monsoon followed by north east and summer season. There is an increasing trend in seasonal rainfall during south west monsoon time according to RCP 4.5 and a decreasing trend in RCP 8.5. As per RCP 4.5 and 8.5 the seasonal rainfall shows a decreasing trend in summer season from 2030 to 2050 and an increase in 2080. Then in the north east monsoon season the rainfall shows an increasing trend as per RCP 4.5 and RCP 8.5 shows a slight decrease. Related to the present condition the projected climate will show a least variation in the rainfall during north east and winter season but in south west and summer season the rainfall shows an increasing trend.

4.1.3.2.2. High rainfall events of Kaipad Land (AEU7) in Kannur district

High rainfall events for the present condition and projected climate of Kaipad land (AEU7) were analysed and represented in table 38.

Table 38. High rainfall events of Kaipad land (AEU7) and the projected climate in Kannur district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

Presently the higher number of rainfall events occur during low rainfall and fewer number of events during high rainfall. As per the projected climate based on RCP 4.5 and 8.5 there is a cumulative trend in rainfall events.

4.1.3.3. Rainfall analysis of Northern laterites (AEU11) and climate change impacts in Kannur districts

Major cropping system in the AEU is coconut based followed by rubber-based cropping system and arecanut based cropping system. Rice based and banana-based cropping systems are also practiced here. In the rice-based cropping system, rice-rice-fallow system dominates. This is followed by rice-rice-vegetable cropping. Among coconut-based systems, coconut monocropping is practiced in around majority of the panchayats and occupies lion's share of the coconut area. Coconut intercropped with pepper and banana is another major coconut-based system.

4.1.3.3.1. Rainfall and Rainy days of Northern laterites (AEU11) in Kannur district

The monthly rainfall scattering of Northern laterites (AEU11) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 39.

Table 39. Monthly rainfall distribution of Northern laterites (AEU11) and the projected climate in Kannur district

Monthly Rainfall (mm)	2016	4.5			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	7.8	0	0	7.8
April	21.8	32.5	43.5	0.2	32.7	43.5	0.2
May	379.6	356.9	223	227.2	383.8	223	227.2
June	1362.9	1225.5	1340.5	1089.3	1367.9	1340.5	1089.3
July	1274.7	1440.2	1492.6	1388.3	1271.4	1492.6	1388.3
August	482.3	550.4	639.3	545.8	549.7	639.3	545.8
September	128.5	169.9	188.4	9.5	169.9	188.4	9.5
October	292.6	219	291.9	177.6	219	291.9	177.6
November	23.8	34.1	24.1	19.6	34.1	24.1	19.6
December	14.2	36.1	15.9	11.4	36.1	15.9	11.4
Total	**3980.4**	**4064.6**	**4259.2**	**3476.7**	**4064.6**	**4259.2**	**3476.7**

Currently June and July are the showery months, having a rainfall of 1362.9 mm and 1274.7 mm. January and December are the months having lowest rainfall of 0 mm and 14.2 mm. As per RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during June and July. Then the lowest rainfall is acquired during January and February. Relating the projected climate and present conditions, the rainfall distribution displays an extreme decline in the month May. According to

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RCP 4.5 and 8.5 the total rainfall expresses a falling trend from 2030 to 2080. Whereas in the projected climate the amount of annual rainfall will be higher in 2030 and 2050 than that of the present-day condition.

The monthly rainy days of Northern laterites (AEU11) for the current and projected climate (RCP 4.5 and 8.5) were examined and given in table 40.

Table 40. Monthly rainy days of Northern laterites (AEU11) and the projected climate in Kannur district

Monthly Rainy days	2016	4.5			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	1	0	0	1
April	4	3	4	0	3	4	0
May	16	14	12	13	15	12	13
June	25	25	27	26	25	27	26
July	29	30	30	28	29	30	28
August	14	16	17	16	16	17	16
September	5	4	4	1	4	4	1
October	11	10	11	7	10	11	7
November	4	4	3	2	4	3	2
December	3	3	3	1	3	3	1
Total	**111**	**109**	**111**	**95**	**109**	**111**	**95**

Present day situation, June and July have the maximum number of rainy days and it is about 25 to 29 days. Then the least is in January and February. Conferring to RCP 4.5 and 8.5, the intense rainy days will be 30 days in July and there will be no rainy days in January, February and March. In accordance with RCP 4.5 and 8.5 the projected climate shows a cumulative trend in the annual rainy days of northern laterites from 2030 to 2050 and it will be declining in 2080. The annual rainy days of projected climate will be lesser in 2030 and 2080 as compared to the present condition.

The seasonal rainy days of northern laterites (AEU11) for the present condition and projected climate were examined and presented in table 41.

Table 41. Seasonal rainy days of Northern laterites (AEU 11) and the projected climate in Kannur 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	0	0	20	401.4	73	3248.4	18	330.6
4.5	2030	0	0	17	389.4	75	3386	17	289.2
	2050	0	0	16	266.5	78	3660.8	17	331.9
	2080	0	0	14	235.2	71	3032.9	10	208.6
8.5	2030	0	0	18	416.5	74	3358.9	17	289.2
	2050	0	0	16	266.5	78	3660.8	17	331.9
	2080	0	0	14	235.2	71	3032.9	10	208.6

Currently, the maximum number of rainy days happens during south west monsoon time (78 days) followed by North East (18 days), summer season (20 days) and winter season (0 days). As per the projected climate the maximum number of rainy days will be in South West monsoon followed by summer season. Here will be an increasing trend in seasonal rainfall in 2030 to 2050 and a decrease in 2080 during south west monsoon time. The number of rainy days occur in summer will be higher than that of north east. The minimum number of rainy days will be occurring during winter.

4.1.3.3.2. Heavy rainfall events of northern laterites (AEU11) in Kannur 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 42.

Table 42. Heavy rainfall events of Northern laterites (AEU 11) and the projected climate in Kannur district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

Currently the number of rainfall events occurring is more in the range of 10 to 25 mm and 25 to 50 mm. 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 there will is a fluctuation in the number of rainfall events during low rainfall. In the case of heavy rainfall also the number of rainfall events show fluctuations.

4.1.3.4. Rainfall analysis of northern foothills (AEU13) and climate change impacts in Kannur districts

Around 70% land area is put to agricultural land use. Coconut plantations intercropped with many perennials, and arecanut, coffee, and rubber plantations constitute the main upland crops, while banana and other vegetables are the main lowland crops.

4.1.3.4.1. Rainfall and Rainy days of northern foothills (AEU13) in Kannur district

The monthly rainfall distribution of northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 43.

Table 43. Monthly rainfall distribution of Northern foothills (AEU 13) and the projected climate in Kannur district

Monthly Rainfall (mm)	2016	4.5			8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	1.8	0	0	0
February	0	0	0	0	0	0	3.6
March	43	29.4	3.4	19.4	10.4	3	25.4
April	14.5	22.3	98.2	23.5	42.1	100	40.6
May	493.7	288	337.4	302.1	392	334.8	215.9
June	1169.9	845	1356.4	1526.4	1025.2	1543.4	613.1
July	1534.9	1699.9	1610	1657.6	1588.5	1625.4	1179.1
August	691.8	695.8	653.4	634.8	654.6	642.2	606.9
September	144.4	145.5	86	10.3	42.5	40.6	15
October	256.2	228.1	305.6	248.1	193.3	181.4	248.5
November	36.1	32.1	23.7	39.6	40.9	23.8	19.2
December	30.5	27.7	38.7	34.7	31.6	40	62.3
Total	**4415**	**4013.8**	**4512.8**	**4498.3**	**4021.1**	**4534.6**	**3029.6**

In the current condition June and July are the wettest months; having a rainfall of 1169.9 mm and 1534.9 mm. January and February are the months having lowest rainfall of 0 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 gets during January and February. According to RCP 4.5 the total rainfall shows a slight increase from 2030 to 2050 and it decreases in 2080. As per RCP 8.5 the total rainfall shows an increasing trend from 2030 to 2050 and a drastic decrease in 2080. In projected climate there will be a drastic decrease in rainfall distribution during March and September from the present state.

The monthly rainy days of northern foothills (AEU 13) for the present and projected climate (RCP 4.5 and 8.5) were analysed and given in table 44.

Table 44. Monthly rainy days of Northern foothills (AEU 13) and the projected climate in Kannur district

Monthly Rainy days	2016	4.5			8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	1
March	7	6	1	2	1	0	3
April	1	2	3	4	2	3	4
May	16	15	18	17	16	18	11
June	25	25	26	26	26	26	25
July	30	30	30	30	30	30	29
August	17	16	18	16	18	16	17
September	6	6	3	1	3	2	2
October	10	11	11	8	6	7	7
November	3	3	2	4	4	2	2
December	5	4	4	4	3	4	5
Total	**120**	**118**	**116**	**112**	**109**	**108**	**106**

Currently, June and July have the maximum number of rainy days and it is about 30 days. And the lowest is in January and February. As per RCP 4.5 and 8.5, the maximum number of rainy days will be occurring during June and July and the minimum will be in January and February. The maximum rainy days will be 30 days and the minimum will be 0 to 1 day. The projected climate shows a decreasing trend in the annual rainy days of northern foothills (AEU13). The annual rainy days of projected climate will be less as compared to the present condition.

The seasonal rainy days of northern foothills (AEU13) for the existing condition and projected climate were examined and represented in table 45.

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Table 45. Seasonal rainy days of Northern foothills (AEU 13) and the projected climate in Kannur 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	0	0	24	551.2	78	3541	18	322.8
4.5	2030	0	0	23	339.7	77	3386.2	18	287.9
	2050	0	0	22	439	77	3705.8	17	368
	2080	0	1.8	23	345	73	3829.1	16	322.4
8.5	2030	0	0	19	444.5	77	3310.8	13	265.8
	2050	0	0	21	437.8	74	3851.6	13	245.2
	2080	1	3.6	18	281.9	73	2414.1	14	330

Presently, the maximum number of rainy days occurs during south west monsoon time (78 days) followed by summer season (24 days), north west (18 days) and winter season (1 day). According to projected climate the maximum number of rainy days will be occurring in south west monsoon followed by summer season. The highest amount of rainfall will be getting in southwest followed by summer season. The minimum number of rainy days will be getting in winter. The projected climate shows an intensified rainfall in South West and there will be less rainfall in north east monsoon as compare to the present condition.

4.1.3.4.2. High rainfall events of northern foothills (AEU13) in Kannur district

For the present and projected climate based on RCP 4.5 and 8.5, the high rainfall events of northern foothills were studied and presented in table 46.

In the present condition the greater number of rainfall events occur during low rainfall and a smaller number of events during high rainfall. According to the projected climate based on RCP 4.5 there is a decrease in during low rainfall (10-50 mm) in 2080 and according to 8.5 there will be a decrease in the number of rainfall events during low rainfall (10-50 mm) in 2050. As per RCP 4.5 from 2050 to 2080 the number of rainfall events shows a decreasing trend. But as per RCP 8.5 there will be an increase in the number of rainfall events from 2050 to 2080.

Table 46. High rainfall events of Northern foothills (AEU13) and the projected climate in Kannur district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

4.1.3.5. Rainfall analysis of northern high hills (AEU15) and climate change impacts in Kannur districts

Major cropping system in this unit is rubber based. Coconut based cropping system is the other major system followed by arecanut (5.07%) based cropping system. Banana based and rice-based cropping systems are also practiced in the AEU. The percentage cultivable area for rice is very meagre. In the rice-based cropping system, rice-rice system dominates followed by rice- rice vegetable cropping system. Among coconut-based systems coconut + pepper + banana system is practiced in majority of the panchayats.

4.1.3.5.1. Rainfall and Rainy days of northern high hills (AEU15) in Kannur 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 given in table 47.

Table 47. Monthly rainfall distribution of Northern high hills (AEU 15) and the projected climate in Kannur district

Monthly Rainfall (mm)	2016	4.5			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	44.9	10.4	3	26.1	38.7	13	17.1
April	33.1	42.1	100	26.4	44.5	28.4	17.8
May	472.5	392	334.8	434.3	432.4	404.5	399.7
June	1066	1025.2	1543.4	1116.4	1033.8	971.9	1336.4
July	1627.5	1588.5	1625.4	1567.4	1622.8	1669	1476.3
August	610.4	654.6	642.2	950.1	825.6	927.6	957.6
September	147.6	42.5	40.6	22.2	167.1	210.7	82.2
October	228	193.3	181.4	340.8	242.2	308.7	331.1
November	19.7	40.9	23.8	31.3	17.3	31.1	20
December	59.2	31.6	40	51.6	89.4	81.3	67.2
Total	**4308.9**	**4021.1**	**4534.6**	**4566.6**	**4513.8**	**4646.2**	**4705.4**

In the existing condition June and July are the wettest months, having a rainfall of 1066 mm and 1627.5 mm. January and February are the months having lowest rainfall of 0 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 lowest rainfall gets during January and February. Compared to the present condition the rainfall of projected climate will be decreasing during March but in the case of August there will be a drastic increase in the rainfall. As per RCP 4.5 and 8.5 the total rainfall shows an increasing trend.

The monthly rainy days of Northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 48.

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Table 48. Monthly rainy days of Northern high hills (AEU15) and the projected climate in Kannur district

Monthly Rainy days	2016	4.5			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	5	1	0	3	4	2	4
April	2	2	3	3	4	4	3
May	18	16	18	14	15	16	15
June	24	26	26	24	25	25	26
July	30	30	30	30	30	29	30
August	15	18	16	18	20	21	22
September	6	3	2	2	6	8	1
October	10	6	7	12	10	10	12
November	3	4	2	3	2	2	1
December	5	3	4	6	9	9	7
Total	**118**	**109**	**108**	**115**	**125**	**126**	**121**

Currently, June and July have the maximum number of rainy days and it is about 25 to 30 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and the minimum will be 0 day in February. As per RCP 4.5 the projected climate shows a decreasing trend in the annual rainy days of northern high hills from 2030 to 2050 and it will be increasing in 2080 and in RCP 8.5 there is a increase in rainy days from 2030 to 2050 and a decrease in 2080. The annual rainy days of projected climate will be less as compared to the present condition in RCP 4.5.

For the current condition and projected climate, the seasonal rainy days of northern high hills (AEU15) were examined and given in table 49.

Table 49. Seasonal rainy days of Northern high hills (AEU 15) and the projected climate in Kannur 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	0	0	25	550.5	75	3451.5	18	306.9
4.5	2030	0	0	19	444.5	77	3310.8	13	265.8
	2050	0	0	21	437.8	74	3851.6	13	245.2
	2080	0	0	20	486.8	74	3656.1	21	423.7
8.5	2030	0	0	23	515.6	81	3649.3	21	348.9
	2050	0	0	22	445.9	83	3779.2	21	421.1
	2080	0	0	22	434.6	79	3852.5	20	418.3

In the present condition, the maximum number of rainy days occurs during south west monsoon time (83 days) followed by summer season (25 days), north east (21 days) and winter season (0 days). According to projected climate the highest number of rainy days will be in South West monsoon followed by summer season and north east. There will be an increasing trend in seasonal rainfall during south west monsoon time. As in the case of summer season the seasonal rainfall shows a decreasing trend as per RCP 4.5 and 8.5. But in north east monsoon season the rainfall will be decreasing as per RCP 8.5 and in RCP 4.5 it shows a decrease from 2030 to 2050 and an increase in 2080.

4.1.3.5.2. High rainfall events of northern high hills (AEU 15) in Kannur district

High rainfall events for the present condition and projected climate of northern high hills (AEU 15) were analysed and represented in table 50.

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Table 50. High rainfall events of Northern high hills (AEU 15) and the projected climate in Kannur district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

Presently the more number of rainfall events occur during low rainfall and less number of events during high rainfall. According to the projected climate based on RCP 4.5 and 8.5, in 2030 there will be a decrease in the number of rainfall events during low rainfall which is in the range of 10 to 50 mm but during high rainfall the number of rainfall events will be increasing. As per RCP 4.5 from 2050 to 2080 the number of rainfall events shows a decreasing trend. But as per RCP 8.5 there will be an increase in the number of rainfall events from 2050 to 2080.

4.1.4. Rainfall analysis of various AEUs of Kasaragod district

The Kasaragod district is divided into five agro-ecological units (fig. 2) such as Northern coastal plain (AEU2), Kaipad lands (AEU7), Northern laterites (AEU11), Northern foothills (AEU13) and Northern high hills (AEU15). These cover an area of 28,341 ha. (14.23%), 9619 ha. (4.83%), 95,379 ha. (47.89%), 10604 ha. (5.32%) and 51,234 (25.72%) respectively.

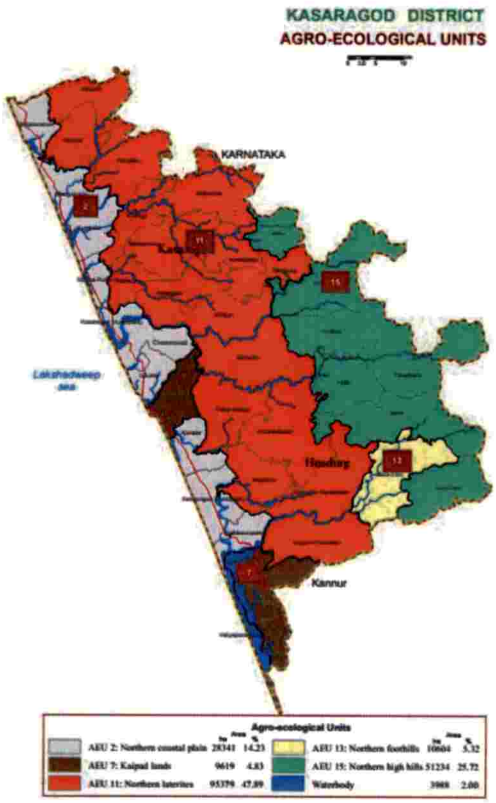

Fig.6. Agro-Ecological Units Map of Kasaragod District

4.1.4.1. Rainfall analysis of Northern coastal plain (AEU2) and climate change impacts in Kasaragod districts

Major cropping system in the unit is coconut based which is practiced in nearly 54 per cent of the cultivable area. This is followed by arecanut based cropping (7.67 %) and by cashew-based cropping system (5.92 %). Rice based cropping systems (5.62 %), banana-based cropping systems (1.56 %) and rubber-based cropping systems (0.09 %) are also seen here. Rice based, coconut based and banana-based cropping systems are followed in all panchayats in this unit whereas arecanut based and cashew-based cropping systems are followed in 90 per cent of panchayats. Rubber based cropping system is seen in 20 per cent of panchayats in the unit. Among rice-based cropping systems, Rice-Rice-Fallow system dominates and accounts to almost 55.44 per cent of rice area in the unit.

4.1.4.1.1. Rainfall and Rainy days of Northern coastal plain (AEU2) in Kasaragod 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 51.

Table 51. Monthly rainfall distribution of Northern coastal plain (AEU2) and the projected climate in Kasaragod district

Monthly Rainfall (mm)	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	43.1	16.7	26.5	16.8	25.6	17.2
April	79.5	7.5	7.9	21.3	1.4	2.2	14.4
May	245.2	188.4	292.3	360.1	289.5	348.2	350.2
June	814.4	1199	1103.8	909.7	1374.7	1308.7	1035.7
July	1363.5	1540.9	1837.4	1722.2	1544	1599.5	1591
August	978.3	762.8	801.5	820.4	806.2	818.5	1110.1
September	290.6	193	194.3	196.1	194.3	194.2	262.8
October	164.8	237.3	211.8	217.2	240.1	239.9	261.2
November	184.4	30	15.2	17.6	30.3	26.8	25.6
December	10.8	28.3	37.6	40.1	30.3	32.6	50
Total	**4131.5**	**4230.3**	**4518.5**	**4331.2**	**4527.6**	**4596.2**	**4718.2**

In the present condition July and August are the wettest months, having a rainfall of 1363.5 mm and 978.3 mm. January and February are the months having

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lowest rainfall of 0 mm. As per projected climate based on RCP 4.5 and 8.5, there will be a probability of getting maximum rainfall during June and July. And the lowest rainfall gets during January and February. Compared to the present condition the projected climate shows a drastic decrease in rainfall distribution during the months April and November. According to RCP 4.5 the total rainfall shows a slight increase from 2030 to 2050 and it decreases in 2080. But as per RCP 8.5 the total rainfall shows an increasing trend.

The monthly rainy days of northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were analysed and represented in table 52.

Table 52. Monthly rainy days of Northern coastal plain (AEU2) and the projected climate in Kasaragod district

Monthly Rainy days	2016	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	4	3	3	2	2	3
April	6	1	2	1	0	0	2
May	14	14	16	14	14	13	14
June	22	26	26	26	26	27	26
July	28	30	30	30	29	30	30
August	24	19	20	20	21	20	21
September	13	7	7	7	7	7	8
October	7	10	10	10	10	10	11
November	16	3	2	2	3	3	3
December	3	5	4	4	5	4	6
Total	**133**	**119**	**120**	**117**	**117**	**116**	**124**

Currently, June and July have the most extreme number of rainy days and it is around 25 days. Also, the lowest is in January and February. According to RCP 4.5 and 8.5, the greatest number of rainy days will be happening in June and July and the base will be in January and February. The greatest rainy days will be 30 days and the base will be 0 day. The projected climate demonstrates an expanding pattern in the yearly rainy days of northern coastal plain from 2030 to 2050 and a decrease in 2080 (RCP 4.5) and an increasing trend in RCP 8.5. The yearly rainy days of projected climate will be less when contrasted with the current condition.

The seasonal rainy days of northern coastal plain (AEU2) for the existing condition and projected climate were examined and given in table 53.

Table 53. Seasonal rainy days of Northern coastal plain (AEU2) and the projected climate in Kasaragod 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	0	0	20	324.7	87	3446.8	26	360
4.5	2030	0	0	19	239	82	3695.7	18	295.6
	2050	0	0	21	316.9	83	3937	16	264.6
	2080	0	0	18	407.9	83	3648.4	16	274.9
8.5	2030	0	0	16	307.7	83	3919.2	18	300.7
	2050	0	0	15	376	84	3920.9	17	299.3

At present, the greatest number of rainy days happens in south west season (87 days) trailed by North East (26 days), summer season (21 days) and winter season (0 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will be in South West monsoon taken after by North East. The base number of rainy days and precipitation will be in winter and summer season. There will be an extreme abatement in precipitation in summer and winter season in RCP 4.5 and an increase in rainy days in RCP 8.5 when contrasted with the current condition. The projected climate demonstrates a

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weak precipitation in South West and North East when contrasted with the earlier years.

4.1.4.1.2 High rainfall events of northern coastal plain (AEU2) in Kasaragod district

For the present condition and projected climate, the high rainfall events of northern coastal plain (AEU2) were studied and given in table 54.

In the present condition the number of rainfall events occurring is more in the range of 10 to 25 mm and 25 to 50 mm. 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 there will be an increasing trend in the number of rainfall events during low rainfall. In the case of heavy rainfall, the number of rainfall events shows a fluctuation trend.

Table 54. High rainfall events of Northern coastal plain (AEU2) and the projected climate in Kasaragod district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

4.1.4.2. Rainfall analysis of Kaipad lands (AEU7) and climate change impacts in Kasaragod district

Major cropping system in the unit is coconut based which is practiced in nearly 63.86% of the cultivable area. Rice based cropping system has second position followed by arecanut based cropping system. Banana based, cashew based and rubber-based cropping systems are also practiced here. Rice based and coconut-based cropping systems are being practiced in all panchayats of the unit. Among rice-based cropping systems, Rice-Rice-Fallow system dominates and accounts to almost 55.71 per cent of rice area in the unit. This is followed by Rice-Fallow-Fallow cropping system that has 16.76 per cent of rice area in the unit.

4.1.4.2.1. Rainfall and Rainy days of Kaipad lands (AEU7) in Kasaragod district

The monthly rainfall distribution of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were analysed and presented in table 55.

Table 55. Monthly rainfall distribution of Kaipad lands (AEU7) and the projected climate in Kasaragod district

Monthly Rainfall (mm)	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	2.7	4.2	1.8	0.1	0
February	0	0	0	0	0	0	0
March	0	0	0	8.8	0	0	4.7
April	82.7	55	32.6	31	15.8	13.5	13.7
May	187.1	161.6	210	482	384	291.4	309.1
June	1314.9	1313.1	1296.8	1110.1	1305	1296.3	1167.2
July	1462.2	1471.7	1483.5	1478	1467.2	1497.6	1455.2
August	497.8	511.2	584.4	625.7	564.6	663.5	656.5
September	130.2	126.1	164.6	188.4	172.1	189.1	4.3
October	301.3	296.4	218.9	297	223.7	297.4	214.3
November	22.4	22.3	31.5	24.7	32.5	22.8	47.4
December	14.7	14.3	37.9	22.3	37.4	14.6	43.9
Total	**4013.3**	**3971.7**	**4062.9**	**4272.2**	**4204.1**	**4286.3**	**3916.3**

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In the existing condition June and July are the wettest months, having a rainfall of 1314.9 mm and 1462.2 mm. January and February are the months having lowest rainfall of 0 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 lowest rainfall gets during January and February. Compared to the present condition the rainfall of projected climate will be decreasing during April. As per RCP 4.5 the total rainfall shows a increasing trend. But according to RCP 8.5 the total rainfall shows an increase from 2030 to 2050 and it will be decreasing in 2080.

The monthly rainy days of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 56.

Table 56. Monthly rainy days of Kaipad lands (AEU7) and the projected climate in Kasaragod district

Monthly Rainy days	2016	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	0	0	0	2	0	0	2
February	0	0	0	0	0	0	0
March	1	0	0	2	0	0	2
April	3	3	2	3	3	2	3
May	14	15	15	17	15	15	17
June	26	24	27	29	24	27	29
July	30	30	30	30	30	30	30
August	16	14	15	15	14	15	15
September	4	5	6	6	5	6	6
October	11	11	11	12	11	11	12
November	5	4	2	2	4	2	2
December	5	4	3	3	4	3	3
Total	**115**	**110**	**111**	**121**	**110**	**111**	**121**

Presently, June and July have the maximum number of rainy days and it is about 25 to 30 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and the minimum will be 0 day in February. As per RCP 4.5 and 8.5 the projected climate shows a

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increasing trend in the annual rainy days of Kaipad lands from 2030 to 2080. The annual rainy days of projected climate will be less as compared to the present condition in 2030 and 2050.

For the current condition and projected climate, the seasonal rainy days of Kaipad lands (AEU7) were examined and given in table 57.

Table 57. Seasonal rainy days of Kaipad lands (AEU9) and the projected climate in Kasaragod 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	0	0	18	385.1	76	3400.2	21	330
4.5	2030	0	0	18	353.8	73	3791.3	19	349.4
	2050	0	0	17	486.5	78	3519.3	16	306.5
	2080	2	11.8	22	462.9	80	3508.8	17	313.5
8.5	2030	0	0	18	353.8	73	3791.3	19	349.4
	2050	0	0	17	486.5	78	3519.3	16	306.5
	2080	2	11.8	22	462.9	80	3508.8	17	313.5

In the present condition, the maximum number of rainy days occurs during south west monsoon time (80 days) followed by North East (21 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 monsoon and summer season. There will be an increasing trend in seasonal rainfall during south west monsoon time. As in the case of summer season the seasonal rainfall shows a decreasing trend from 2030 to 2050 and increases in 2080 as per RCP 4.5 and 8.5. In the north east monsoon season the rainfall will be decreasing from 2030 to 2050 and increases in 2080 as per RCP 4.5 and RCP 8.5. Comparing the present condition to the projected climate there will be a decrease

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in rainfall from 2030 to 2050 and an increase in 2080 during north east monsoon and in the case of south west and summer season the rainfall shows a decrease from 2030 to 2050 and then increases in 2080.

4.1.4.2.2. High rainfall events of Kaipad lands (AEU7) in Kasaragod district

High rainfall events for the present condition and projected climate of Kaipad lands (AEU7) were analysed and represented in table 58.

Table 58. High rainfall events of Kaipad lands (AEU 7) and the projected climate in Kasaragod district

Year	Season	RCP 4.5 10 <25	RCP 4.5 25 <50	RCP 4.5 50 <75	RCP 4.5 75 <100	RCP 4.5 >= 100	RCP 8.5 10 <25	RCP 8.5 25 <50	RCP 8.5 50 <75	RCP 8.5 75 <100	RCP 8.5 >= 100
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

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In the existing condition, more number of rainfall events occur during low rainfall and less number of events during high rainfall. As per RCP 4.5 from 2050 to 2080 the number of rainfall events shows an increasing trend in summer season while south west monsoon shows a decrease. But as per RCP 8.5 there will be an increase in the number of rainfall events from 2050 to 2080 in summer season and south west monsoon.

4.1.4.3 Rainfall analysis of Northern laterites (AEU11) and climate change impacts in Kasaragod district

Major cropping system in the unit is coconut based which is practiced in nearly 26 per cent of the cultivable area. Arecanut based cropping system has second position followed by rubber-based cropping system. Cashew based, rice based and banana-based cropping systems are also practiced here. All these cropping systems are practiced in all the panchayat of the unit. Among rice-based cropping systems, Rice-Rice-Fallow dominates and accounts to almost 41.01 per cent of rice area in the unit.

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

The monthly rainfall distribution of northern laterites (AEU11) for the present and projected climate (RCP 4.5 and 8.5) were analysed and presented in table 59.

Table 59. Monthly rainfall distribution of Northern laterites (AEU11) and the projected climate in Kasaragod district

Monthly Rainfall (mm)	2016	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	73.3	56.5	44.9	32.7	49.2	33	32.5
April	6.8	1.6	6.3	26.4	6.3	18.7	29
May	369	319.8	320.7	345.3	213.5	269.1	479.1
June	1339.4	1237.1	1382.2	973.2	1303.4	1420.3	1145.3
July	1656.6	1715	1828.2	2023.4	1745.9	1838.2	1755
August	815.6	857.1	828.2	834.4	853.6	832.1	927.2
September	266.2	266.3	133.7	137.5	266.3	138.4	57.2
October	228.3	230.9	260.8	260.8	232.2	258.3	340.8
November	17.5	15.5	14.9	14.7	16.1	15.7	31.2
December	40.2	43.1	50.6	66.9	43.7	48.6	58.9
Total	**4812.9**	**4742.9**	**4870.5**	**4715.3**	**4730.2**	**4872.4**	**4856.2**

Presently, June and July are the wettest months, having a rainfall of 1339.4 mm and 1656.6 mm. January and February are the months having lowest rainfall of 0 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 lowest rainfall gets during January and February. Compared to the present condition the rainfall of projected climate will be decreasing during March and September. As per RCP 4.5 and 8.5 the total rainfall shows an increasing trend from 2030 to 2050 and a decrease in 2080.

The monthly rainy days of Northern laterites (AEU11) for the present and projected climate (RCP 4.5 and 8.5) were studied and represented in table 60.

Table 60. Monthly rainy days of Northern laterites (AEU11) and the projected climate in Kasaragod district

Monthly Rainy days	2016	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	9	6	6	6	5	4	4
April	1	0	1	3	2	2	2
May	15	14	14	14	12	14	12
June	28	27	27	26	27	25	26
July	29	29	30	30	30	30	30
August	20	21	21	21	21	21	21
September	8	8	3	3	8	3	4
October	10	10	10	10	10	10	10
November	2	2	2	2	2	2	2
December	4	5	6	7	5	6	6
Total	**126**	**122**	**120**	**122**	**122**	**117**	**117**

In the current condition, June and July have the maximum number of rainy days and it is about 28 to 29 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and the minimum will be 0 day in February. As per RCP 4.5 and 8.5 the projected climate shows a decreasing trend in the annual rainy days of northern laterites lands from 2030 to 2050 and it will be increasing in 2080. 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 laterites (AEU11) were examined and given in table 61.

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Table 61. Seasonal rainy days of Northern laterites (AEU11) and the projected climate in Kasaragod 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	0	0	25	449.1	85	4077.8	16	286
4.5	2030	0	0	20	377.9	85	4075.5	17	289.5
	2050	0	0	21	371.9	81	4172.3	18	326.3
	2080	0	0	23	404.4	80	3968.5	19	342.4
8.5	2030	0	0	19	269	86	4169.2	17	292
	2050	0	0	20	320.8	79	4229	18	322.6
	2080	0	0	18	540.6	81	3884.7	18	430.9

In the present condition, the maximum number of rainy days occurs during south west monsoon time (86 days) followed by summer season (25 days), north east (19 days) and winter season (0 days). According to the projected climate the highest number of rainy days will be in South West monsoon followed by summer season and north east. There will be a decreasing trend in seasonal rainfall during south west monsoon time. As in the case of summer season the seasonal rainfall shows an increasing trend from 2030 to 2080 as per RCP 4.5 and 8.5 there is an increase from 2030 to 2050 and decreases in 2080. But in north east monsoon season the rainfall will be increasing as per RCP 4.5 and in RCP 8.5 it shows a slight increase from 2030 to 2050. Comparing the present condition to the projected climate there will be drastic increase in rainfall during north east monsoon season but in the case of south west monsoon season there is a decrease in seasonal rainfall and summer season as per RCP 4.5 there is an increase in the rainfall and in RCP 8.5 there is an increase from 2030 to 2050 and decreases in 2080.

4.1.4.3.2 High rainfall events of northern laterites (AEU11) in Kasaragod district

High rainfall events for the present condition and projected climate of northern laterites (AEU11) were analysed and represented in table 62.

Table 62. High rainfall events of Northern laterites (AEU 11) and the projected climate in Kasaragod district

Year	Season	RCP 4.5					RCP 8.5				
		Days									
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

Currently, more number of rainfall events occur during low rainfall and less number of events during high rainfall. According to the projected climate based on RCP 4.5 and 8.5, in 2030 there will be a increase in the number of rainfall events during low rainfall which is in the range of 10 to 50 mm but during high rainfall the number of rainfall shows a fluctuating trend.

4.1.4.4. Rainfall analysis of Northern foothills (AEU13) and climate change impacts in Kasaragod district

Major cropping system in the unit is rubber based which is practiced in nearly 35.36 per cent of the cultivable area. Coconut based cropping system has second position (21.21 %) followed by arecanut based cropping system (9.04 %). Cashew based, banana based and rice-based cropping systems are also practiced here. All these cropping systems are being practiced in almost all the panchayats of the unit in the rice-based cropping system, Rice-Fallow-Fallow system dominates and accounts to almost 66.08 per cent of rice area in the unit.

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

The monthly rainfall distribution of northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were analysed and presented in table 63.

Table 63. Monthly rainfall distribution of Northern foothills (AEU13) and the projected climate in Kasaragod district

Monthly Rainfall (mm)	2016	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	39	40.6	27.1	35.8	47.4	27.1	14
April	23.1	7.2	26.6	30.7	39.9	37.5	27.7
May	222	194.2	506.3	483.6	401.5	535.3	233.9
June	1228.3	1320.6	1273.7	932.1	1090.8	946.8	1277.2
July	1837.8	2064.7	1937.5	1762.3	1987	2078	1762.5
August	939.4	945.4	951.6	932	914.8	928.1	1046.5
September	83.8	85.1	86.7	136.2	89.4	137.8	55.7
October	322.2	328.7	274.9	321.8	269	318.8	360.2
November	25	25.7	14.5	27.3	14.4	27.3	27.3
December	106.2	106.9	105.5	116.2	72.3	80.3	87.7
Total	**4826.8**	**5119.1**	**5204.4**	**4778**	**4926.5**	**5117**	**4892.7**

In the present condition, June and July are the wettest months, having a rainfall of 1228.3 mm and 1837.8 mm. January and February are the months having lowest rainfall of 0 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 gets during January and February. As per RCP 4.5 the total rainfall shows an increasing trend from 2030 to 2050 and decreasing in 2080. According to RCP 8.5 the total rainfall shows an increasing trend from 2030 to 2050 and it will be decreasing in 2080. In projected climate the amount of annual rainfall will be higher than that of the present condition in 2030, 2050 (RCP 4.5) and2030, 2050, 2080 (RCP 8.5).

The monthly rainy days of Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were examined and given in table 64.

Table 64. Monthly rainy days of Northern foothills (AEU13) and the projected climate in Kasaragod district

Monthly Rainy days	2016	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	4	3	6	4	6	4	3
April	2	1	3	3	2	2	3
May	12	12	14	14	14	14	11
June	26	25	23	26	26	25	28
July	30	30	30	30	30	30	30
August	21	21	21	21	21	21	22
September	1	1	1	4	1	4	4
October	11	11	10	11	10	11	11
November	3	3	2	3	2	3	3
December	8	8	10	9	7	6	7
Total	**118**	**115**	**120**	**125**	**119**	**120**	**122**

In the current condition, June and July have the maximum number of rainy days and it is about 25 to 30 days. And the lowest is in January and February. According to RCP 4.5 and 8.5, the maximum rainy days will be 30 days in July and there will be no rainy days in February. As per RCP 4.5 and 8.5 the projected climate shows an increasing trend in the annual rainy days of northern foothills from 2030 to 2080. The annual rainy days of projected climate will be more as compared to the present condition.

For the current condition and projected climate, the seasonal rainy days of northern foothills (AEU13) were examined and presented in table 65.

Table 65. Seasonal rainy days of Northern foothills (AEU 13) and the projected climate in Kasaragod 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	0	0	18	284.1	78	4089.3	22	453.4
4.5	2030	0	0	16	242	77	4415.8	22	461.3
	2050	0	0	23	560	75	4249.5	22	394.9
	2080	0	0	21	550.1	81	3762.6	23	465.3
8.5	2030	0	0	22	488.8	78	4082	19	355.7
	2050	0	0	20	599.9	80	4090.7	20	426.4
	2080	0	0	17	275.6	84	4141.9	21	475.2

Presently, the maximum number of rainy days occurs during south west monsoon time (78 days) followed by North East (22 days), summer season (18 days) and winter season (0 days). According to projected climate the highest number of rainy days will get in South West monsoon followed by north east. There will be decreasing trend in seasonal rainfall during south west monsoon time from 2030 to 2050 and increases in 2080 (RCP 4.5) and shows an increasing trend in RCP 8.5. The minimum number of rainy days will be occurring during winter.

4.1.4.4.2 Heavy rainfall events of northern foothills (AEU13) in Kasaragod district

The heavy rainfall events of northern foothills 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 of Northern foothills (AEU 13) and the projected climate in Kasaragod district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm and 25 to 50 mm. 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. In the case of heavy rainfall, the number of rainfall events shows a fluctuation trend. In projected climate the number of rainfall events during low rainfall shows a decrease from the present condition in 2050 and 2080 summer and north east season.

4.1.4.5. Rainfall analysis of Northern high hills (AEU15) and climate change impacts in Kasaragod district

Major cropping system in this unit is mainly rubber based. Coconut based cropping system is the other major system followed by arecanut based cropping system. Banana based and rice-based cropping systems are also practiced in the AEU.

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

The monthly rainfall distribution of northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were analysed and presented in table 67.

Table 67. Monthly rainfall distribution of Northern high hills (AEU15) and the projected climate in Kasaragod district

Monthly Rainfall (mm)	2016	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	33.5	21.2	23.8	21.9	21.2	23.8	21.9
April	4.9	17.6	46.4	7.9	17.6	46.4	7.9
May	256.7	303	480.6	366.3	303	480.6	366.3
June	1316.8	1284.8	811.8	1074.8	1284.8	811.8	1074.8
July	1714.7	1694.6	1728.9	1654.2	1694.6	1728.9	1654.2
August	803.6	809.3	815.2	821.9	809.3	815.2	821.9
September	202.7	203.9	204.5	212.2	203.9	204.5	212.2
October	265.8	234.7	239.8	306.5	234.7	239.8	306.5
November	31.1	15.1	15.7	28.7	15.1	15.7	28.7
December	31.2	45.8	47.2	56.3	45.8	47.2	56.3
Total	**4661**	**4630**	**4413.9**	**4550.7**	**4630**	**4413.9**	**4550.7**

In the present condition June and July are the wettest months; having a rainfall of 1316.8 mm and 1714.7 mm. January and February are the months having lowest rainfall of 0 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 gets during January and February. According to RCP 4.5 the total rainfall shows a decrease from 2030 to 2050 and it increases in 2080. As per RCP 8.5 the total rainfall shows a decreasing trend from 2030 to 2050 and it increases in 2080. In projected climate there will be a drastic increase in rainfall distribution during April and May from the present state.

The monthly rainy days of northern high hills (AEU15) for the present and projected climate (RCP 4.5 and 8.5) were analysed and given in table 68.

Table 68. Monthly rainy days of Northern high hills (AEU 15) and the projected climate in Kasaragod district

Monthly Rainy days	2016	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	2	4	4	3	4	4	3
April	1	2	3	1	2	3	1
May	14	15	15	14	15	15	14
June	25	26	25	25	26	25	25
July	30	30	30	30	30	30	30
August	20	20	20	20	20	20	20
September	7	7	7	8	7	7	8
October	10	10	10	10	10	10	10
November	3	2	2	2	2	2	2
December	5	6	6	6	6	6	6
Total	**117**	**122**	**122**	**119**	**122**	**122**	**119**

In the current condition, June and July have the maximum number of rainy days and it is about 30 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 June and July and the minimum will be in January and February. The maximum rainy days will be 30days and the minimum will be 0 day. The projected climate shows an increasing trend in the annual rainy days of northern high hills (AEU15) from 2030 to 2050 and decreases in 2080. The annual rainy days of projected climate will be more as compared to the present condition.

The seasonal rainy days of northern high hills (AEU15) for the existing condition and projected climate were examined and represented in table 69.

Table 69. Seasonal rainy days of Northern high hills (AEU 15) and the projected climate in Kasaragod 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	0	0	17	295.1	82	4037.8	18	328.1
4.5	2030	0	0	21	341.8	83	3992.6	18	295.6
	2050	0	0	22	550.8	82	3560.4	18	302.7
	2080	0	0	18	396.1	83	3763.1	18	391.5
8.5	2030	0	0	21	341.8	83	3992.6	18	295.6
	2050	0	0	22	550.8	82	3560.4	18	302.7
	2080	0	0	18	396.1	83	3763.1	18	391.5

In the existing condition, the maximum number of rainy days occurs during south west monsoon time (82 days) followed by North East (18 days), summer season (17 days) and winter season (0 days). According to the projected climate the maximum number of rainy days will be occurring in south west monsoon followed by summer season. The minimum number of rainy days will be in winter. The projected climate shows an intensified rainfall in South West and there will be more rainfall in summer season as compare to the present condition.

4.1.4.5.2. Heavy rainfall events of northern high hills (AEU15) in Kasaragod 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 70.

Presently, the greater number of rainfall events occur during low rainfall and a smaller number of events during high rainfall. As per RCP 4.5 and 8.5 from 2050 to 2080 the number of rainfall events shows a decreasing trend in summer season. Comparing the present and projected climate there will be a slight variation in the number of rainfall events.

Table 70. Heavy rainfall events of Northern high hills (AEU 15) and the projected climate in Kasaragod district

Year	Season	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
		Days									
2016	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	4	2	0	0	9	4	1	1	0
	SW monsoon	19	21	16	5	5	17	21	16	2	6
	NE monsoon	7	1	0	0	1	7	1	0	0	1
	Total	**30**	**26**	**18**	**5**	**6**	**33**	**26**	**17**	**3**	**7**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	8	5	0	0	0	4	5	2	0	1
	SW monsoon	13	21	11	6	6	14	24	9	6	6
	NE monsoon	6	1	0	0	1	6	3	0	0	1
	Total	**27**	**27**	**11**	**6**	**7**	**24**	**32**	**11**	**6**	**8**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	9	3	1	0	0
	SW monsoon	11	19	13	6	8	12	23	16	4	5
	NE monsoon	6	1	0	0	1	5	1	0	0	1
	Total	**22**	**22**	**15**	**6**	**9**	**26**	**27**	**17**	**4**	**6**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	4	1	0	1	5	2	1	0	0
	SW monsoon	13	23	15	5	4	13	29	10	4	6
	NE monsoon	6	1	0	0	1	7	2	0	0	1
	Total	**24**	**28**	**16**	**5**	**6**	**25**	**33**	**11**	**4**	**7**

4.2. THE LENGTH OF GROWING PERIOD OF VARIOUS AEUS OF KANNUR, KASARAGOD, KOZHIKODE AND WAYANAD

The length of growing period of various AEUs of Kannur, Kasaragod, Kozhikode and Wayanad comprises northern Kerala is represented in table 71.

Table 71. The length of growing period of various AEUs of Kannur, Kasaragod, Kozhikode and Wayanad

LGP (weeks)	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
KANNUR							
AEU 2	25	23	21	22	22	23	22
AEU 7	25	22	21	23	20	21	20
AEU 11	23	21	22	19	20	40	19
AEU 13	22	22	41	20	24	41	24
AEU 15	24	23	26	21	27	23	21
KASARAGOD							
AEU 2	25	23	23	24	22	22	22
AEU 7	25	22	22	22	22	23	22
AEU 11	23	25	23	25	25	25	25
AEU 13	22	27	24	27	25	24	21
AEU 15	24	23	24	25	23	25	24
KOZHIKODE							
AEU 2	25	23	22	24	23	20	20
AEU 7	25	21	20	20	20	20	20
AEU 11	23	20	21	20	21	20	21
AEU 15	24	20	20	20	21	25	23
WAYANAD							
AEU 15	24	28	21	22	24	21	20
AEU 20	26	22	22	20	21	22	24
AEU 21	13	21	23	22	24	21	22

In Kannur district there are five agro ecological units comprising Northern Coastal Plain (AEU2), Kaipad lands (AEU8), Northern laterites (AEU11), Northern foot hills (AEU 13) and Northern High Hills (AEU 15). The length of growing period of these five AEUs under the present situation is having values 25, 25, 23, 22 and 24 respectively. Considering the projected climate of RCP 4.5 and RCP 8.5 by 2030, 2050 and 2080 there is a decrease in the length of growing period in AEU 2, AEU 7, AEU 11 and AEU 15. In the case of AEU 11 and AEU 13 there is a drastic increase in length of growing period in 2050 RCP 8.5 rest of the years shows a decrease in both RCPs.

In Kasaragod district, there are five agro ecological units such as Northern Coastal Plain (AEU2), Kaipad lands (AEU7), Northern Laterites (AEU11), Northern Foot hills (AEU13) and Northern High Hills (AEU 15) the length of growing period of these five AEUs under the present situation is 25, 25, 23, 22 and 24 weeks respectively. Comparing the present condition with the projected climate of RCP 4.5 and RCP 8.5 there is a decrease in length of growing period in all considered cases.

In Kozhikode district there is four agro ecological units comprises Northern coastal plain (AEU 2), Kaipad lands (AEU 7), Northern laterites (AEU 11) and Northern high hills (AEU 15). The length of growing period of these four AEUs under the present situation is 25, 25, 23 and 24 weeks respectively. While considering the projected climate of RCP 4.5 and RCP 8.5 there is a decreasing trend in length of growing period.

The Wayanad district have three agro ecological units including Northern high hills (AEU 15), Wayanad central plateau (AEU 20) and Wayanad eastern plateau (AEU 21). The length of growing period of these three AEUs under the present situation is 24, 26 and 13 weeks respectively. Under the projected climate of RCP 4.5 and RCP 8.5 there will be an increase in the length of growing period in AEU 15 in 2030 RCP 4.5 and AEU 20 show a decrease in the length of growing period and in case of AEU 21 there is an increase in length of growing period.

4.3. WATER BALANCE

4.3.1. Computed water balance of various AEUs in Kozhikode district

4.3.1.1 Monthly Potential evapotranspiration, Deficit and Surplus of Northern coastal plain (AEU2) in Kozhikode district

The monthly potential evapotranspiration of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 72.

Table 72. Monthly potential evapotranspiration of Northern coastal plain (AEU2) and the projected climate in Kozhikode district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	112	108	112	120	108	124	152
February	156	152	156	156	152	160	168
March	205	205	205	210	205	210	220
April	168	168	168	172	168	172	180
May	225	225	225	225	225	230	235
June	160	160	160	160	156	164	172
July	180	175	180	185	175	185	200
August	156	152	156	156	152	160	168
September	180	175	180	185	180	185	200
October	164	160	164	164	164	168	176
November	140	140	140	144	140	148	160
December	156	152	156	160	152	160	168
Total	**2002**	**1972**	**2002**	**2037**	**1977**	**2066**	**2199**

At the current situation, the monthly potential evapotranspiration is maximum in May (225 mm.) and the base value is 112 mm. in January. In projected climate based on RCP 4.5 and 8.5, every month show potential evapotranspiration greater than 150 mm. The maximum values will occur during May, March and September and the minimum will be in January. Totally there will be an increase in potential evapotranspiration in 2080 from the present condition.

The monthly Deficit of Northern coastal plain (AEU2) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 73.

Table 73. Monthly Deficit of Northern coastal plain (AEU2) and the projected climate in Kozhikode district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	112	107	111	118.9	107	123	151
February	156	152	156	156	152	160	168
March	199.7	192.6	199.7	197.2	199.1	207.1	199.7
April	98.3	130.3	98.3	83.6	104.9	108.3	161.8
May	0	26	0	57	51	33.4	80.1
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	1	9.1	1	5.2	9	6	0.7
September	83.5	90.6	83.5	93.2	93.5	93.7	141.7
October	51	93.7	51	39.1	41.7	46.8	56.7
November	116.3	98.9	116.3	117.4	112.6	115.8	117.3
December	125.1	82.7	125.1	148	139.4	146.6	129.1
Total	**942.9**	**982.9**	**941.9**	**1015.6**	**1010.2**	**1040.7**	**1206.1**

At present the maximum amount of deficit occurs during the month March and it is about 199.7 mm. and there is no deficit during May, June 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.

The monthly Surplus of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 74.

Table 75. Monthly Surplus of Northern coastal plain (AEU2) and the projected climate in Kozhikode district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	8.6	0	8.6	3.4	0	18.5	0
May	322.7	280.5	322.7	349.2	189.6	359.2	319.2
June	1216.4	1169.8	1216.4	1421.7	1127	1235.6	806.2
July	1275	1257.8	1275	1272	1262.5	1395	1418.8
August	200.5	256.3	200.5	279.5	254.9	319.6	332.6
September	188.3	294.7	188.3	267	260.4	249.5	110.3
October	37.3	0	37.3	49.9	44.7	60.5	122.5
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3248.8**	**3259.1**	**3248.8**	**3642.7**	**3139.1**	**3637.9**	**3109.6**

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 occurring in June 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 in RCP 4.5 2050, 2080 and RCP 8.5 2050.

4.3.1.2 Monthly Potential evapotranspiration, Deficit and Surplus of Kaipad lands (AEU7) in Kozhikode district

The monthly potential evapotranspiration of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 76.

Table 76. Monthly potential evapotranspiration of Kaipad lands (AEU7) and the projected climate in Kozhikode district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	147.2	112	140	140	112	124	156
February	163.2	152	160	160	156	156	168
March	213.6	205	210	210	205	205	220
April	166.9	168	172	172	168	168	180
May	187.3	225	230	230	225	225	235
June	138	160	164	164	160	160	172
July	181.7	175	185	185	175	180	200
August	151.6	156	160	160	156	156	168
September	178.9	175	185	185	180	180	200
October	127.2	164	168	168	164	164	176
November	131.2	140	148	148	140	144	160
December	131.2	156	160	160	156	156	168
Total	**1918**	**1988**	**2082**	**2082**	**1997**	**2018**	**2203**

At the present condition, the maximum potential evapotranspiration is occurring during March (213.6 mm.) and the minimum is 127.2 mm. in October. In projected climate based on RCP 4.5 and 8.5 the potential evapotranspiration 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 Kaipad lands (AEU7) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 77.

Table 77. Monthly Deficit of Kaipad lands (AEU7) and the projected climate in Kozhikode district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	145.9	103.1	135.2	111.6	109	121	154.8
February	163.2	152	160	160	156	156	168
March	197	199.1	201	195	194	181.6	189.5
April	139.5	147.6	157	146.9	154.1	157.3	165.5
May	30.6	35	48.8	87.5	37.7	34.1	59.4
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	6.9	14.8	7	7	11.1	10.4	0
September	140.8	87.7	145	145	136.2	135.7	141
October	30.3	51.4	91.1	99.3	50.8	108.9	102.8
November	99.5	107.2	115.5	124.9	105.9	102.7	124.8
December	123.5	140.4	153.1	124.3	148.2	120.6	132.5
Total	**1077.2**	**1038.3**	**1213.7**	**1201.5**	**1103**	**1128.3**	**1238.3**

In the current climate the maximum amount of deficit occurs in March (197 mm.) and there is no deficit happening in June and July. 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 Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 78.

Table 78. Monthly Surplus of Kaipad lands (AEU7) and the projected climate in Kozhikode district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	255.2	349.9	437.2	277.8	152.5	198.9	338.4
June	1277.5	991.1	1197.6	1076.7	1452.9	1271.4	907.5
July	1343.4	1769	1259.1	1292	1413.3	1372.2	1469.7
August	300.8	292.9	340	311.3	288.9	320.3	309.7
September	99.9	286.7	89.5	64.6	109.6	102.9	0
October	77.3	62.5	15.6	10	59.8	20.7	132.7
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3354.1**	**3752.1**	**3339**	**3032.4**	**3477**	**3286.4**	**3158**

In the present condition the surplus during January, February, March, April, November and December is zero. The maximum amount of surplus is occurring in July and it is about 1343.4 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 in 2030 RCP 4.5 and 2030 RCP 8.5.

4.3.1.3 Monthly Potential evapotranspiration, Deficit and Surplus of Northern laterites (AEU11) in Kozhikode 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 79.

Table 79. Monthly potential evapotranspiration of Northern laterites (AEU11) and the projected climate in Kozhikode district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	124	108	140	156	112	120	160
February	156	152	160	168	156	156	168
March	205	205	210	220	205	210	215
April	168	168	172	180	168	172	184
May	225	225	225	230	225	225	205
June	160	160	164	172	160	160	148
July	180	175	185	195	175	180	200
August	156	156	160	168	156	156	148
September	180	175	185	200	175	180	210
October	164	164	168	176	164	164	148
November	144	140	148	164	140	144	160
December	156	152	160	164	156	156	156
Total	**2018**	**1980**	**2077**	**2193**	**1992**	**2023**	**2102**

In the current condition, the maximum amount of potential evapotranspiration is occurring in May followed by March and it is about 225 mm. and 205 mm. and the minimum in January (124 mm.). In projected climate the maximum potential evapotranspiration will occur in March, May and July 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 80.

Table 80. Monthly Deficit of Northern laterites (AEU11) and the projected climate in Kozhikode district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	122	101.8	138.9	130.7	109.1	117.1	159
February	156	152	160	168	156	156	168
March	181.6	190.5	183.1	183.1	194.6	193.6	189.8
April	157.3	151.7	148.5	157.4	153	160.9	147.4
May	34.1	32.4	47.3	87.8	32.4	33.9	70.2
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	10.4	11.9	8	9.5	11.6	11.4	0.2
September	135.7	139.3	144.8	157.4	139.3	142.8	152.6
October	108.9	108.8	88.5	117.9	67.8	110.4	79.1
November	102.7	98.3	115.8	121.4	96.1	102.8	126
December	120.6	122.6	152.7	127.1	124.6	121.1	120.5
Total	**1129.3**	**1109.3**	**1187.6**	**1260.3**	**1084.5**	**1150**	**1212.8**

At present the maximum deficit occurs during the month March (181.6 mm.) and there is no deficit during June and July. 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. Annually the projected climate shows an increasing trend in deficit.

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 81.

Table 81. Monthly Surplus of Northern laterites (AEU11) and the projected climate in Kozhikode district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	198.9	167.3	236.9	223.7	296.1	191.5	310.7
June	1271.4	1040.6	1242.6	896.9	998.9	1059	797.6
July	1372.2	1213.4	1260	1247.4	1185.7	1444.3	1564.1
August	320.3	274.4	322.8	317.4	274.1	327.1	352.2
September	102.9	107.7	94.6	93.2	107.4	109	0
October	20.7	10.7	18.4	16.9	64	22.1	150.9
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3286.4**	**2814.1**	**3175.3**	**2795.5**	**2926.2**	**3153**	**3175.5**

Currently, there is surplus in all the months except January, February, March and April and the maximum amount of surplus is occurring in July (1372.2 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. Yearly surplus shows a decrease in projected climate.

4.3.1.4 Monthly Potential evapotranspiration, Deficit and Surplus of Northern high hills (AEU15) in Kozhikode 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 82.

Table 82. Monthly potential evapotranspiration of Northern high hills (AEU15) and the projected climate in Kozhikode district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	120	108	140	156	116	140	76
February	156	152	160	168	156	160	112
March	210	205	210	220	205	210	165
April	172	168	172	180	168	172	140
May	225	225	230	230	225	230	205
June	160	160	164	172	160	164	124
July	180	175	185	200	175	185	115
August	156	156	160	168	156	160	116
September	180	175	185	200	180	185	115
October	164	164	168	176	164	168	132
November	144	140	148	164	140	148	84
December	156	152	160	164	152	160	96
Total	**2023**	**1980**	**2082**	**2198**	**1997**	**2082**	**1480**

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At the present condition, the maximum potential evapotranspiration is during May (225 mm.) and the minimum is in January (120 mm.). In projected climate based on RCP 4.5 the annual potential evapotranspiration shows an increasing trend and in RCP 8.5 the annual potential evapotranspiration shows a decrease from 2050 to 2080. In projected climate the maximum values will occur in May, July and September and the minimum will be in January.

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 83.

Table 83. Monthly Deficit of Northern high hills (AEU15) and the projected climate in Kozhikode district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	124	115	123	139	115	123	139
February	152	148	152	140	148	152	156
March	181.2	178.8	181.2	173.1	178.8	181.2	183.1
April	121.6	146.4	121.6	156.1	146.4	121.6	164.1
May	47	26.3	47	27.6	26.3	47	29.6
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0.3
September	53.6	40.4	53.6	57	40.4	53.6	50
October	57.1	55.6	57.1	46.8	55.6	57.1	56.8
November	135.9	132.2	135.9	133	132.2	135.9	117
December	103.5	100.8	103.5	105.6	100.8	103.5	109.6
Total	**975.9**	**943.5**	**974.9**	**978.2**	**943.5**	**974.9**	**1005.5**

In the current climate the maximum amount of deficit occurs in March (181.2 mm.) and there is no deficit during June, July and August. 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 in 2080 RCP 4.5 and 2080 RCP 8.5.

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 84.

Table 84. Monthly Surplus of Northern high hills (AEU15) and the projected climate in Kozhikode district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	312.6	145.2	312.6	280.1	145.2	312.6	272.1
June	654.7	1081.4	654.7	810.8	1081.4	654.7	826.8
July	1701.1	1690.8	1701.1	1598.7	1690.8	1701.1	1618.7
August	514.9	513.3	514.9	525.2	513.3	514.9	516
September	83.8	88.5	83.8	75.2	88.5	83.8	83.2
October	121.7	121.3	121.7	196.9	121.3	121.7	189.3
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3388.8**	**3640.5**	**3388.8**	**3486.9**	**3640.5**	**3388.8**	**3506.1**

In the present condition the surplus during January, February, March, April, November and December is zero and the maximum amount of surplus is occurring in July (1701.1 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 in 2030 and 2080 RCP and in 2030 and 2080 RCP 8.5.

4.3.2. Computed water balance of various AEUs in Wayanad district

4.3.2.1 Monthly Potential evapotranspiration, Deficit and Surplus of Northern high hills (AEU15) in Wayanad 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 85.

Table 85. Monthly potential evapotranspiration of Northern high hills (AEU15) and the projected climate in Wayanad district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	72	68	76	96	68	72	80
February	104	100	112	124	100	108	116
March	155	150	165	185	150	170	180
April	132	124	140	156	124	140	144
May	200	195	200	210	195	200	205
June	120	116	124	148	116	128	136
July	110	105	115	135	110	115	120
August	112	108	116	140	108	116	124
September	110	105	115	125	105	115	120
October	128	120	132	148	124	132	140
November	80	76	84	108	80	84	88
December	92	88	96	104	88	92	100
Total	**1415**	**1355**	**1475**	**1679**	**1368**	**1472**	**1553**

At the current situation, the monthly potential evapotranspiration is maximum in May (200 mm.) and the base value is 72 mm. in January. In projected climate based on RCP 4.5 and 8.5, every month shows potential evapotranspiration greater than 100 mm except January, November and December. The maximum values will occur during May, October and June and the minimum will be in January, November 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 86.

Table 86. Monthly Deficit of Northern high hills (AEU15) and the projected climate in Wayanad district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	71.2	67	74.6	94.4	67	62.5	79
February	104	100	112	124	100	108	113.8
March	92.7	64.8	153.1	136.3	89.8	157.9	162.1
April	127.3	100.2	117.6	126.4	109.8	112.6	124.8
May	70.1	26.1	25.8	53.1	57.7	38.9	68.6
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	15.2	14.2	12.5	23.2	14.2	13	6.2
September	77.4	60.3	89.8	99.2	50.3	71.1	76
October	38.8	37.5	77.1	89.2	45.9	74.7	68.4
November	58	56.5	62.3	86.4	59.8	61.3	69.7
December	17	12.2	41	46.3	14.9	51	45.3
Total	**671.7**	**538.8**	**765.8**	**878.5**	**609.4**	**751**	**813.9**

At present the maximum amount of deficit occurs during the month April and it is about 127.3 mm. and there is no deficit during June 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 December.

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 87.

Table 87. Monthly Surplus of Northern high hills (AEU15) and the projected climate in Wayanad district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	106.3	157.9	176.7	154.7	183.8	92.5	139
June	898.1	734.4	659.9	671.6	934.1	422.8	660.3
July	1646.7	1573.6	1403.8	1331.8	1450.8	1191.2	1677.2
August	347.1	400.4	380.9	372.3	345.3	300	402.5
September	0	18.5	1	0	19.2	0	0
October	162.1	160.2	13.4	9.6	139.4	104.6	29.3
November	0	0	0	0	0	0	0
December	0	0	0	2.3	0	0	0
Total	**3160.3**	**3045**	**2635.7**	**2542.3**	**3072.6**	**2111.1**	**2908.3**

Currently, there is surplus during the months May, June, July, August and October whereas in remaining months the surplus is zero. The maximum amount of surplus is occurring in May and July. As per RCP 4.5 and 8.5, in projected climate the maximum surplus will occur during the month July.

4.3.2.2 Monthly Potential evapotranspiration, Deficit and Surplus of Wayanad central plateau (AEU20) in Wayanad district

The monthly potential evapotranspiration of Wayanad central plateau (AEU20) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 88.

Table 88. Monthly potential evapotranspiration of Wayanad central plateau (AEU20) and the projected climate in Wayanad district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	72	68	80	96	72	72	76
February	108	104	112	128	104	108	112
March	170	160	175	190	160	165	175
April	140	132	144	160	132	140	144
May	200	200	205	215	200	200	205
June	128	120	140	152	120	128	132
July	115	110	120	140	110	115	120
August	116	112	124	144	112	116	124
September	115	110	120	135	110	110	120
October	132	128	140	152	128	132	140
November	84	80	92	108	80	80	84
December	92	88	96	108	92	92	96
Total	**1472**	**1412**	**1548**	**1728**	**1420**	**1458**	**1528**

At the present condition, the maximum potential evapotranspiration is occurring during May (200 mm.) and the minimum is 72 mm. in January. In projected climate based on RCP 4.5 and 8.5 the potential evapotranspiration shows an increasing trend from the present value. The maximum values will occur in May and the minimum will be in January.

The monthly Deficit of Wayanad central plateau (AEU20) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 89.

Table 89. Monthly Deficit of Wayanad central plateau (AEU20) and the projected climate in Wayanad district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	63.5	66.5	70.2	92.2	62.5	62.6	75.1
February	108	104	112	128	104	108	108.4
March	157.9	147.5	163.7	179.5	149.2	153.5	149.1
April	112.6	114.4	93.1	126.5	109.1	90.9	103.1
May	38.9	25.6	14.8	29.4	28.4	8.2	52.2
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	13	12.2	14.5	19.6	12.2	13.3	3.8
September	71.1	64.9	85.9	90	64.6	65	82.3
October	74.7	72.3	77.7	86.8	72	72.7	79.1
November	61.3	58.4	66	78	58.4	57.1	58.4
December	51	49.7	56.9	71.3	49.4	52.5	40.4
Total	**752**	**715.5**	**754.8**	**901.3**	**709.8**	**683.8**	**751.9**

In the current climate the maximum amount of deficit occurs in March (157.9 mm.) and there is no deficit happening in June and July. 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.

The monthly Surplus of Wayanad central plateau (AEU20) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 90.

Table 90. Monthly Surplus of Wayanad central plateau (AEU20) and the projected climate in Wayanad district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	92.5	91.3	116.4	136	144.4	124.3	79
June	422.8	493.1	488.9	408	533.6	462.8	577
July	1191.2	1114.7	1190.7	1159	1076.3	1174	1233
August	300	300.4	316.6	259.2	296.8	266.7	334
September	0	0	0	0	0	0	5.4
October	104.6	101.8	126.6	114.6	103.8	116.8	160.5
November	0	0	0	0	0.1	0	0
December	0	0	0	0	0	0	0
Total	**2111.1**	**2101.3**	**2239.2**	**2076.8**	**2155**	**2144.6**	**2388.9**

In the present condition the surplus during January, February, March, April, September, November and December is zero. The maximum amount of surplus is occurring in July and it is about 300 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. Annually the amount of deficit will be higher in projected climate than the present condition.

4.3.2.3 Monthly Potential evapotranspiration, Deficit and Surplus of Wayanad eastern plateau (AEU21) in Wayanad district

The monthly potential evapotranspiration of Wayanad eastern plateau (AEU21) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 91.

Table 91. Monthly potential evapotranspiration of Wayanad eastern plateau (AEU21) and the projected climate in Wayanad district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	72	68	80	96	68	80	96
February	108	104	112	132	104	112	132
March	165	155	175	190	160	175	190
April	140	132	144	160	132	144	160
May	200	200	205	215	200	205	215
June	128	120	140	152	120	140	152
July	115	110	120	140	110	120	140
August	116	112	124	144	112	124	144
September	110	110	115	135	110	115	135
October	132	124	140	152	128	140	152
November	80	76	88	108	80	88	108
December	92	88	92	104	88	92	104
Total	**1458**	**1399**	**1535**	**1728**	**1412**	**1535**	**1728**

In the current condition, the maximum amount of potential evapotranspiration is occurring in May followed by March and it is about 200 mm and 165 mm and the minimum in January (72 mm.). In projected climate the maximum potential evapotranspiration will occur in May and March and the minimum will occur during January, November and December. In the yearly value it shows an increasing trend compared to the present condition.

The monthly Deficit of Wayanad eastern plateau (AEU21) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 92.

Table 92. Monthly Deficit of Wayanad eastern plateau (AEU21) and the projected climate in Wayanad district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	63.5	67	70.3	92	58.5	70.3	92
February	108	104	112	132	104	112	132
March	153.5	138.7	166.6	185.8	149.3	166.6	185.8
April	90.9	114.5	114.5	126.5	120	114.5	126.5
May	8.2	48.6	24.5	42.4	10.6	24.5	42.4
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	13.3	15.2	16.3	21.3	15.2	16.3	21.3
September	65	64.9	56.3	68.2	64.2	56.3	68.2
October	72.7	70	82.4	91.4	70.1	82.4	91.4
November	57.1	55.5	78.4	94.4	57.2	78.4	94.4
December	52.5	48.8	50.3	63.2	48.1	50.3	63.2
Total	**684.7**	**727.2**	**771.6**	**917.2**	**697.2**	**771.6**	**917.2**

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At present the maximum deficit occurs during the month March (153.5 mm.) and there is no deficit during June and July. 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. Annually the projected climate shows an increasing trend in deficit.

The monthly Surplus of Wayanad eastern plateau (AEU21) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 93.

Table 93. Monthly Surplus of Wayanad eastern plateau (AEU21) and the projected climate in Wayanad district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	124.3	69.3	163.1	35.2	79.6	163.1	35.2
June	462.8	371.1	428.5	494.6	525.5	428.5	494.6
July	1174	1102.3	1118	1061	1123	1118	1061
August	266.7	267.9	312.5	294.3	264	312.5	294.3
September	0	0	22.3	19.9	0	22.3	19.9
October	116.8	92.6	72	64.2	115.9	72	64.2
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**2144.6**	**1903.2**	**2116.4**	**1969.2**	**2108**	**2116.4**	**1969.2**

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Currently, there is surplus in all the months except January, February, March, April, September, November and December and the maximum amount of surplus occur in July (1174 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. Yearly surplus shows a decrease in projected climate.

4.3.3. Computed water balance of various AEUs in Kannur district

4.3.3.1. Monthly Potential evapotranspiration, Deficit and Surplus of Northern coastal plain (AEU2) in Kannur district

The monthly potential evapotranspiration of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 94.

Table 94. Monthly potential evapotranspiration of Northern coastal plain (AEU2) and the projected climate in Kannur district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	149.2	112	116	160	111.2	106.8	113.2
February	165.6	152	156	168	155.2	117.2	122.4
March	219.4	205	205	215	206.5	152.5	159.5
April	172.3	168	172	184	169.2	124.4	130.8
May	192.3	225	225	205	210	167	173
June	139.6	160	160	148	160	119.6	125.2
July	181	180	180	200	180	139	145.5
August	151.3	156	156	152	152	117.2	122.4
September	180.5	180	185	210	180	139	146
October	130.8	164	164	148	164	121.6	126.8
November	133.2	140	144	160	140	111.2	116.8
December	133.2	156	156	156	156	117.6	123.2
Total	**1948.4**	**1998**	**2019**	**2106**	**1984.1**	**1533.1**	**1604.8**

At the current situation, the monthly potential evapotranspiration is maximum in March (219.4 mm.) and the base value is 130.8 mm. in October. In projected climate based on RCP 4.5 and 8.5, every month shows potential evapotranspiration greater than 100 mm. The maximum values will occur during May and the minimum will be in January. Totally there will be an increase in potential evapotranspiration during projected climate from the present condition except 2050 and 2080 (RCP 8.5).

The monthly Deficit of Northern coastal plain (AEU2) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 95.

Table 95. Monthly Deficit of Northern coastal plain (AEU2) and the projected climate in Kannur district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	149.1	111	115	156.5	110.2	105.8	112.2
February	165.6	152	156	168	155.2	117.2	122.4
March	217	205	204.6	199.9	206.5	152.5	151.7
April	120.3	124.4	162.6	160.7	141.5	123.9	127
May	55.3	36.5	74.8	26.4	59.6	49.4	52.1
June	9.7	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	22.4	1.2	11.5	7.5	12	1.7	4.5
September	42.7	94.8	104	118	101	72.9	114.7
October	0	48.4	111.1	39.4	110.3	31.1	64.5
November	106.9	119.4	114.8	138	109.6	84.5	79.3
December	131	133.9	120.8	135	121.4	104.3	88.2
Total	**1020**	**1026.6**	**1175.2**	**1149.4**	**1127.3**	**843.3**	**916.6**

At present the maximum amount of deficit occurs during the month February and it is about 165.6 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 an amount of deficit except in June and July. Comparing the present and future climate the deficit shows a decreasing trend during the months of June and August and there is a drastic increase in month of October.

The monthly Surplus of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 96.

Table 96. Monthly Surplus of Northern coastal plain (AEU2) and the projected climate in Kannur district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	41.6	38	0	0	0	0	0
May	157.4	126.2	308.2	295.4	367.6	320.3	243.6
June	365.7	1700	1516	1112.5	1072.2	1113.5	1091
July	983.7	1238.5	1230.2	1245.5	1225.7	1407.3	1353.3
August	530.9	212.3	298.6	324.9	281.9	393.2	349.4
September	48.7	178.7	244.2	236.9	261.4	251.5	115.6
October	318.4	44	0	47.9	0	74.7	19.4
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**2446.4**	**3537.7**	**3597.2**	**3263.1**	**3208.8**	**3560.5**	**3172.3**

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 occurring in July and August. As per RCP 4.5 and 8.5, in projected climate the maximum surplus will occur during the month of June in 2030 and 2050 of RCP 4.5 and the rest in July. In projected climate the month in which surplus begins will shift from April to May and the ending month will shift from October to September in 2050 (RCP 4.5) and 2030 (RCP 8.5).

4.3.3.2. Monthly Potential evapotranspiration, Deficit and Surplus of Kaipad lands (AEU7) in Kannur district

The monthly potential evapotranspiration of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 97.

Table 97. Monthly potential evapotranspiration of Kaipad lands (AEU7) and the projected climate in Kannur district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	147.2	112	116	140	112	140	156
February	163.2	152	156	160	156	160	168
March	213.6	205	205	210	205	210	220
April	166.9	168	172	172	168	172	180
May	187.3	225	225	230	225	230	235
June	138	160	160	164	160	168	172
July	181.7	180	185	190	180	190	200
August	151.6	152	156	160	156	160	168
September	178.9	180	185	185	180	190	200
October	127.2	164	164	168	164	168	176
November	131.2	140	144	148	144	152	160
December	131.2	156	160	164	156	164	168
Total	**1918**	**1994**	**2028**	**2091**	**2006**	**2104**	**2203**

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In the present condition, the maximum potential evapotranspiration is occurring during March (213.6 mm.) and the minimum is 127.2 mm. in October. In projected climate based on RCP 4.5 and 8.5 the potential evapotranspiration shows an increasing trend from the present value in the months May to December. The maximum values will occur in March and May months and the minimum will be in January.

The monthly Deficit of Kaipad lands (AEU7) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 98.

Table 98. Monthly Deficit of Kaipad lands (AEU7) and the projected climate in Kannur district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	144.5	111	112.3	134.8	109.2	138.9	155
February	163.2	152	156	160	156	160	168
March	213.6	205	205	201.2	205	210	215.3
April	135.2	124	140.3	145.8	155.3	166.7	166.3
May	67.9	74.2	78.5	7	68.7	54.5	52.6
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	8.6	0.9	9.2	7.2	10.2	7	12.4
September	98.4	89.4	101.2	99.4	98.2	102.3	158.7
October	70.8	45.8	107.6	47	107.1	51.6	99.7
November	103.5	121.2	116.3	127.5	115.2	127	121.4
December	94.7	143	123.5	142.6	120	151.6	131.7
Total	**1100.4**	**1066.5**	**1149.9**	**1072.5**	**1144.9**	**1169.6**	**1281.1**

Presently, the maximum amount of deficit occurs in March (213.6 mm.) and there is no deficit happening in June, July. 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.

The monthly Surplus of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 99.

Table 99. Monthly Surplus of Kaipad lands (AEU7) and the projected climate in Kannur district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	1.5	0	0	0	0	0
May	186.4	127.5	159.3	350.2	263.1	249.8	192.7
June	1230.6	1198.1	1208.6	1005.9	1269.8	1043.2	950.8
July	1267.8	1272.9	1264.5	1288.2	1261.6	1394.6	1387.2
August	308.4	221.1	304.9	325.7	287.3	382	350.3
September	252.1	178.7	248.5	245	262.2	229	97.5
October	0	45.4	0	39.7	0	54.3	16.9
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3245.3**	**3045.2**	**3185.8**	**3254.7**	**3344**	**3352.9**	**2995.4**

At the current situation, the surplus during January, February, March and April is zero. The maximum amount of surplus is occurring in July and it is about 1267.8 mm. As per RCP 4.5 and 8.5 in the projected climate, during the months January, February, March, April, November and December the amount of surplus will be zero except month of October in 2030, 2080 (RCP 4.5) and 2050 and 2080 (RCP 8.5). The maximum amount of surplus will occur in July as per projected climate. Annually the amount of deficit will be higher in projected climate than the present condition in 2080 (RCP 4.5) and 2030, 2050 (RCP 8.5).

4.3.3.3. Monthly Potential evapotranspiration, Deficit and Surplus of Northern laterites (AEU11) in Kannur 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 100.

Table 100. Monthly potential evapotranspiration of Northern laterites (AEU11) and the projected climate in Kannur district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	140	112	140	152	112	140	152
February	160	152	160	168	152	160	168
March	210	205	210	220	205	210	220
April	172	168	172	180	168	172	180
May	230	225	230	235	225	230	235
June	164	160	164	172	156	164	172
July	185	180	185	200	180	185	200
August	160	156	160	168	156	160	168
September	185	180	185	200	180	185	200
October	168	164	168	176	164	168	176
November	148	140	148	160	140	148	160
December	160	156	160	168	156	160	168
Total	**2082**	**1998**	**2082**	**2199**	**1994**	**2082**	**2199**

In the current condition, the maximum amount of potential evapotranspiration is occurring in May followed by March and it is about 230 mm and 210 mm and the minimum in January (140 mm.). In projected climate the maximum potential evapotranspiration will occur in May and the minimum will occur during January. In the yearly value it shows an increasing trend.

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 101.

Table 101. Monthly Deficit of Northern laterites (AEU11) and the projected climate in Kannur district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	140	111	139	151	111	139	151
February	160	152	160	168	152	160	168
March	210	205	210	212.2	184.6	210	212.2
April	143.7	140.3	143.7	179.8	155.9	143.7	179.8
May	56.4	65.6	56.4	78	70.4	56.4	78
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	7.5	10.2	7.5	4.8	19.1	7.5	4.8
September	99.7	98.2	99.7	150.8	97.6	99.7	150.8
October	51.5	107.5	51.5	106.9	121.2	51.5	106.9
November	121.3	109.6	121.3	148.9	109.6	121.3	148.9
December	146.7	121.4	146.7	162.4	121.4	146.7	162.4
Total	**1136.8**	**1120.8**	**1135.8**	**1362.8**	**1142.8**	**1135.8**	**1362.8**

At present, the maximum deficit occurs during the month of March (210 mm.) and there is no deficit during June and July. August shows an amount of deficit below 10 mm. As per RCP 4.5 and 8.5 in the projected climate every month shows a deficit except in 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 in RCP 4.5 and shows a decrease from 2030 to 2050 and increases in 2080.

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 102.

Table 102. Monthly Surplus of Northern laterites (AEU11) and the projected climate in Kannur district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	122.3	355.8	122.3	148.1	373.2	122.3	148.1
June	1186.4	1072.2	1186.4	885	1096.5	1186.4	885
July	1161	1040.8	1161	1110.1	1064.6	1161	1110.1
August	565.2	463.8	565.2	415.5	411.2	565.2	415.5
September	140.7	124.1	140.7	0	123.5	140.7	0
October	138.4	0	138.4	82.8	145.4	138.4	82.8
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3314**	**3056.7**	**3314**	**2641.5**	**3214.4**	**3314**	**2641.5**

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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 June (1186.4 mm.). As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July, August and September whereas in remaining months the surplus will be zero. In the projected climate the maximum surplus will occur during the month of June. Yearly surplus shows an increasing trend in projected climate from 2030 to 2050 and 2080.

4.3.3.3. Monthly Potential evapotranspiration, Deficit and Surplus of Northern foot hills (AEU13) in Kannur district

The monthly potential evapotranspiration of Northern foot hills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 103.

Table 103. Monthly potential evapotranspiration of Northern foot hills (AEU13) and the projected climate in Kannur district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	112	112	124	144	144	140	96
February	152	152	156	160	160	160	132
March	205	205	205	210	210	210	190
April	168	168	168	172	172	172	160
May	225	225	225	230	230	230	215
June	160	160	164	164	164	164	152
July	175	175	180	185	185	185	140
August	156	156	156	160	160	160	144
September	175	175	180	185	185	185	135
October	164	164	164	168	168	168	152
November	136	136	144	144	144	148	108
December	148	148	152	156	156	156	104
Total	**1976**	**1976**	**2018**	**2078**	**2078**	**2078**	**1728**

At the current situation, the maximum potential evapotranspiration is during May (225 mm.) and the minimum is in January (112 mm.). In the projected climate based on RCP 4.5 and 8.5 the annual potential evapotranspiration shows an increasing trend in RCP 4.5 and a decreasing trend in 2080 (RCP 8.5). In the projected climate the maximum values will occur in March and May and the minimum will be in January and November.

The monthly Deficit of Northern foot hills (AEU13) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 104.

Table 104. Monthly Deficit of Northern foot hills (AEU13) and the projected climate in Kannur district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	112	111	123	141.2	141.2	139	95
February	152	152	156	160	160	160	128.4
March	201.6	175.6	202	190.6	190.6	207	164.6
April	87.1	145.7	79.7	148.5	148.5	82.7	119.4
May	23.8	55.8	25.2	52.1	52.1	26.2	56.7
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	1	29	0	1.1	1.1	0.1	7.8
September	95	65.4	126.8	134.2	134.2	131.7	98.4
October	56.6	54.1	96.7	94.7	94.7	99.7	91.7
November	122.3	108.5	130.9	111.4	111.4	134.9	76.7
December	113	128.5	115.8	129.3	129.3	119.8	54.3
Total	**964.4**	**1025.6**	**1056.1**	**1163.1**	**1163.1**	**1101.1**	**893**

In the current climate the maximum amount of deficit occurs in March (201.6 mm.) and there is no deficit during June and July. August have a deficit below 10 mm. In the projected climate as per RCP 4.5 and 8.5 the maximum deficit occurs in March whereas in June and July the deficit will be zero. In the projected climate the yearly deficit shows an increasing trend from the current condition in RCP 4.5 and a decreasing tern in RCP 8.5.

The monthly Surplus of Northern foot hills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 105.

Table 105. Monthly Surplus of Northern foot hills (AEU13) and the projected climate in Kannur district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	7.3	0	11.7	0	0	10.7	0
May	209.7	143.8	207.8	150.3	150.3	203.8	73.9
June	1158.3	787	1335.1	1439.8	1439.8	1335.1	531.8
July	1551.3	1563.1	1606.9	1525.2	1525.2	1601.9	1136.5
August	379.5	403.6	319.6	316.3	316.3	316.6	291.7
September	18.2	122.3	0.7	125.8	125.8	0	5.5
October	176.9	44.6	91.9	27	27	90.6	156.2
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3501.2**	**3064.4**	**3573.7**	**3584.4**	**3584.4**	**3558.7**	**2195.6**

In the present condition the surplus during January, February, March, November and December is zero and the maximum amount of surplus is occurring in July (1551.3 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 except in the projections 2050 (RCP 4.5 and 8.5) and the maximum amount of surplus will be in July. Projected climate shows an increasing trend in annual surplus from the current condition except in 2030 (RCP 4.5) and 2080 (RCP 8.5).

4.3.3.4. Monthly Potential evapotranspiration, Deficit and Surplus of Northern high hills (AEU15) in Kannur 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 106.

Table 106. Monthly potential evapotranspiration of Northern high hills (AEU15) and the projected climate in Kannur district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	140	116	116	156	116	140	152
February	160	152	152	168	148	156	164
March	210	205	205	220	200	205	220
April	172	168	168	180	168	172	180
May	230	225	225	230	220	215	230
June	164	160	160	172	160	180	172
July	185	175	175	195	175	205	195
August	160	156	156	168	152	144	168
September	185	175	175	200	155	200	190
October	168	164	164	176	160	140	172
November	148	140	140	160	128	148	160
December	156	148	148	164	144	148	156
Total	**2078**	**1984**	**1984**	**2189**	**1926**	**2053**	**2159**

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At the present condition, the maximum potential evapotranspiration is during May (230 mm.) and the minimum is in January (140 mm.). In projected climate based on RCP 4.5 and 8.5 the annual potential evapotranspiration shows an increasing trend. In projected climate the maximum values will occur in May and the minimum will be in November and January except in RCP 8.5 (October and January in 2050, December and January in 2080).

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 107.

Table 107. Monthly Deficit of Northern high hills (AEU15) and the projected climate in Kannur district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	140	115	115	155	115	139	151
February	160	152	152	168	148	156	164
March	207	194.6	194.6	193.9	161.3	192	202.9
April	82.7	125.9	125.9	153.6	123.5	143.6	163.5
May	26.2	21.3	21.3	41.6	0	11.6	40
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	0.1	7.3	7.3	2.9	24.7	1.6	0
September	131.7	124.5	124.5	153.5	56.6	57.9	132
October	99.7	97.9	97.9	54.7	58.1	47.5	69
November	134.9	113.1	113.1	134.5	118.4	114.4	140
December	119.8	117.3	117.3	122.9	57.6	81.5	88.8
Total	**1102.1**	**1068.9**	**1068.9**	**1180.6**	**863.2**	**945.1**	**1151.2**

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In the current condition the maximum amount of deficit occurs in March (207 mm.) and there is no deficit during June and July. August 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 and July the deficit will be zero. In projected climate the yearly deficit is higher than the present value in 2080 RCP 4.5 and 2080 RCP 8.5.

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 108.

Table 108. Monthly Surplus of Southern high hills (AEU15) and the projected climate in Kannur district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	10.7	0	0	0	0	0	0
May	203.8	199.7	199.7	326	244.3	196.7	310.4
June	1335.1	853.1	853.1	858	869.6	870.8	1079.6
July	1601.9	1608.3	1608.3	1569.6	1595.1	1656.6	1577.2
August	316.6	319.8	319.8	605.9	523.3	515.4	469.1
September	0	0	0	0	91.7	97.5	34.2
October	90.6	126.1	126.1	199.7	128	202.3	228.1
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3558.7**	**3107**	**3107**	**3559.2**	**3452**	**3539.3**	**3698.6**

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In the present condition, the surplus during January, February, March, September, November and December is zero and the maximum amount of surplus is occurring in July (1601.9 mm.). As per RCP 4.5 the projected climate, during the months January, February, March, April, September, November and December the amount of surplus will be zero and the maximum amount of surplus will be in July and according to RCP 8.5 there will be zero surplus in January, February, March, April, November and December and the maximum amount of surplus will be in July. In the projected climate the annual surplus will be higher than the present value in 2080 RCP 4.5 and 2030, 2050 and 2080 RCP 8.5.

4.3.4. Computed water balance of various AEUs in Kasaragod district

4.3.4.1 Monthly Potential evapotranspiration, Deficit and Surplus of Northern coastal plain (AEU2) in Kasaragod district

The monthly potential evapotranspiration of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 109.

Table 109. Monthly potential evapotranspiration of Northern coastal plain (AEU2) and the projected climate in Kasaragod district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	124	112	124	140	148	140	152
February	152	148	152	152	156	152	164
March	200	195	200	200	205	205	215
April	168	164	168	168	176	168	176
May	225	220	225	225	195	225	230
June	160	156	160	164	128	160	172
July	175	160	175	180	190	180	195
August	156	152	156	156	116	156	164
September	175	155	175	175	200	175	190
October	164	160	164	164	140	164	172
November	144	140	144	148	144	148	160
December	152	148	152	152	152	152	160
Total	**1995**	**1910**	**1995**	**2024**	**1950**	**2025**	**2150**

At the current situation, the monthly potential evapotranspiration is maximum in May (225 mm.) and the base value is 124 mm. in January. In the projected climate the maximum values will occur during May and the minimum will be in January. Totally there will be an increase in potential evapotranspiration during projected climate from the present condition in 2080 (RCP 4.5) and in 2050 and 2080 (RCP 8.5).

The monthly Deficit of Northern coastal plain (AEU2) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 110.

Table 110. Monthly Deficit of Northern coastal plain (AEU2) and the projected climate in Kasaragod district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	124	111	123	139	147	139	151
February	152	148	152	152	156	152	164
March	183.3	151.9	183.3	173.5	188.2	179.4	197.8
April	160.1	156.5	160.1	146.7	174.6	165.8	161.6
May	33.9	61.6	33.9	47.2	34.5	23.3	44.1
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0
September	55.3	41.3	55.3	55.5	69.7	56.4	101.2
October	56.6	47.2	56.6	56.3	36.6	51.1	65.1
November	137.1	120.4	137.1	138.6	126.8	131.9	134.4
December	116.5	122.8	116.5	114.2	122.6	120.8	110
Total	**1018.8**	**960.7**	**1017.8**	**1023**	**1056**	**1019.7**	**1129.2**

At present the maximum amount of deficit occurs during the month March and it is about 183.3 mm. and there is no deficit during June, July and August. As per RCP 4.5 and 8.5 in projected climate all the months will shows an amount of deficit except in June, July and August. Comparing the present and future climate during the months January and March there will be a drastic increase in the deficit.

The monthly Surplus of Northern coastal plain (AEU2) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 111.

Table 111. Monthly Surplus of Northern coastal plain (AEU2) and the projected climate in Kasaragod district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	125.8	137.4	125.8	190.1	139.3	175.1	206.1
June	1018.6	948.5	1018.6	756.6	1231.3	1228.2	862.8
July	1720.9	1558.2	1720.9	1686.1	1517.9	1473.2	1677.6
August	508.8	442.8	508.8	523.6	551.4	522.8	619.8
September	73.5	79.9	73.5	75	68.1	73.7	177.8
October	94.7	115.2	94.7	99.8	126.6	118.9	154.3
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3542.3**	**3282**	**3542.3**	**3331.2**	**3634.6**	**3591.9**	**3698.4**

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 occurring in June and July. As per RCP 4.5 and 8.5, in projected climate the maximum surplus will occur during the month July.

4.3.4.2 Monthly Potential evapotranspiration, Deficit and Surplus of Kaipad lands (AEU7) in Kasaragod district

The monthly potential evapotranspiration of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 112.

Table 112. Monthly potential evapotranspiration of Kaipad lands (AEU9) and the projected climate in Kasaragod district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	147.2	108	116	140	108	116	140
February	163.2	152	156	160	152	156	160
March	213.6	200	205	210	200	205	210
April	166.9	168	168	172	168	168	172
May	187.3	225	225	230	225	225	230
June	138	160	160	164	160	160	164
July	181.7	180	180	185	180	180	185
August	151.6	152	156	160	152	156	160
September	178.9	175	180	185	175	180	185
October	127.2	160	164	168	160	164	168
November	131.2	140	144	148	140	144	148
December	131.2	156	160	164	156	160	164
Total	**1918**	**1976**	**2014**	**2086**	**1976**	**2014**	**2086**

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At the present condition, the maximum potential evapotranspiration occurs during March (213.6 mm.) and the minimum is 127.2 mm. in October. In projected climate based on RCP 4.5 and 8.5 the potential evapotranspiration shows an increasing trend from the present value. The maximum values will occur in March and May and the minimum will be in January.

The monthly Deficit of Kaipad lands (AEU7) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 113.

Table 113. Monthly Deficit of Kaipad lands (AEU7) and the projected climate in Kasaragod district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	147.2	107	115	127.2	107	115	127.2
February	163.2	152	156	160	152	156	160
March	213	200	199.9	204.3	200	199.9	204.3
April	76.4	152.2	131	154.7	152.2	131	154.7
May	1	16.4	71.6	41.7	16.4	71.6	41.7
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	60.5	0.2	0.8	0.2	0.2	0.8	0.2
September	21.2	75	76.9	77.7	75	76.9	77.7
October	83.6	37	53.6	54.9	37	53.6	54.9
November	83.2	120.3	125.3	129.2	120.3	125.3	129.2
December	129.2	125.7	129.8	130.4	125.7	129.8	130.4
Total	**978.5**	**985.8**	**1059.9**	**1080.3**	**985.8**	**1059.9**	**1080.3**

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In the current climate, the maximum amount of deficit occurs in March (213 mm.) and there is no deficit happening in June and July. May 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 May, September and November in projected climate there will be an increase in deficit compared to the present climate and in October there is a decrease in the deficit value.

The monthly Surplus of Kaipad lands (AEU7) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 114.

Table 114. Monthly Surplus of Kaipad lands (AEU7) and the projected climate in Kasaragod district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	27.6	0	0	0	0	0	0
May	620	315	507.2	270	315	507.2	270
June	1693.2	1418.3	910	1056.3	1418.3	910	1056.3
July	958.3	1317	1443.9	1451	1317	1443.9	1451
August	30.9	235.7	298	317.7	235.7	298	317.7
September	225	173.2	146.9	143.1	173.2	146.9	143.1
October	0	46.1	53.2	54.2	46.1	53.2	54.2
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3555**	**3505.3**	**3359.2**	**3292.3**	**3505.3**	**3359.2**	**3292.3**

In the present condition the surplus during January, February and March is zero. The maximum amount of surplus is occurring in June and it is about 1693.2 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 except in June in 2030 RCP 4.5. Annually the amount of deficit will be lesser in projected climate than the present condition.

4.3.4.3 Monthly Potential evapotranspiration, Deficit and Surplus of Northern laterites (AEU11) in Kasaragod 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 115.

Table 115. Monthly potential evapotranspiration of Northern laterites (AEU11) and the projected climate in Kasaragod district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	112	108	112	124	108	120	148
February	144	140	144	152	140	148	160
March	195	190	195	200	190	200	210
April	160	156	160	164	160	164	176
May	220	215	220	220	215	220	225
June	156	152	156	156	152	156	168
July	150	145	150	160	145	170	190
August	148	144	148	152	144	152	160
September	140	135	140	150	135	150	180
October	156	152	156	160	156	160	168
November	128	120	128	140	120	140	156
December	144	140	144	148	140	148	156
Total	**1853**	**1797**	**1853**	**1926**	**1805**	**1928**	**2097**

In the current condition, the maximum amount of potential evapotranspiration occurs in May followed by March and it is about 220 mm and 195 mm and the minimum in January (112 mm.). In projected climate the maximum potential evapotranspiration will occur in May and the minimum will occur during January. In the yearly value it shows an increasing trend compared to the present condition except in 2030 RCP 4.5.

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 116.

Table 116. Monthly Deficit of Northern laterites (AEU11) and the projected climate in Kasaragod district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	112	107	111	123	107	119	147
February	144	140	144	152	140	148	160
March	150.1	133.9	150.1	167.3	140.8	167	177.5
April	153.7	154.4	153.7	137.6	153.7	145.3	147
May	49.3	16.3	49.3	46.7	74	30	33.6
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	0	0	0	0	0	0	1.4
September	70.6	13.6	70.6	76.6	13.6	76.6	94.9
October	55.4	51.3	55.4	56.6	53	56.8	59.8
November	118.1	112.4	118.1	131.6	112	130	118.6
December	96.9	99.4	96.9	84.1	98.9	102.8	114
Total	**950.1**	**828.3**	**949.1**	**975.5**	**893**	**975.5**	**1053.8**

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At present the maximum deficit occurs during the month April (153.7 mm.) and there is no deficit during June, July 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 the projected climate April will be the month having maximum deficit except in 2080 (RCP 4.5) and 2050 and 2080 (RCP 8.5) whereas August (2080 RCP 8.5) shows a deficit below 10 mm. Annually the projected climate shows an increase in the deficit in 2080 (RCP 4.5) and in RCP 8.5.

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 117.

Table 117. Monthly Surplus of Northern laterites (AEU11) and the projected climate in Kasaragod district

Surplus (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	0	0	0	0	0
March	0	0.4	0	0	0	0	0
April	0	0	0	0	0	0	0
May	156.2	133.9	156.2	191.8	164.9	166.7	317.7
June	1352.8	1104.5	1352.8	841.2	1074.7	1226.1	943.5
July	1712.8	1713.3	1712.8	1988.3	1759.2	1786.8	1829
August	533.8	533.8	533.8	535.1	551.8	533.6	503.4
September	71.3	147.2	71.3	72.7	147.5	73.5	12.8
October	140.7	122.1	140.7	136.7	121.1	134.2	207.6
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3967.6**	**3755.2**	**3967.6**	**3765.8**	**3819.2**	**3920.9**	**3814**

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

4.3.4.4. Monthly Potential evapotranspiration, Deficit and Surplus of Northern foothills (AEU13) in Kasaragod 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 118.

Table 118. Monthly potential evapotranspiration of Northern foothills (AEU13) and the projected climate in Kasaragod district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	104	104	108	120	108	124	148
February	128	128	140	124	140	152	160
March	185	185	190	185	190	205	210
April	156	156	160	160	160	168	176
May	210	210	215	205	215	225	225
June	148	148	152	176	152	160	164
July	135	135	140	195	140	180	185
August	140	140	144	124	144	156	160
September	125	125	130	190	135	175	180
October	148	148	152	116	156	164	168
November	112	112	120	160	120	144	152
December	112	112	120	140	120	148	152
Total	**1703**	**1703**	**1771**	**1895**	**1780**	**2001**	**2080**

At the present condition, the maximum potential evapotranspiration is occurring during May (210 mm.) and the minimum is 104 mm. in January. In projected climate based on RCP 4.5 and 8.5 the annual potential evapotranspiration shows an increasing trend from the present value. The maximum values will occur in March and May and the minimum will be in January.

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 119.

Table 119. Monthly Deficit of Northern foothills (AEU13) and the projected climate in Kasaragod district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	104	103	107	119	107	123	147
February	128	128	140	124	140	152	160
March	157.9	144.4	162.9	149.2	142.6	181.2	196
April	129.4	148.8	133.4	129.3	120.1	121.6	160.1
May	22	55.8	24	0	19.6	47	97.9
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	1.6	1.8	2	0	2.1	0	0
September	61.7	61.7	64.6	100.6	67.6	53.6	117.3
October	50.9	47.3	52.9	31.3	55.1	57.1	65.9
November	103.1	81.4	111.1	125.6	111	135.9	124.7
December	18.6	24.6	22.6	40.1	51	103.5	64.3
Total	**777.2**	**796.8**	**820.5**	**819.1**	**816.1**	**974.9**	**1133.2**

In the current climate, the maximum amount of deficit occurs in March (157.9 mm.) and there is no deficit happening in June and July. 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 Northern foothills (AEU13) for the present and projected climate (RCP 4.5 and 8.5) were studied and given in table 120.

Table 120. Monthly Surplus of Northern foothills (AEU13) and the projected climate in Kasaragod district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	337.5	102	334.5	341.8	250.6	312.6	160.2
June	1212.4	1123.6	1208.4	758.3	964.6	654.7	1093.6
July	1960.4	2178.9	1955.4	1757.8	2026.9	1701.1	1897.6
August	541.9	537.7	538.9	542.2	515.8	514.9	533.8
September	57.1	54.4	54.5	94.7	55.9	83.8	3.6
October	160.4	211.7	158.4	208.3	149.8	121.7	258.1
November	0	0	0	0	0	0	0
December	8.8	5.2	4.8	0	0	0	0
Total	**4278.5**	**4213.5**	**4254.9**	**3703.1**	**3963.6**	**3388.8**	**3946.9**

In the present condition, the surplus during January, February, March, April and November is zero whereas in December the surplus is below 10 mm. The maximum amount of surplus is occurring in July and it is about 1960.4 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 in 2080 (RCP 4.5) and in RCP 8.5.

4.3.4.5 Monthly Potential evapotranspiration, Deficit and Surplus of Northern high hills (AEU15) in Kasaragod 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 121.

Table 121. Monthly potential evapotranspiration of Northern high hills (AEU15) and the projected climate in Kasaragod district

PET (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	124	116	124	140	116	124	140
February	152	148	152	140	148	152	156
March	205	200	205	195	200	205	205
April	168	164	168	164	164	168	172
May	225	220	225	215	220	225	225
June	160	160	160	180	160	160	164
July	180	175	180	205	175	180	185
August	156	152	156	148	152	156	160
September	175	155	175	200	155	175	180
October	164	160	164	144	160	164	164
November	144	140	144	164	140	144	148
December	148	144	148	148	144	148	152
Total	**2001**	**1934**	**2001**	**2043**	**1934**	**2001**	**2051**

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In the current condition, the maximum amount of potential evapotranspiration is occurring in May followed by March and it is about 225 mm and 205 mm and the minimum in January (124 mm.). In projected climate the maximum potential evapotranspiration will occur in May and March and the minimum will occur during January. In the yearly value, it shows an increase from the present condition in 2080 (RCP 4.5) and 2080 (RCP 8.5).

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 122.

Table 122. Monthly Deficit of Northern high hills (AEU15) and the projected climate in Kasaragod district

Deficit (mm)	RCP 4.5				RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	124	115	123	139	115	123	139
February	152	148	152	140	148	152	156
March	181.2	178.8	181.2	173.1	178.8	181.2	183.1
April	121.6	146.4	121.6	156.1	146.4	121.6	164.1
May	47	26.3	47	27.6	26.3	47	29.6
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0.3
September	53.6	40.4	53.6	57	40.4	53.6	50
October	57.1	55.6	57.1	46.8	55.6	57.1	56.8
November	135.9	132.2	135.9	133	132.2	135.9	117
December	103.5	100.8	103.5	105.6	100.8	103.5	109.6
Total	**975.9**	**943.5**	**974.9**	**978.2**	**943.5**	**974.9**	**1005.5**

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At present the maximum deficit occurs during the month March (181.2 mm.) and there is no deficit during June, July 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 the projected climate March will be the month having maximum deficit. Annually the projected climate shows an increase in deficit in 2080 (RCP 4.5) and 2080 (RCP 8.5).

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 123.

Table 123. Monthly Surplus of Northern high hills (AEU15) and the projected climate in Kasaragod district

Surplus (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	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	312.6	145.2	312.6	280.1	145.2	312.6	272.1
June	654.7	1081.4	654.7	810.8	1081.4	654.7	826.8
July	1701.1	1690.8	1701.1	1598.7	1690.8	1701.1	1618.7
August	514.9	513.3	514.9	525.2	513.3	514.9	516
September	83.8	88.5	83.8	75.2	88.5	83.8	83.2
October	121.7	121.3	121.7	196.9	121.3	121.7	189.3
November	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**3388.8**	**3640.5**	**3388.8**	**3486.9**	**3640.5**	**3388.8**	**3506.1**

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Currently, there is surplus in all the months except January, February, March and April and the maximum amount of surplus occurs in July (1701.1 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. Yearly surplus shows an increasing trend in projected climate.

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4.4. IRRIGATION WATER REQUIREMENT

4.4.1. Irrigation water requirement of major cropping systems of various AEUs in Kozhikode district and impact of projected climate change

The Crop evapotranspiration (ETc) values of various cropping systems for AEU2, AEU7, AEU11 and AEU15 of Kozhikode district were studied and presented in table 124.

Rice-rice-fallow and coconut monocropping are the major cropping systems of AEU2. In case of rice-rice-fallow the first cropping season is Virippu with a duration of four months (May to August) transplanted during first week of June and harvested during last week of August. The second crop Mundakan is having duration of six months (August to January) transplanted last week of September and harvested in first week of January. Since, coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend in case of rice-rice-fallow. In coconut there is a decreasing trend in projected ETc value except in the case of 2080 of RCP 8.5.

Rice-rice-vegetable and coconut are major cropping systems in AEU7. Since coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend in the case of coconut except 2080 RCP 8.5 and in case of rice-rice-vegetable the ETc values show a decreasing trend from the present value.

Rice-rice-vegetable and coconut are major cropping systems in AEU11. Since coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend in the case of coconut. In case of rice-rice-vegetable the ETc value shows a decreasing trend.

Fallow-rice-fallow and coconut as major cropping systems in AEU15. Since coconut is a perennial crop the ETc values for a year is considered. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend from the present value. In case of fallow-rice-fallow the ETc value shows a decreasing trend from the present value.

The irrigation requirement for various cropping systems of AEU2, AEU7, AEU11 and AEU15 of Kozhikode district were studied and presented table 125.

The annual irrigation requirement of rice-rice-fallow and coconut for the present is 150.3 and 416.1 mm respectively in AEU2. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of rice-rice-fallow show a decreasing trend from the present value and in case of coconut the ETc value shows an increasing trend except in 2080 RCP 8.5. Irrigation is not required during the months June and July in both present and future projections in case of rice-rice-fallow. In coconut, irrigation is not required for six months (May to October) except in 2050 and 2080 RCP4.5 and 2030, 2050 and 2080 RCP 8.5.

The annual irrigation requirement of rice-rice-vegetable and coconut monocropping for the present is 129.4 and 388.4 mm respectively in AEU7. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut in the projected climate shows an increasing trend from the present value and in case of rice-rice-vegetable the irrigation requirement shows a decrease from the present value. In coconut cropping system the number of months that does not require irrigation in the projected climate is about six months except in 2050 and 2080 RCP 4.5 and 2030, 2050 and 2080 RCP 8.5 and in case of rice-rice-vegetable the number of months that does not require irrigation in the projected climate is about three months (April to July except May).

The annual irrigation requirement of rice-rice-vegetable and coconut monocropping for the present is 124.3 and 432.2 mm respectively in AEU11. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut shows a decreasing trend and in case of rice-rice-vegetable the annual irrigation requirement show decrease from the present. In coconut cropping system the number of months that does not require irrigation is about five months (May to October except September) in projected climate and in case of rice-rice-vegetable the number of months that does not require irrigation is about three months (April to July except May).

The annual irrigation requirement of fallow-rice-fallow and coconut monocropping for present is 298.3 and 413.3 mm respectively in AEU15. Comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut shows a decreasing trend except in 2050 RCP 8.5 and in case of fallow-rice-fallow the annual irrigation requirement shows an increase in 2050 and 2080 RCP 4.5 and 2030 and 2050 RCP 8.5. In coconut cropping system the number of months that does not requires irrigation is about four months (May to August) and in case of fallow-rice-fallow the number of months that does not requires irrigation is about one month in 2050 RCP 4.5 and 2030, 2050 and 2080 RCP 8.5.

Coconut of AEU2 and AEU7 have high irrigation requirement within the district.

Table 124. ETc value of various cropping systems in different AEUs of Kozhikode district

				Crop evapotranspiration ETc (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU2 Northern Coastal Plain	Coconut		current	93.9	90	104	99.2	99.3	86	84.2	84.4	82.2	80.3	76.6	83.7	**1063.8**
		4.5	2030	87.3	84	100.3	94.5	103	81.3	71.4	74.4	76.4	84.4	81.7	90.9	**1029.6**
			2050	87.6	84.3	100.7	94.8	103.3	81.2	71.5	74.5	76.7	84.8	82.2	91.2	**1032.8**
			2080	88.9	85.4	101.9	96.1	104.5	82	72.4	75.2	77.6	85.7	83.2	92.5	**1045.4**
		8.5	2030	87.1	83.9	100.4	94.8	103.3	81	71.3	74.4	76.7	84.4	81.9	91.1	**1030.3**
			2050	88.8	85.5	101.8	96	105	82.7	72.6	75.8	77.9	86	83.7	92.7	**1048.5**
			2080	92.1	88.1	104.8	99.1	108.2	85.4	74.9	78	80.7	88.9	86.9	95.4	**1082.5**
	Rice – rice-fallow		current	4.2	*	*	3.4	75	127.1	123.9	43.9	44.8	50.3	118.2	118.3	**704.9**
		4.5	2030	4.2	*	*	3.4	78.3	119.6	104	37.6	38.4	46	124.1	126.1	**677.5**
			2050	4.2	*	*	3.5	78.5	119.5	104.1	37.6	38.4	46.2	124.7	126.8	**679.3**
			2080	4.3	*	*	3.5	79.4	120.8	105.4	38.1	38.9	46.6	126	128.4	**687.1**
		8.5	2030	4.2	*	*	3.4	78.4	119.2	103.9	37.6	38.4	45.8	124.3	126.4	**677.4**
			2050	4.3	*	*	3.5	79.8	121.8	105.5	38.2	39	46.8	126.4	128.8	**689.8**
			2080	4.5	*	*	3.6	82.3	125.6	108.7	39.3	40.1	48.5	130.7	133.7	**712.5**
AEU7 Kaipad Lands	Coconut		current	94.1	90.1	104.1	99.2	99.3	86	84	84.4	82.2	80.5	76.8	84	**1064.7**
		4.5	2030	86.9	83.6	99.9	93.9	102.9	81.3	71.1	74.6	76.5	84.7	81.9	91	**1028.3**
			2050	88	84.7	101.1	94.9	103.7	81.9	71.9	75.2	77.3	85.6	82.8	92.1	**1039.2**
			2080	89.4	85.7	102.1	95.8	104.8	82.7	72.7	75.9	78.2	86.5	83.8	93.3	**1050.9**
		8.5	2030	87.4	84.1	100.3	94.2	103.2	81.5	71.3	74.9	77	85	82.1	91.4	**1032.4**
			2050	89.1	85.5	101.4	95.7	104.8	82.9	72.7	76.1	77.8	86.3	83.9	92.7	**1048.9**
			2080	92.6	87.9	104.4	98.4	107.6	85.7	75	78.4	81.1	89.2	87.3	95.4	**1083**
	Rice- rice-vegetable		current	81.2	97.2	148.7	145.9	103.4	127	123.8	44.8	48.1	118.3	118.6	126.4	**1283.4**
		4.5	2030	79.1	95.9	150.1	144.6	104.2	119.7	103.3	38.3	46.1	124.5	126.2	139.7	**1271.7**
			2050	80.4	97.1	152	146.1	105.3	120.6	104.5	38.8	46.5	125.7	127.5	141.5	**1286**
			2080	81.5	98.2	153.5	147.5	103.6	121.8	105.7	39.2	47.2	127.1	129.1	143.4	**1297.8**
		8.5	2030	79.4	96.2	150.5	144.9	105.4	120	103.8	38.6	46.3	124.9	126.6	140.4	**1277**
			2050	81.6	98.3	153	147.6	108.5	121.9	105.7	39.2	46.8	126.8	129.4	142.5	**1301.3**
			2080	85.1	101.6	158.2	152.7	108.5	126.1	108.8	40.2	48.7	131.1	134.3	146.7	**1342**

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Crop evapotranspiration ETc (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU11 Northern Laterites	Coconut		current	95.4	90.1	104.2	99.3	100	86.1	83.8	83.8	83.3	85.3	82.5	90.4	**1084.2**
		4.5	2030	63.5	61.2	75.5	74.1	92.9	74.6	67.9	74.7	77.3	82.1	70.9	69.1	**883.8**
			2050	64.5	62	76.1	74.8	93.9	75.2	68.4	75.3	78.1	82.8	71.8	69.5	**892.4**
			2080	65.4	62.6	76.6	75.5	94.7	76	69.1	75.9	78.9	83.6	72.6	70.3	**901.2**
		8.5	2030	63.8	61.4	75.7	74.4	93.1	74.7	68.1	74.9	77.6	82.3	71	69.3	**886.3**
			2050	65.2	62.4	76.6	75.4	94.5	74.2	69.1	75.9	79	83.7	72.6	70.3	**898.9**
			2080	67.5	64	78.2	77.2	96.7	78	70.8	78	81.3	86.1	75.4	72.1	**925.3**
	Rice – rice-vegetable		current	82.6	97.4	149.1	146.2	99.8	127.1	123.1	44.3	49.2	125.5	127.9	137.1	**1309.3**
		4.5	2030	65.6	81.3	128.6	129.2	96.6	108.5	93.8	36	46.2	120.4	106.1	107.5	**1119.8**
			2050	66.6	82.4	129.7	130.5	97.5	109.4	94.4	36.3	46.8	121.5	107.3	108	**1130.4**
			2080	67.6	83.2	130.7	131.7	98.5	110.4	95.3	36.6	47.1	122.4	108.5	109.4	**1141.4**
		8.5	2030	65.9	81.5	128.8	129.9	96.8	108.7	94.1	36.3	46.4	120.6	106.1	107.8	**1122.9**
			2050	67.4	83.1	130.7	131.9	98.4	107.8	95.3	36.6	47.2	122.7	108.5	109.5	**1139.1**
			2080	70.4	86	134.4	136	100.7	113.3	97.3	37.5	48.7	126.1	112.7	112.1	**1175.2**
AEU15 Northern High Hills	Coconut		current	93.9	90.1	104	99.2	99.3	86	84.2	84.4	82.2	80.4	76.7	83.8	**1064.2**
		4.5	2030	63.9	61.8	76.7	75.2	93.3	74.8	68.1	74.9	77.6	82.1	70.7	69.1	**888.2**
			2050	64.7	62.6	77.1	75.8	94.1	75.4	68.6	75.5	78.2	82.8	71.6	69.6	**896**
			2080	65.6	63.3	77.8	76.4	95.1	74.4	69.3	76.2	79	83.5	72.4	70.5	**903.5**
		8.5	2030	64.4	62.1	76.5	75.3	93.6	75.1	68.2	75	77.9	82.3	71.1	69.3	**890.8**
			2050	65.3	63.1	77.5	76.4	95.1	74.4	69.3	76.3	78.5	83.4	72.4	70.5	**902.2**
			2080	67.9	64.7	79.3	78.3	97.1	76.5	71.1	78.2	81.5	86.1	75.3	72.1	**928.1**
	Fallow – rice-fallow		current	*	*	*	0.9	48.1	118.3	118.4	126.1	*	*	*	*	**411.8**
		4.5	2030	*	*	*	0.8	46.4	120.4	106	107.4	*	*	*	*	**381**
			2050	*	*	*	0.8	46.7	121.3	107.1	108	*	*	*	*	**383.9**
			2080	*	*	*	0.8	47.2	122.4	108.2	109.5	*	*	*	*	**388.1**
		8.5	2030	*	*	*	0.8	46.6	120.5	106.4	107.3	*	*	*	*	**381.6**
			2050	*	*	*	0.8	47	122.3	108.3	109.3	*	*	*	*	**387.7**
			2080	*	*	*	0.8	48.8	126.3	112.6	112	*	*	*	*	**400.5**

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Table 125. Irrigation requirement of various cropping systems in different AEUs of Kozhikode district

				Irrigation requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU2 Northern Coastal Plain	Coconut		current	93.7	89.8	99.4	49.1	0	0	0	0	0	0	44.8	39.3	**416.1**
		4.5	2030	79.3	83.9	94.5	71	0	0	0	0	0	0	54	72.2	**454.9**
			2050	86.2	84.1	84.6	65.6	0	0	0	0	74.9	0	54.9	80.5	**530.8**
			2080	62.7	85.3	87.4	69.7	0	0	0	0	75.7	0	70.1	50.5	**501.4**
		8.5	2030	85.1	83.8	89.7	77.4	0	0	0	0	68.8	0	52.8	79.9	**537.5**
			2050	85	85.5	93.1	81.3	0	0	0	0	72.5	0	43.6	78.5	**539.5**
			2080	91.7	87.9	82.2	78.3	0	0	0	0	39	0	37.6	61.7	**478.4**
	Rice – rice-fallow		current	4.2	*	*	0	143.1	0	0	8.1	144.4	0	86.6	81.7	**463.9**
		4.5	2030	4.2	*	*	0	143.2	0	0	7	144.4	2	98.2	120.5	**515.3**
			2050	4.2	*	*	0	143.2	0	0	7	188.7	0	99.4	129.2	**567.5**
			2080	4.3	*	*	0	143.2	0	0	7.1	189.1	11.2	115.2	99.8	**565.6**
		8.5	2030	4.2	*	*	0	143.2	0	0	7	182.8	0	97.3	128.5	**558.8**
			2050	4.3	*	*	0	143.2	0	0	7.1	185.7	5.4	88.6	127.9	**557.9**
			2080	4.5	*	*	0	143.3	0	0	7.3	169.4	3.1	84.3	112.6	**520**
AEU7 Kaipad Lands	Coconut		current	94	90	91.9	22.6	0	0	0	0	0	0	39	50.9	**388.4**
		4.5	2030	79.1	83.6	94	70.3	0	0	0	0	0	0	54	72.4	**453.4**
			2050	86.7	84.6	85	65.6	0	0	0	0	75.6	0	55.5	81.4	**534.4**
			2080	63.3	85.5	87.5	69.2	0	0	0	0	76.3	0	70.7	51.2	**503.7**
		8.5	2030	85.2	84	89.6	76.9	0	0	0	0	69.1	0	52.9	80.2	**537.9**
			2050	85.4	85.4	92.8	80.9	0	0	0	0	72.4	0	43.9	78.4	**539.2**
			2080	92.1	87.7	81.8	77.6	0	0	0	0	39.5	0	37.9	61.8	**478.4**
	Rice – rice-vegetable		current	81.1	97.1	136.4	62.7	123.8	0	0	8.1	124.7	0.3	80.7	93.5	**808.4**
		4.5	2030	71.2	95.8	144.3	117.6	125.7	0	0	7	124.6	2.1	98.4	121	**907.7**
			2050	79	96.9	135.9	113.4	127.2	0	0	7.1	169.4	0	100.2	130.7	**959.8**
			2080	55.4	98.1	139	117.6	128.6	0	0	7.2	169.9	11.8	115.9	101.3	**944.8**
		8.5	2030	77.5	96	139.8	124.1	128.3	0	0	7.1	163.2	0	97.5	129.2	**962.7**
			2050	77.8	98.2	144.2	129.4	124.7	0	0	7.2	166	5.6	89.3	128.3	**970.7**
			2080	84.8	101.4	135.6	128.2	126.7	0	0	7.3	149.9	3.2	85	113.2	**935.3**

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				Irrigation requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU11 Northern Laterites	Coconut		current	95.2	90	92.1	50.6	0	0	0	0	0	0	46	58.3	**432.2**
		4.5	2030	58.4	61.1	61.4	45.8	0	0	0	0	76.8	0	38.6	34.4	**376.5**
			2050	62.5	61.9	53.8	64.2	0	0	0	0	68.1	0	37	31	**378.5**
			2080	42.1	62.5	42	53.7	0	0	0	0	74.2	0	39.3	28.1	**341.9**
		8.5	2030	61.8	61.3	65.3	36.7	0	0	0	0	77.1	0	37.1	32.3	**371.6**
			2050	64.9	62.3	50.8	52.8	0	0	0	0	74.2	0	32.9	55.6	**393.5**
			2080	67.4	63.9	54.1	42.8	0	0	0	0	43.6	0	38.9	26.4	**337.1**
	Rice – rice-vegetable		current	82.4	97.2	137.1	94.2	122.9	0	0	8	119.9	3.1	91.5	104.9	**124.3**
		4.5	2030	60.4	81.2	114.4	97.6	119.7	0	0	6.7	165.2	0.3	73.7	72.8	**123.1**
			2050	64.4	82.2	107.2	116.5	120	0	0	6.8	158	0	72.6	69.7	**123.3**
			2080	65.5	83.1	108.3	117.7	120.2	0	0	6.8	162.2	1.4	75.1	67.2	**123.3**
		8.5	2030	63.9	81.4	118.5	88.6	118.3	0	0	6.8	165.5	0	72.3	70.9	**123.3**
			2050	67.1	83	105.1	105.9	120.2	0	0	6.8	162.3	0.7	68.7	94.8	**123.3**
			2080	70.3	85.9	108.7	110	120.7	0	0	7	147.4	0.2	76.1	66.4	**123.5**
AEU15 Northern High Hills	Coconut		current	93.8	90	97.2	39.7	0	0	0	0	0	0	47.1	45.5	**413.3**
		4.5	2030	58.3	61.7	62.1	46.7	0	0	0	0	77	0	38.8	34.5	**379.1**
			2050	62.7	62.5	61.3	64.8	0	0	0	0	74.5	0	37.2	31.3	**394.3**
			2080	52.6	63.1	62	66.2	0	0	0	0	74.4	0	39.6	28.5	**386.4**
		8.5	2030	61.4	61.9	59.2	65.9	0	0	0	0	74.7	0	37.8	31.1	**392**
			2050	65.1	63	64	72.7	0	0	0	0	73.9	0	33.2	55.7	**427.6**
			2080	67.8	64.5	73.8	58.1	0	0	0	0	43.2	0	39.3	26.8	**373.5**
	Fallow – rice-fallow		current	*	*	*	0.9	119.7	0.6	89	88.1	*	*	*	*	**298.3**
		4.5	2030	*	*	*	0.8	119.6	0.6	76.6	69.4	*	*	*	*	**267**
			2050	*	*	*	0.8	162.7	0	72.8	69.7	*	*	*	*	**306**
			2080	*	*	*	0.8	162.3	0.3	75.4	67.4	*	*	*	*	**306.2**
		8.5	2030	*	*	*	0.8	165.5	0	75.5	69.3	*	*	*	*	**311.1**
			2050	*	*	*	0.8	162.1	0	69.1	94.7	*	*	*	*	**326.7**
			2080	*	*	*	0.8	147.2	0	76.4	66.6	*	*	*	*	**291**

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4.4.2. Irrigation water requirement of major cropping systems of various AEUs in Wayanad district and impact of projected climate change

The Crop evapotranspiration (ETc) values of various cropping systems for AEU15, AEU 20 and AEU 21 of Wayanad district were studied and presented in table 126.

Rice-rice and coconut-banana-pepper are the major cropping systems of AEU 15. In case of rice-rice the first cropping season is Virippu with a duration of four months (May to August) transplanted during first week of June and harvested during last week of August. The second crop Mundakan is having duration of six months (August to January) transplanted last week of September and harvested in first week of January. Since, coconut-pepper are perennial crops the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show an increasing trend in case of rice-rice and in case of coconut-banana-pepper the annual value of ETc shows an increasing trend.

Rice-fallow and coconut are major cropping systems in AEU20. Since coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate shows an increasing trend in the case of coconut and in the case of rice-fallow the annual ETc value shows an increasing trend.

Rice-rice and coconut-pepper are major cropping systems in AEU21. Since coconut-pepper are perennial crops the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate shows an increasing trend in the case of coconut and in case of rice-rice the annual ETc value of projected climate shows an increasing trend.

The irrigation requirement for various cropping systems of AEU15, AEU20 and AEU21 of Wayanad district were studied and presented table 144.

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The annual irrigation requirement of rice-rice and coconut-banana-pepper is 146.6 and 371.3 mm respectively in AEU15. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut-banana-pepper shows an increasing trend from the present value in 2050 and 2080 RCP4.5 and RCP 8.5 and in case of rice-rice the annual irrigation requirement shows an increasing trend. Irrigation is not required during the months June and July in rice-rice cropping system and in case of coconut-banana-pepper the irrigation is not required during the months May to August.

The annual irrigation requirement of rice-fallow and coconut monocropping for present is 62.3 and 478.9 mm respectively in AEU20. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut in projected climate shows a decreasing trend from the present value and in case of rice-fallow the values show an increasing trend except in 2030 RCP 8.5. In coconut cropping system the number of months does not requires irrigation is about four months (May to August) and in case of rice-fallow it is about two months (June and July).

The annual irrigation requirement of rice-rice and coconut-pepper for present is 223.4 and 492.9 mm respectively in AEU21. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of rice-rice shows a decreasing trend and in case of coconut-pepper the values show a decreasing trend from the present value. In coconut cropping system the number of months that does not require irrigation is about five months (May to October except September).

Table 126. ETc value of various cropping systems in different AEUs of Wayanad district

				Crop evapotranspiration ETc (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern High Hills	Coconut – banana-pepper		current	82.7	82	97.5	94	89	73.3	68.6	73.5	73.9	76.9	71.6	75.4	**958.4**
		4.5	2030	80.1	80.9	97.1	95.8	113.4	80.1	69.8	78.2	75	82	72.9	78	**1003.3**
			2050	81	81.9	98.4	94.6	99	80.6	70.4	78.8	75.7	82.9	73.6	78.8	**995.7**
			2080	82.4	82.8	99.4	95.6	100.3	81.6	71.5	79.8	76.7	83.8	74.5	79.9	**1008.3**
		8.5	2030	80.3	81.1	97.2	93.8	98.4	79.9	70	78.5	75.3	82.3	73	78	**987.8**
			2050	80.9	82	98.4	94.6	98.8	80.6	70.4	78.8	75.7	82.9	73.6	78.7	**995.4**
			2080	85.9	84.8	101.4	98.7	102.5	84.6	74.2	82.7	79.1	86.4	78.2	81.8	**1040.3**
	Rice – rice		current	*	*	*	4.2	75.9	108.2	99.3	30.7	*	*	*	*	**318.3**
		4.5	2030	*	*	*	3.9	89.8	118	101.3	36.1	*	*	*	*	**349.1**
			2050	*	*	*	3.8	81.6	118.7	102.2	36.4	*	*	*	*	**342.7**
			2080	*	*	*	3.3	77.8	120.1	104.1	40.4	*	*	*	*	**345.7**
		8.5	2030	*	*	*	3.8	80.9	117.6	101.8	36.3	*	*	*	*	**340.4**
			2050	*	*	*	3.8	81.6	118.7	102.2	36.4	*	*	*	*	**342.7**
			2080	*	*	*	3.4	80	124.6	107.8	41.9	*	*	*	*	**357.7**
AEU20 Wayanad Central Plateau	Coconut		current	82.6	81.9	97.4	94	89	73.4	68.6	73.5	73.9	76.9	71.6	75.3	**958.1**
		4.5	2030	81.3	82.5	99.8	95.8	100	80.9	70.7	79.2	75.9	83.1	73.7	78.7	**1001.6**
			2050	82.2	83.4	100.5	96.6	100.6	81.6	71.4	79.9	76.8	83.8	74.4	79.6	**1010.8**
			2080	83.6	84.3	101.6	97.5	101.8	82.7	72.4	80.8	77.6	84.8	75.3	80.9	**1023.3**
		8.5	2030	81.6	82.6	99.7	96.1	106.6	81	70.9	79.4	76	83.3	73.7	79	**1009.9**
			2050	83.7	83.8	100.7	97.3	108.1	82.9	72.4	81.1	77.7	84.8	75.7	80.2	**1028.4**
			2080	86.9	86.2	103.7	100.8	107.6	85.6	75.1	83.8	80.2	87.5	78.9	82.7	**1059**
	Rice – fallow		current	*	*	*	3.6	71.8	108.2	99.7	34	*	*	*	*	**317.3**
		4.5	2030	*	*	*	3.8	81.9	119.3	102.9	36.7	*	*	*	*	**344.6**
			2050	*	*	*	3.3	77.9	120.4	104.3	40.7	*	*	*	*	**346.6**
			2080	*	*	*	3.4	78.8	121.9	105.8	41.1	*	*	*	*	**351**
		8.5	2030	*	*	*	3.8	82.1	119.6	103.5	36.8	*	*	*	*	**345.8**
			2050	*	*	*	3.9	82.6	120.5	104.1	37	*	*	*	*	**348.1**
			2080	*	*	*	3.5	80.9	126.1	109.4	42.5	*	*	*	*	**362.4**

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Crop evapotranspiration ETc (mm)

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU21 Wayanad Eastern Plateau	Coconut- pepper		current	85.3	78.1	99.3	95.2	95.8	75.6	71.3	73.6	74.8	80.5	74.5	79.9	**983.9**
		4.5	2030	81	82.6	99.8	96.1	100.1	80.9	70.6	79.1	75.7	82.9	73.3	78.5	**1000.6**
			2050	82	83.6	100.9	97	100.7	81.6	71.1	79.9	76.6	83.6	74.1	79.4	**1010.5**
			2080	83.3	84.4	101.7	98	102.2	82.6	72.3	80.8	77.5	84.7	75	80.4	**1022.9**
		8.5	2030	81.3	82.8	100	96.4	100.2	81	70.8	79.4	76.2	83.1	73.4	78.7	**1003.3**
			2050	83.3	83.8	100.7	97.5	101.5	82.7	72.3	81.1	77.5	84.6	75.4	79.8	**1020.2**
			2080	86.7	86.4	103.7	101.1	104.4	85.6	75	83.8	80.1	87.4	78.6	82.4	**1055.2**
	Rice – rice		current	*	*	*	3.7	76.7	111.7	104.2	34.4	*	*	*	*	**330.7**
		4.5	2030	*	*	*	3.8	81.7	119.3	102.7	36.6	*	*	*	*	**344.1**
			2050	*	*	*	3.3	77.8	120.1	103.6	40.5	*	*	*	*	**345.3**
			2080	*	*	*	3.4	78.8	121.8	105.6	41.1	*	*	*	*	**350.7**
		8.5	2030	*	*	*	3.8	81.9	119.4	103.2	36.8	*	*	*	*	**345.1**
			2050	*	*	*	3.9	83.2	122	105.2	37.5	*	*	*	*	**351.8**
			2080	*	*	*	3.5	80.9	126	109.2	42.5	*	*	*	*	**362.1**

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Table 127. Irrigation requirement of various cropping systems in different AEUs of Wayanad district

Irrigation requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern High Hills	Coconut – banana-pepper		current	82.6	74.8	45.7	92.4	0	0	0	0	26.9	0	34.1	14.8	**371.3**
		4.5	2030	79.9	75.5	27.5	72.8	0	0	0	0	27	0	49.3	11.1	**343.1**
			2050	80.9	76	47	89.7	0	0	0	0	65.2	0	32.4	20.1	**411.3**
			2080	81.7	82.7	87.2	36.5	0	0	0	0	69.9	12.9	48.5	22.9	**442.3**
		8.5	2030	80.2	74.9	47.7	79.8	0	0	0	0	26.7	0	54.3	14.2	**377.8**
			2050	80.8	76	47.1	89.7	0	0	0	0	65.2	0	32.4	20.1	**411.3**
			2080	85.8	82.5	84.1	79.9	0	0	0	0	41.4	8.3	62.7	21.3	**466**
	Rice – rice		current	*	*	*	3	143.6	0	0	0	*	*	*	*	**146.6**
		4.5	2030	*	*	*	0	233.3	0	0	3.3	*	*	*	*	**236.6**
			2050	*	*	*	2	233.6	0	0	3.4	*	*	*	*	**239**
			2080	*	*	*	0	143.2	0	0	69.3	*	*	*	*	**212.5**
		8.5	2030	*	*	*	0	167.8	0	0	66.2	*	*	*	*	**234**
			2050	*	*	*	2	167.8	0	0	3.4	*	*	*	*	**173.2**
			2080	*	*	*	0	143.2	0	0	67.4	*	*	*	*	**210.6**
AEU20 Wayanad Central Plateau	Coconut		current	82.5	81.8	90.7	93.8	0	0	0	0	27.1	0	55	48	**478.9**
		4.5	2030	80.7	82.4	87.7	78.6	0	0	0	0	46.7	0	34.6	51.9	**462.6**
			2050	73.8	83.3	88.6	70.2	0	0	0	0	48.6	0	33.2	51	**448.7**
			2080	80.7	84.2	91.1	65.7	0	0	0	0	47.5	0	36.8	47.7	**453.7**
		8.5	2030	73.1	82.6	89	73.9	0	0	0	0	46.7	0	32.4	50.3	**448**
			2050	74.9	83.6	89.4	42.6	0	0	0	0	47	0	49.9	36	**423.4**
			2080	86.8	82.6	78.9	62.5	0	0	0	0	65.6	0	60	26.5	**462.9**
	Rice – fallow		current	*	*	*	3.5	55.7	0	0	3.1	*	*	*	*	**62.3**
		4.5	2030	*	*	*	0	84	0	0	3.4	*	*	*	*	**87.4**
			2050	*	*	*	0	85.3	0	0	6.9	*	*	*	*	**92.2**
			2080	*	*	*	0	85.4	0	0	63.6	*	*	*	*	**149**
		8.5	2030	*	*	*	0	66.2	0	0	3.4	*	*	*	*	**69.6**
			2050	*	*	*	0	132.6	0	0	3.4	*	*	*	*	**136**
			2080	*	*	*	0	86	0	0	62	*	*	*	*	**148**

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Irrigation requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU21 Wayanad Eastern Plateau	Coconut- pepper		current	85.2	78	93.6	95.1	0	0	0	0	33.2	0	46.1	61.7	**492.9**
		4.5	2030	80.9	82.5	84.1	79	0	0	0	0	45.1	0	34.6	51.4	**457.6**
			2050	73.6	83.5	89.5	43.4	0	0	0	0	46.3	0	37.6	47.9	**421.8**
			2080	80.3	84.4	97.4	66.3	0	0	0	0	25.6	0	58.1	37.8	**449.9**
		8.5	2030	72.7	82.7	89.6	84.5	0	0	0	0	45.1	0	37	47.2	**458.8**
			2050	74.6	83.6	92.3	69.4	0	0	0	0	24.9	0	60.3	38.2	**443.3**
			2080	86.6	82.8	79.4	63.1	0	0	0	0	65.4	0	59.9	26.4	**463.6**
	Rice – rice		current	*	*	*	3.6	156	0	0	63.8	*	*	*	*	**223.4**
		4.5	2030	*	*	*	0	156	0	0	3.4	*	*	*	*	**159.4**
			2050	*	*	*	0	115.2	0	0	6.9	*	*	*	*	**122.1**
			2080	*	*	*	0	115.2	0	0	63.6	*	*	*	*	**178.8**
		8.5	2030	*	*	*	0	156	0	0	3.4	*	*	*	*	**159.4**
			2050	*	*	*	0	212.1	0	0	3.5	*	*	*	*	**215.6**
			2080	*	*	*	0	115.2	0	0	62	*	*	*	*	**177.2**

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4.4.3. Irrigation water requirement of major cropping systems of various AEUs in Kannur district and impact of projected climate change

The Crop evapotranspiration (ETc) values of various cropping systems for AEU 2, AEU 7, AEU 11, AEU 13 and AEU 15 of Kannur district were studied and presented in table 128.

Rice-rice-vegetable and coconut monocropping are the major cropping systems of AEU2. In case of rice-rice-vegetable the first cropping season is Virippu with a duration of four months (May to August) transplanted during first week of June and harvested during last week of August. The second crop Mundakan is having duration of six months (August to January) transplanted last week of September and harvested in first week of January. Since, coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show an increasing trend from April to July and decreases in August in case of rice-rice-vegetable. In coconut there is a decreasing trend in projected ETc value except in the case of 2080 of RCP 8.5.

Coconut and rice-fallow are the major cropping systems in AEU7. Since coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend in the case of coconut except RCP 8.5 of 2080 and in rice-fallow system the ETc values increases from April to July and decreases in August.

Coconut and arecanut are major cropping systems in AEU11. Since coconut and arecanut are perennial crops the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend in the case of arecanut and in case of coconut there is a decreasing trend in ETc values except 2080 RCP 4.5 and 8.5.

Rubber and coconut + arecanut as major cropping systems in AEU13. Since rubber, coconut+ arecanut are perennial crops the ETc values for a year is considered. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend from the present value in both rubber and coconut + arecanut cropping systems.

Coconut-pepper-banana and rice-rice are major cropping systems in AEU15. Since coconut-pepper are perennial crops the ETc values for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of coconut will show an increasing trend in 2080 of RCP 4.5 and 8.5 remaining cases will show a decreasing trend and in the case of rice-rice the ETc values of projected climate will show an increasing trend.

The irrigation requirement for various cropping systems of AEU2, AEU7, AEU11, AEU13 and AEU15 of Kannur district were studied and presented table 129.

The annual irrigation requirement of rice-rice-vegetable and coconut for the present situation is 164.6 and 511.5 mm respectively in AEU2. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of both rice-rice-vegetable and coconut will show a decreasing trend from the present value except in the case of 2080 RCP 8.5 of coconut. Irrigation is not required during the months May, June, July and August for present and future projections. In coconut, irrigation is not required for six months (May to October) and there is not much variation in the number of months that does not requires irrigation under projected climate. In rice-rice-vegetable irrigation is not required for three months (June to August) and there is not much variation in the number of months that does not requires irrigation under projected climate.

The annual irrigation requirement of rice-fallow and coconut monocropping for the present condition is 105.6 and 538.5 mm respectively in AEU7. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of both rice-fallow and coconut of projected climate will show an increasing trend from the present value except in 2080 RCP 4.5 and 2050

RCP 8.5. In rice-fallow systems there is an increase in the number of months that does not requires irrigation in projected climate and in case of coconut there is no increase in the number of months that does not requires irrigation in projected climate.

The annual irrigation requirement of arecanut and coconut-pepper-banana for the present condition is 703 and 536.8 mm respectively in AEU11. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of both arecanut and coconut-pepper-banana will show an increasing trend in 2080 in both RCP 4.5 and 8.5. In arecanut cropping systems there will be an increasing trend in the number of months that does not require irrigation from five months (June to October except September) in projected climate 2080 RCP 4.5 and 8.5. In case of coconut-pepper-banana the annual irrigation requirement values show a decreasing trend except 2080 RCP 4.5 and 8.5.

The annual irrigation requirement of rubber and coconut-arecanut for the present condition is 486.4 and 660.3 mm respectively in AEU13. Comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of both rubber and coconut-arecanut will show a decreasing trend except in 2080 RCP 4.5. In coconut-arecanut cropping systems the number of months that does not require irrigation of projected climate will show a decreasing trend from six months (May to October) under present situation to five months and in case of rubber the number of months that does not require irrigation of projected climate will show a decreasing trend from five months (June to October) under present situation to four months.

The annual irrigation requirement of coconut-pepper-banana and rice-rice for the present is 430.3 and 72 mm respectively in AEU15. Comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut will show an increasing trend from the present value except in the cases of 2050 RCP 4.5 and 2030 RCP 8.5. In the case of rice-rice except in the cases of 2080 RCP 4.5 and 2050 and 2080 RCP 8.5 will show a decrease in the annual irrigation requirement. In coconut-pepper-banana cropping systems the number of months that does not requires irrigation is about six months (May to October) except in 2030, 2050 and 2080 RCP) 4.5 and 2080 RCP 8.5. In case of rice-rice cropping system the number of months that does not requires irrigation is about four months (April to August except May).

Arecanut of AEU11 is having high irrigation requirement within the district.

Table 128. ETc value of various cropping systems in different AEUs of Kannur district

				Crop evapotranspiration ETc (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		Current	*	*	*	6.5	96	114.8	99.6	20.6	*	*	*	*	**337.5**
		4.5	2030	*	*	*	6.3	101.7	119.5	102.2	21.5	*	*	*	*	**351.2**
			2050	*	*	*	5.8	97.7	120.4	103.2	24.8	*	*	*	*	**351.9**
			2080	*	*	*	4.7	89.4	121.8	105.1	31.6	*	*	*	*	**352.6**
		8.5	2030	*	*	*	5.8	97.2	119.5	102.7	24.7	*	*	*	*	**349.9**
			2050	*	*	*	4.7	89.4	122.1	105.1	31.6	*	*	*	*	**352.9**
			2080	*	*	*	4.9	92	125.7	108.3	32.5	*	*	*	*	**363.4**
	Coconut		current	100.8	96.9	114.3	106.4	96.1	78	70.2	71.9	77.1	82.6	85.8	96	**1076.1**
		4.5	2030	58.7	83.4	99.3	93.8	97.3	81	71.4	74.4	76.7	84.5	81.2	91.2	**992.9**
			2050	88.3	84.1	99.9	94.4	97.9	81.6	72	75.1	77.6	85.5	83.6	92.6	**1032.6**
			2080	89.8	85	100.8	95.4	99.2	82.6	72.9	75.8	78.3	86.3	84.5	93.9	**1044.5**
		8.5	2030	87.7	83.7	99.6	94.2	97.7	81.1	71.6	74.6	77	84.8	82.8	92	**1026.8**
			2050	89.5	85	100.7	95.1	99.2	82.9	72.7	75.9	78.1	86.3	84.4	93.8	**1043.6**
			2080	92.9	87.8	103.9	98.4	102	85.5	75.1	78.3	80.8	89.3	87.5	97.3	**1078.8**
AEU7 Kaipad Lands	Rice- Fallow		current	*	*	*	6.5	96.1	114.8	99.6	20.6	*	*	*	*	**337.6**
		4.5	2030	*	*	*	6.3	101.8	119.7	102.6	21.6	*	*	*	*	**352**
			2050	*	*	*	5.8	97.8	120.6	103.7	24.9	*	*	*	*	**352.8**
			2080	*	*	*	4.7	89.4	121.8	105.4	31.6	*	*	*	*	**352.9**
		8.5	2030	*	*	*	5.8	97.5	120	103.3	24.8	*	*	*	*	**351.4**
			2050	*	*	*	4.7	89.8	122.7	105.6	31.7	*	*	*	*	**354.5**
			2080	*	*	*	4.9	92.4	126.3	108.6	32.6	*	*	*	*	**364.8**
	Coconut		current	100.7	96.8	114.3	106.4	96.1	78.1	70.2	72	77.1	82.6	85.8	95.8	**1075.9**
		4.5	2030	87.6	83.5	99.2	94	97.5	81.1	71.6	74.4	76.7	84.7	82.8	91.7	**1024.8**
			2050	60.4	84.1	100.2	94.7	98	81.8	72.2	75.1	77.3	85.4	83.7	92.8	**1005.7**
			2080	89.8	85	100.7	95.5	99.3	82.7	73	75.7	78.2	86.3	84.7	94.2	**1045.1**
		8.5	2030	88	83.8	99.6	94.4	97.8	81.4	71.9	74.8	77	84.9	83	92.3	**1028.9**
			2050	90.1	85.5	101.3	95.7	99.6	83.3	73.3	76.2	78.3	86.7	85	94.5	**1049.5**
			2080	93	87.6	103.6	98.5	102.4	85.8	75.3	78.4	80.9	89.3	88.1	97.1	**1080**

Crop evapotranspiration ETc (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU11 Northern Laterites	Arecanut		current	127.2	123.8	144.8	134.4	102.8	97.9	88.1	90.3	95.8	101.5	104.7	118.8	**1330.1**
		4.5	2030	110.8	109.7	129.7	121.9	108.1	101.6	89.7	93.1	93.2	99.7	95.7	110.8	**1264**
			2050	112.7	111.8	132.8	125	109.6	103.2	89.9	93.8	93.6	100.4	96.3	109.8	**1278.9**
			2080	117.1	115.3	135.5	127.5	110.3	107.4	94.2	97.6	97.9	104.4	100.4	115.5	**1323.1**
		8.5	2030	110.8	109.5	130	122.3	108.2	101.4	90	92.9	93.2	99.7	95.5	110.4	**1263.9**
			2050	112.9	111.8	131.9	123.6	107.3	104.1	91.2	94.8	94.7	101.2	97	112.6	**1283.1**
			2080	117.1	115.3	135.5	127.5	110.3	107.4	94.2	97.6	97.9	104.4	100.4	115.5	**1323.1**
	Coconut- pepper- banana		current	100.8	96.1	112.9	106.1	92.4	78.1	70.2	72	77.1	82.6	86.1	96.3	**1070.7**
		4.5	2030	87.5	83.5	99.5	94.2	97.7	81.1	71.6	74.7	76.9	84.8	82.7	92	**1026.2**
			2050	89.4	85.3	101.3	95.5	99.2	83	72.8	76	78.1	86.3	84.3	93.8	**1045**
			2080	92.9	87.6	103.6	98.2	102.1	85.6	75.2	78.3	80.9	89.2	87.8	96.7	**1078.1**
		8.5	2030	87.7	83.6	99.8	94.6	97.5	80.9	71.6	74.5	77	84.7	82.7	91.7	**1026.3**
			2050	89.6	85.4	101.1	95.4	99.4	83	72.8	76	78.1	86.3	84.4	94	**1045.5**
			2080	92.9	87.6	103.6	98.2	102.1	85.6	75.2	78.3	80.9	89.2	87.8	96.7	**1078.1**
AEU13 Northern Foot Hills	Coconut- arecanut		current	100.8	96.1	112.9	106.1	92.4	78	70.2	71.9	77.1	82.6	86.1	96.4	**1070.6**
		4.5	2030	88.8	85.8	102.2	96.5	99	81.5	71.3	74.6	76.2	84.6	82	91	**1033.5**
			2050	90.3	86.9	103.4	97.6	99.5	82.3	71.8	75.2	77.1	85.2	83.3	91.7	**1044.3**
			2080	91.8	87.8	104.2	98.6	101.2	83	72.7	76.1	78.1	86.3	84.2	93.6	**1057.6**
		8.5	2030	89.6	86.4	102.7	97	99.4	81.8	71.3	74.9	76.6	84.7	82.5	91.1	**1038**
			2050	91.4	87.6	104.1	98.4	100.7	83.2	72.8	76.2	78.2	86.3	84.3	93	**1056.2**
			2080	87.6	86.2	103.7	98.6	96.8	79.4	69	72.6	73.7	84.4	79.8	86	**1017.8**
	Rubber		current	128.8	125.4	146.7	136.2	104.2	98.9	89	91.2	96.8	102.7	106	120.2	**1346.1**
		4.5	2030	112.9	112.5	133.4	125.8	110.2	103.2	90.2	94.1	93.8	101.2	96.8	111.3	**1285.4**
			2050	114.3	113.4	134.7	127	110.9	104.3	90.9	94.8	94.7	101.7	97.8	111.3	**1295.8**
			2080	116.7	115.4	136.5	128.5	110.3	105.2	92	95.9	96	103.4	99.1	114.1	**1313.1**
		8.5	2030	113.6	112.7	133.6	126.2	110.5	103.7	90.5	94.4	94.3	101.2	97.2	111	**1288.9**
			2050	115.9	114.8	136.1	128.3	109.9	105.3	92.1	96.1	96.2	103.2	99	112.9	**1309.8**
			2080	108.6	109.6	132.6	126.4	105	100.5	87.4	91.6	91.1	101.7	94.5	103.9	**1252.9**

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Crop evapotranspiration ETc (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern High Hills	Coconut-pepper-banana		current	100.7	96.1	112.8	106.1	92.4	78.1	70.2	72.1	77.1	82.6	86.1	96.2	**1070.5**
		4.5	2030	90.4	86.3	101.9	96.4	94.8	81.8	71.3	74.9	76.6	84.7	83.1	92	**1034.2**
			2050	91.4	87.6	104.1	98.4	100.7	83.2	72.8	76.1	76.7	85.8	84.3	93	**1054.1**
			2080	94.9	90	106.5	101.4	103.4	85.9	75.1	78.4	80.6	89	87.8	95.7	**1088.7**
		8.5	2030	89.8	86.8	103.3	97.9	99.2	81.4	71	74.5	75.8	84	81.9	90	**1035.6**
			2050	92.1	87.7	104.4	99.3	98.8	82.9	72.5	75.7	76.9	85.4	84	92	**1051.7**
			2080	95	90.4	107.8	102.6	101.4	85.5	75	77.9	79.5	88	87.4	94.4	**1084.9**
	Rice- rice		current	*	*	*	*	44.1	114.5	102.6	57.9	*	*	*	*	**319.1**
		4.5	2030	*	*	*	5.8	97.4	120.6	102.6	24.8	*	*	*	*	**351.2**
			2050	*	*	*	4.7	89.5	122.5	105.1	31.8	*	*	*	*	**353.6**
			2080	*	*	*	4.9	92.1	126.6	108.2	32.6	*	*	*	*	**364.4**
		8.5	2030	*	*	*	5.7	96.7	120	102.1	24.7	*	*	*	*	**349.2**
			2050	*	*	*	4.7	87.2	122.1	104.7	31.6	*	*	*	*	**350.3**
			2080	*	*	*	4.9	89.9	126	108.4	32.6	*	*	*	*	**361.8**

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Table 129. Irrigation requirement of various cropping systems in different AEUs of Kannur district

				Irrigation 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		current	*	*	*	0.6	164	0	0	0	*	*	*	*	**164.6**
		4.5	2030	*	*	*	0.6	164	0	0	0	*	*	*	*	**164.6**
			2050	*	*	*	0	136.5	0	0	0	*	*	*	*	**136.5**
			2080	*	*	*	0	135.9	0	0	0	*	*	*	*	**135.9**
		8.5	2030	*	*	*	0	136.4	0	0	0	*	*	*	*	**136.4**
			2050	*	*	*	2.6	135.9	0	0	0	*	*	*	*	**138.5**
			2080	*	*	*	1.1	135.9	0	0	0	*	*	*	*	**137**
	Coconut		current	100.6	96.9	114.2	63.8	0	0	0	0	0	0	62.8	73.2	**511.5**
		4.5	2030	87	83.4	99.2	20.5	0	0	0	0	0	0	57.9	68.8	**416.8**
			2050	88.2	84.1	99.8	20.9	0	0	0	0	0	0	60.2	70	**423.2**
			2080	87.2	84.9	86	65.1	0	0	0	0	0	0	59.4	72.9	**455.5**
		8.5	2030	87.6	83.7	99.5	63.4	0	0	0	0	0	0	50.5	58.1	**442.8**
			2050	89.4	85	100.6	93	0	0	0	0	0	0	61.3	78.4	**507.7**
			2080	92.8	87.7	96.4	94.4	0	0	0	0	79.4	0	57.7	59	**567.4**
AEU7 Kaipad Lands	Rice- Fallow		current	*	*	*	0.6	105	0	0	0	*	*	*	*	**105.6**
		4.5	2030	*	*	*	0.6	112.2	0	0	0	*	*	*	*	**112.8**
			2050	*	*	*	0	135.5	0	0	0	*	*	*	*	**135.5**
			2080	*	*	*	0	67.9	0	0	0	*	*	*	*	**67.9**
		8.5	2030	*	*	*	0	132.2	0	0	0	*	*	*	*	**132.2**
			2050	*	*	*	0	67.9	0	0	0	*	*	*	*	**67.9**
			2080	*	*	*	0	67.9	0	0	63.3	*	*	*	*	**131.2**
	Coconut		current	100.6	96.8	114.1	83.5	0	0	0	0	0	0	63.7	79.8	**538.5**
		4.5	2030	87.5	83.5	99	43.7	0	0	0	0	0	0	61.2	77.9	**452.8**
			2050	60.2	84.1	100.1	44.5	0	0	0	0	0	0	62.1	78.9	**429.9**
			2080	85.7	84.9	92	66	0	0	0	0	0	0	60.9	72.8	**462.3**
		8.5	2030	86	83.7	99.5	78.9	0	0	0	0	0	0	52.2	57.2	**457.5**
			2050	89.9	85.5	101.1	82.4	0	0	0	0	0	0	62.8	80.3	**502**
			2080	92.9	87.5	98.8	85	0	0	0	0	76.4	0	44.2	56.3	**541.1**

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Irrigation requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU11 Northern Laterites	Arecanut		current	127	123.8	144.7	111.6	8.1	0	0	0	2.9	0	82.2	102.7	**703**
		4.5	2030	110.7	109.7	129.6	91.2	0	0	0	0	0	0	63.5	77	**581.7**
			2050	112.5	111.7	104.8	103.4	2.2	0	0	0	0	0	65.7	83.4	**583.7**
			2080	117	115.2	127.9	127.2	24.3	0	0	0	88.4	0	81.3	104.4	**785.7**
		8.5	2030	110.7	109.5	129.8	91.2	0	0	0	0	0	0	63.2	76.4	**580.8**
			2050	112.8	111.8	131.7	83.1	19.9	0	0	0	0	0	73.9	97.1	**630.3**
			2080	117	115.2	127.9	127.2	24.3	0	0	0	88.4	0	81.3	104.4	**785.7**
	Coconut- pepper- banana		current	100.7	96.1	112.8	83.1	0	0	0	0	0	0	64	80.1	**536.8**
		4.5	2030	87.3	83.5	99.4	63.4	0	0	0	0	0	0	50.5	58	**451.1**
			2050	89.2	85.3	101.2	64.7	0	0	0	0	0	0	52.1	59.9	**452.4**
			2080	92.7	87.5	95.9	97.9	0	0	0	0	71.4	0	68.7	85.6	**599.7**
		8.5	2030	87.6	83.6	99.7	63.6	0	0	0	0	0	0	50.2	57.8	**442.5**
			2050	89.5	85.4	100.9	54.9	0	0	0	0	0	0	61.2	78.6	**470.5**
			2080	92.7	87.5	95.9	97.9	0	0	0	0	71.4	0	68.7	85.6	**599.7**
AEU13 Northern Foot Hills	Cooconut- arecanut		current	100.7	96	76.7	92.9	0	0	0	0	0	0	52.2	67.9	**486.4**
		4.5	2030	88.7	85.7	74.3	74.9	0	0	0	0	0	0	51.6	64.6	**439.8**
			2050	90.1	86.8	100	19.1	0	0	0	0	10.2	0	60.3	55.5	**422**
			2080	89.9	87.7	85.5	75.8	0	0	0	0	67.7	0	47	60.9	**514.5**
		8.5	2030	89.5	86.3	92.4	57.7	0	0	0	0	36.9	0	44.2	61.2	**468.2**
			2050	91.3	87.4	101	18.7	0	0	0	0	40.1	0	61.3	55.6	**455.4**
			2080	87.5	82.5	79.3	60.6	0	0	0	0	59.1	0	61.1	30	**460.1**
	Rubber		current	128.6	125.2	110.5	123	7.8	0	0	0	1.2	0	72.1	91.9	**660.3**
		4.5	2030	112.8	112.4	105.5	104.1	2.6	0	0	0	0	0	66.3	84.8	**588.5**
			2050	114.1	113.3	106.8	105.3	2.8	0	0	0	0	0	67.1	85.1	**594.5**
			2080	114.8	115.2	117.9	105.8	20.2	0	0	0	85.8	0	61.9	81.3	**702.9**
		8.5	2030	113.4	112.6	123.3	86.8	0	0	0	0	54.5	0	58.8	81	**630.4**
			2050	115.8	114.7	132.9	44.4	16.8	0	0	0	58.1	0	76.2	75.6	**634.5**
			2080	108.5	106	108.3	88.4	19.8	0	0	0	76.3	0	75.7	47.9	**630.9**

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Irrigation requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern High Hills	Coconut- pepper- banana		current	100.6	96	82.3	61.5	0	0	0	0	0	0	70.4	19.5	**430.3**
		4.5	2030	90.3	86.2	91.5	57.2	0	0	0	0	36.9	0	44.7	62.1	**468.9**
			2050	91.3	87.4	101	18.7	0	0	0	0	38.7	0	61.3	55.6	**454**
			2080	94.8	89.9	81.5	76	0	0	0	0	59.1	0	57.9	48.5	**507.7**
		8.5	2030	89.6	86.7	79.5	54.5	0	0	0	0	0	0	66.8	12.5	**389.6**
			2050	92	87.6	91.6	72.1	0	0	0	0	0	0	54.4	21.3	**419**
			2080	94.9	90.3	91.3	85.2	0	0	0	0	14.9	0	67.9	34.7	**479.2**
	Rice- rice		current	*	*	*	*	72	0	0	0	*	*	*	*	**72**
		4.5	2030	*	*	*	0	72.4	0	0	0	*	*	*	*	**72.4**
			2050	*	*	*	0	71.9	0	0	0	*	*	*	*	**71.9**
			2080	*	*	*	0	69.9	0	0	0	*	*	*	*	**69.9**
		8.5	2030	*	*	*	0	136.2	0	0	0	*	*	*	*	**136.2**
			2050	*	*	*	0	69.7	0	0	0	*	*	*	*	**69.7**
			2080	*	*	*	0	69.8	0	0	0	*	*	*	*	**69.8**

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4.4.4. Irrigation water requirement of major cropping systems of various AEUs in Kasaragod district and impact of projected climate change

The Crop evapotranspiration (ETc) values of various cropping systems for AEU2, AEU7, AEU11, AEU13 and AEU15 of Kasaragod district were studied and presented in table 130.

Rice-rice-fallow and coconut monocropping are the major cropping systems of AEU2. In case of rice-rice-fallow the first cropping season is Virippu with a duration of four months (May to August) transplanted during first week of June and harvested during last week of August. The second crop Mundakan is having duration of six months (August to January) transplanted last week of September and harvested in first week of January. Since, coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show an increasing trend in case of rice-rice-fallow. In coconut there is a decreasing trend in projected ETc value except in the case of 2080 of RCP 8.5.

Rice-rice-fallow and coconut are major cropping systems in AEU7. Since coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend in the case of coconut and in the case of rice-rice-fallow the annual ETc values show an increasing trend.

Rice-rice-fallow and coconut are major cropping systems in AEU11. Since coconut is a perennial crop the ETc value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of projected climate will show a decreasing trend in the case of coconut except in 2080 RCP 8.5 and in case of rice-rice-fallow the annual ETc value shows a decreasing trend from current condition and increases in 2080 RCP 8.5.

Rice-fallow-fallow and coconut as major cropping systems in AEU13. Since coconut is a perennial crop the ETc values for a year is considered. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual

ETc value of projected climate will show a decreasing trend from the present value and in case of rice-fallow-fallow the annual ETc values decreases from present value.

Coconut-arecanut and rubber are major cropping systems in AEU15. Since coconut-arecanut and rubber are perennial crops the ETc values for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ETc value of coconut-arecanut will show an increasing trend and in the case of rubber ETc values of projected climate will show an increasing trend.

The irrigation requirement for various cropping systems of AEU2, AEU7, AEU11, AEU13 and AEU15 of Kasaragod district were studied and presented table 131.

The annual irrigation requirement of rice-rice-fallow and coconut for the present is 831.2 and 405.5 mm respectively in AEU2. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut will show an increasing trend from the present value and in case of rice-rice-fallow the values show a decreasing trend from the present. Irrigation is not required during the months May to October in both present and future projections of coconut. In rice-rice-fallow, the irrigation is not required for three months (April to July except May) for 2050 and 2080 RCP 4.5 and 2080 RCP 8.5.

The annual irrigation requirement of rice-rice-fallow and coconut monocropping for present is 91.2 and 408.8 mm respectively in AEU7. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut in the projected climate will show a increasing trend from the present value and in rice-rice-fallow system there is a slight difference in irrigation requirement values. In rice-rice-fallow cropping systems the number of months that does not requires irrigation in projected climate is about three months (April to July except May). In coconut cropping systems the number of months that does not requires irrigation in projected climate is about six months (May to October) except in 2030 RCP 8.5.

The annual irrigation requirement of rice-rice-fallow and coconut monocropping is 96.9 and 389.4 mm respectively in AEU11. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut will show an increasing trend and in case of rice-rice-fallow annual irrigation requirement shows an increase in 2030 RCP 4.5 and rest of the values show slight fluctuations. In coconut cropping system the number of months that does not require irrigation is about six months (May to October) in projected climate except in 2080 RCP 8.5 and in case of rice-rice-fallow the number of months that does not require irrigation is about two months (June and July).

The annual irrigation requirement of rice-fallow-fallow and coconut monocropping for the present is 96.7 and 367.1 mm respectively in AEU13. Comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut shows an increasing trend in 2050 RCP 4.5 and 2080 RCP 8.5 and in case of rice-fallow-fallow the annual irrigation requirement shows a slight decrease from the present value. In coconut cropping systems the number of months that does not requires irrigation of projected climate is about four months (May to August) and in case of rice-fallow-fallow the number of months that does not requires irrigation of projected climate is about two months (June and July) also in April in 2050 and 2080 RCP 4.5 and 2030, 2050 and 2080 RCP 8.5.

The annual irrigation requirement of coconut-arecanut and rubber monocropping for present is 394.5 and 526.5 mm respectively in AEU15. Comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual irrigation requirement of coconut will show an increasing trend from the present value except in the case of 2050 RCP 4.5 and 8.5. In the case of rubber, the irrigation requirement shows an increase from the present. In both cropping systems the number of months that does not requires irrigation is about six months (May to October).

Coconut of AEU7 have high irrigation requirement within the district.

Table 130. ETc value of various cropping systems in different AEUs of Kasaragod district

				Crop evapotranspiration ETc (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU2 Northern Coastal Plain	Coconut		current	89.3	80.1	89.3	90.9	97.4	85.8	79	82.8	83.9	89.8	90.1	93.5	**1051.9**
		4.5	2030	83.8	78.8	89.1	84.3	96.8	85.9	79.7	83	78.2	87.1	83.2	87.6	**1017.5**
			2050	85.1	79.4	89.3	85	97.6	87	80.7	83.9	78.9	87.8	84.5	88.1	**1027.3**
			2080	86.1	80	89.9	85.6	98.1	87.5	81.2	84.5	79	88.2	85	89	**1034.1**
		8.5	2030	84	79.2	90.1	85.8	100.3	86.4	80.8	84.1	79.9	88.4	83.8	89.1	**1031.9**
			2050	85.7	79.8	89.9	85.5	98.2	87.4	81.2	84.5	79.3	88.4	85.1	88.7	**1033.7**
			2080	89.1	82.1	92.5	88.4	100.8	90.6	84.6	87.1	81.7	90.9	88.9	91.4	**1068.1**
	Rice – Rice - fallow		current	4.3	*	*	3.2	74.1	126.4	115.2	43	50	132.3	142	145	**831.2**
		4.5	2030	4.1	*	*	3.1	75	126.4	115.7	43.2	46.8	128.1	128.6	134.8	**801.7**
			2050	4.1	*	*	3.2	75.6	127.9	117	43.7	47.1	129.1	130.4	135.4	**809.4**
			2080	4.2	*	*	3.2	76.1	128.6	117.6	44	47.3	129.6	131.1	136.7	**814.2**
		8.5	2030	4.1	*	*	3.2	77.5	127.2	117.5	43.8	47.9	130.1	129.4	136.7	**813.3**
			2050	4.2	*	*	3.2	76.2	128.6	117.5	44	47.4	129.9	131.2	136.5	**814.5**
			2080	4.3	*	*	3.3	78.4	133.1	122.3	45.5	48.9	133.8	136.9	140.5	**842.7**
AEU7 Kaipad Lands	Coconut		current	88.6	80.6	90.3	90.9	97.2	86.3	78.9	83.5	84.5	90.4	89.6	90.2	**1051**
		4.5	2030	83.8	78.3	89.1	84.8	97.4	86	80.5	83.7	79.6	88.1	83.9	89	**1024.2**
			2050	84.9	79.7	90.1	85.4	98.3	87.1	81.2	84.6	80.1	89.1	84.8	90.3	**1035.6**
			2080	86.1	80.3	90.9	86.1	101.2	88.2	82.2	85.5	81	90.1	85.8	91.4	**1048.8**
		8.5	2030	83.8	78.3	89.1	84.8	97.4	86	80.5	83.7	79.6	88.1	83.9	89	**1024.2**
			2050	84.9	79.7	90.1	85.4	98.3	87.1	81.2	84.6	80.1	89.1	84.8	90.3	**1035.6**
			2080	86.1	80.3	90.9	86.1	101.2	88.2	82.2	85.5	81	90.1	85.8	91.4	**1048.8**
	Rice – rice - Fallow		current	4.2	*	*	3.2	74.5	127.1	115.2	43.2	48	118.2	139.6	138.2	**807.2**
		4.5	2030	4.1	*	*	3.2	75.5	126.6	116.9	43.6	47.6	129.7	129.7	137	**809.8**
			2050	4.2	*	*	3.2	76.3	128.2	117.7	44.1	48	131	130.8	138.9	**818.2**
			2080	4.2	*	*	3.2	78.4	129.7	119.1	44.5	48.4	132.2	132.1	140.7	**828.3**
		8.5	2030	4.1	*	*	3.2	75.5	126.6	116.9	43.6	47.6	129.7	129.7	137	**809.8**
			2050	4.2	*	*	3.2	76.3	128.2	117.7	44.1	48	131	130.8	138.9	**818.2**
			2080	4.2	*	*	3.2	78.4	129.7	119.1	44.5	48.4	132.2	132.1	140.7	**828.3**

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Crop evapotranspiration ETc (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU11 Northern Laterites	Coconut		current	88.3	80.5	90.2	90.9	97.3	86.3	79	83.5	84.5	90.3	89.3	89.7	**1049.8**
		4.5	2030	83.6	78.5	88.7	83.9	95.1	84.3	78.1	81.2	76.3	85.2	81.5	85.5	**1001.9**
			2050	84.4	79.2	89.4	84.7	96	84.9	78.8	82	76.9	85.9	82.4	86.4	**1011**
			2080	85.8	80.3	90.5	85.5	97	86	79.7	83	77.8	86.9	83.5	87.6	**1023.6**
		8.5	2030	83.9	78.7	88.8	84.4	95.6	84.4	78.2	81.6	76.3	85.5	81.8	85.8	**1005**
			2050	85.3	79.8	90	85.6	97	86	79.7	83	78.1	87.1	83.6	87.3	**1022.5**
			2080	88.6	82.1	92.8	88.4	99.7	88.8	82.7	85.7	80.5	89.8	87	90.2	**1056.3**
	Rice – rice - fallow		current	4.2	*	*	3.2	74.6	127.2	115.2	43.2	50.3	133.1	139.3	137.6	**823.7**
		4.5	2030	4	*	*	3.1	73.5	124	112.8	42.2	45.7	125.3	125.7	130.5	**782.8**
			2050	4	*	*	3.1	74	124.9	113.9	42.5	46.1	126.4	127	132	**789.9**
			2080	4.1	*	*	3.1	74.9	126.3	115.1	43.1	46.7	127.8	128.6	133.9	**799.5**
		8.5	2030	4	*	*	3.1	73.7	124.1	113	42.3	45.8	125.6	126	130.8	**784.4**
			2050	4.1	*	*	3.1	74.9	126.4	115.4	43.2	46.8	128.1	128.7	133.5	**800.1**
			2080	4.2	*	*	3.3	77.2	130.5	119.4	44.5	48.1	132	133.9	137.9	**826.8**
AEU13 Northern Foot Hills	Coconut		current	88.4	80.6	90.3	90.9	97.2	86.3	79	83.5	84.5	90.3	89.3	90	**1050.3**
		4.5	2030	83.3	78.5	89.5	84.9	94.5	83.1	76.9	80.4	75.1	84.1	80.8	83.8	**994.9**
			2050	84.3	79.4	90.3	85.5	95.1	83.9	77.8	81.1	75.9	85	81.8	85	**1005.1**
			2080	86.5	81.2	91.4	86.7	96.8	85.5	79.4	82.7	77.5	86.9	83.7	87	**1025.3**
		8.5	2030	82.8	77.8	88.4	83.9	94.3	83.4	77.2	80.6	75.4	84.4	81	83.7	**992.9**
			2050	86.1	80.6	91.3	86.9	97	85.7	79.4	82.7	77.6	87.1	83.8	87	**1025.2**
			2080	86.1	80.6	91.3	86.9	97	85.7	79.4	82.7	77.6	87.1	83.8	87	**1025.2**
	Rice – fallow - fallow		current	*	*	*	3.2	74.6	127.2	115.2	42.3	*	*	*	*	**362.5**
		4.5	2030	*	*	*	3.1	72.5	122.3	111.3	40.9	*	*	*	*	**350.1**
			2050	*	*	*	3.1	73.2	123.4	112.4	41.4	*	*	*	*	**353.5**
			2080	*	*	*	3.1	74.6	125.8	114.8	42.2	*	*	*	*	**360.5**
		8.5	2030	*	*	*	3.1	72.8	122.7	111.2	40.9	*	*	*	*	**350.7**
			2050	*	*	*	3.2	74.6	126	114.8	42.2	*	*	*	*	**360.8**
			2080	*	*	*	3.2	74.6	126	114.8	42.2	*	*	*	*	**360.8**

Crop evapotranspiration ETc (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU15 Northern High Hills	Coconut-arecanut		current	84.4	74.7	87.5	87.2	90.3	77.6	71.8	75.9	76.7	82.7	80.9	85.3	**975**
		4.5	2030	86.1	80.1	90.2	86.2	93.1	86.2	80	83.6	78.4	87.5	84.4	88.3	**1024.1**
			2050	86.7	80.8	90.9	86.8	93.6	86.8	80.7	84.3	79.3	88.3	85.2	89.2	**1032.6**
			2080	87.9	81.6	91.6	87.4	94.6	88	81.8	85.2	80.2	89.3	86.3	90.5	**1044.4**
		8.5	2030	86.1	80.1	90.2	86.2	93.1	86.2	80	83.6	78.4	87.5	84.4	88.3	**1024.1**
			2050	86.7	80.8	90.9	86.8	93.6	86.8	80.7	84.3	79.3	88.3	85.2	89.2	**1032.6**
			2080	87.9	81.6	91.6	87.4	94.6	88	81.8	85.2	80.2	89.3	86.3	90.5	**1044.4**
	Rubber		current	106.9	69.1	112.4	112	96.9	98.4	91.1	95.9	95.8	102.1	98.7	105.8	**1185.1**
		4.5	2030	109.3	105.3	118.6	112.9	106.4	109.2	101.3	105	95.8	104.2	99.1	107.2	**1274.3**
			2050	110.3	106.4	119.5	113.8	107.2	110	102.3	106	96.7	104.8	99.8	108.3	**1285.1**
			2080	111.9	107.7	120.7	114.8	108.5	111.4	103.5	107	97.9	105.8	100.9	109.7	**1299.8**
		8.5	2030	109.3	105.3	118.6	112.9	106.4	109.2	101.3	105	95.8	104.2	99.1	107.2	**1274.3**
			2050	110.3	106.4	119.5	113.8	107.2	110	102.3	106	96.7	104.8	99.8	108.3	**1285.1**
			2080	111.9	107.7	120.7	114.8	108.5	111.4	103.5	107	97.9	105.8	100.9	109.7	**1299.8**

Table 131. Irrigation requirement of various cropping systems in different AEUs of Kasaragod district

Irrigation requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU2 Northern Coastal Plain	Coconut		current	89.2	80.1	89.2	70.1	0	0	0	0	0	0	0	76.9	**405.5**
		4.5	2030	83.7	78.7	48.9	76.7	0	0	0	0	0	0	54.6	60.7	**403.3**
			2050	85	79.3	73.1	77.1	0	0	0	0	0	0	69.5	52.9	**436.9**
			2080	86	79.9	64.8	64.8	0	0	0	0	0	0	67.8	51.5	**414.8**
		8.5	2030	83.9	79.1	73.8	84.2	0	0	0	0	0	0	55	60.3	**436.3**
			2050	85.5	79.6	65.3	83.2	0	0	0	0	0	0	59.4	57.9	**430.9**
			2080	89	82	75.8	74.2	0	0	0	0	0	0	64.2	45.5	**430.7**
	Rice – rice - fallow		current	4.3	*	*	0	84.2	0	0	72.5	87	18.5	11.4	128.6	**402.2**
		4.5	2030	4.1	*	*	0.2	84.2	0	0	7.9	86.7	5.9	100.1	107.8	**392.8**
			2050	4.1	*	*	0	84.2	0	0	8	86.7	9.5	115.5	100.2	**404.1**
			2080	4.2	*	*	0	84.2	0	0	8.1	86.7	9	113.9	99.3	**401.2**
		8.5	2030	4.1	*	*	2.5	84.3	0	0	8	86.8	6.2	100.5	108	**396.3**
			2050	4.2	*	*	2.2	84.2	0	0	8.1	86.7	6.7	105.5	105.6	**399**
			2080	4.3	*	*	0	84.3	0	0	8.3	86.9	8	112.2	94.6	**394.3**

Irrigation requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU7 Kaipad Lands	Coconut		current	88.5	80.5	83.7	53.9	0	0	0	0	0	0	58.3	43.9	**408.8**
		4.5	2030	83.6	78.3	89	59	0	0	0	0	0	0	61.4	58.8	**430.1**
			2050	84.8	79.6	84.9	49	0	0	0	0	0	0	72.6	56	**426.9**
			2080	74.5	80.2	85.1	56.6	0	0	0	0	0	0	74.3	53.4	**424.1**
		8.5	2030	83.8	78.3	89.1	84.8	97.4	86	80.5	83.7	79.6	88.1	83.9	89	**1024.2**
			2050	84.8	79.6	84.9	49	0	0	0	0	0	0	72.6	56	**426.9**
			2080	74.5	80.2	85.1	56.6	0	0	0	0	0	0	74.3	53.4	**424.1**
	Rice – rice - Fallow		current	4.2	*	*	0	84.2	0	0	7.9	91	5	108.4	92	**388.5**
		4.5	2030	4.1	*	*	0	84.2	0	0	8	89.7	3.8	107	106.9	**399.6**
			2050	4.2	*	*	0	84.2	0	0	8.1	88.1	6.4	118.6	104.6	**410**
			2080	4.2	*	*	0	84.3	0	0	8.1	88.8	6.8	120.6	102.7	**411.3**
		8.5	2030	4.1	*	*	0	84.2	0	0	8	89.7	3.8	107	106.9	**399.6**
			2050	4.2	*	*	0	84.2	0	0	8.1	88.1	6.4	118.6	104.6	**410**
			2080	4.2	*	*	0	84.3	0	0	8.1	88.8	6.8	120.6	102.7	**411.3**
AEU11 Northern Laterites	Coconut		current	88.1	80.4	25.2	83.7	0	0	0	0	0	0	56.7	55.3	**389.4**
		4.5	2030	83.5	78.4	37.4	82.1	0	0	0	0	0	0	66.3	45.5	**393.2**
			2050	84.3	79.1	47.7	78.4	0	0	0	0	0	0	67.8	40	**397.3**
			2080	85.6	80.2	59.6	60.1	0	0	0	0	0	0	69.1	28	**382.6**
		8.5	2030	83.7	78.6	47.4	78	0	0	0	0	0	0	67.2	39.4	**394.3**
			2050	85.2	79.7	58.9	67.2	0	0	0	0	0	0	68.1	42.7	**401.8**
			2080	88.5	82	62.1	60.7	60.7	0	0	0	28.6	0	57.3	36.9	**476.8**
	Rice – rice - fallow		current	4.2	*	*	0.7	89.2	0	0	7.9	92	6.7	106.7	103.2	**406.4**
		4.5	2030	4	*	*	2.4	89.2	0	0	7.7	91.5	7	110.5	90.6	**398.9**
			2050	4	*	*	0.6	89.2	0	0	7.7	94.1	4.4	112.3	85.6	**393.9**
			2080	4.1	*	*	0	89.2	0	0	7.9	94	5	114.2	74.2	**384.5**
		8.5	2030	4	*	*	0.6	89.2	0	0	7.7	93.8	4.1	111.3	84.4	**391.1**
			2050	4.1	*	*	0	89.2	0	0	7.9	94	5.1	113.2	88.7	**398.1**
			2080	4.2	*	*	0	89.3	0	0	8.1	110.8	1.4	104.2	84.5	**398.3**

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Irrigation requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU13 Northern Foot Hills	Coconut		current	88.3	80.5	23.4	82.6	0	0	0	0	17.4	0	65.5	9.4	**367.1**
		4.5	2030	83.2	78.4	51.6	77.7	0	0	0	0	10.9	0	56	5.2	**363**
			2050	84.1	79.3	64.5	60.1	0	0	0	0	10.4	0	67.5	6.7	**372.6**
			2080	86.3	81	57.8	57.4	0	0	0	0	0	0	57.5	4.6	**344.6**
		8.5	2030	82.7	77.6	44.7	46.3	0	0	0	0	9.2	0	66.8	19.7	**347**
			2050	86	80.5	65.5	51.5	0	0	0	0	0	0	57.6	17.6	**358.7**
			2080	86	80.5	77.6	60.3	0	0	0	0	28.1	0	57.5	14.5	**404.5**
	Rice – fallow-fallow		current	*	*	*	0.5	89.2	0	0	7	*	*	*	*	**96.7**
		4.5	2030	*	*	*	0.2	89.1	0	0	6.8	*	*	*	*	**96.1**
			2050	*	*	*	0	89.1	0	0	6.9	*	*	*	*	**96**
			2080	*	*	*	0	89.2	0	0	7	*	*	*	*	**96.2**
		8.5	2030	*	*	*	0	89.1	0	0	6.8	*	*	*	*	**95.9**
			2050	*	*	*	0	89.2	0	0	7	*	*	*	*	**96.2**
			2080	*	*	*	0	89.2	0	0	7	*	*	*	*	**96.2**
AEU15 Northern High Hills	Coconut-arecanut		current	84.3	74.6	47.9	80	0	0	0	0	0	0	51.6	56.1	**394.5**
		4.5	2030	85.9	80	69.9	69	0	0	0	0	0	0	69.6	45.9	**420.3**
			2050	86.6	80.7	68	43.8	0	0	0	0	0	0	69.8	45.7	**394.6**
			2080	87.8	81.5	70.6	79.5	0	0	0	0	0	0	58.8	39.3	**417.5**
		8.5	2030	85.9	80	69.9	69	0	0	0	0	0	0	69.6	45.9	**420.3**
			2050	86.6	80.7	68	43.8	0	0	0	0	0	0	69.8	45.7	**394.6**
			2080	87.8	81.5	70.6	79.5	0	0	0	0	0	0	58.8	39.3	**417.5**
	Rubber		current	106.8	95.9	72.8	104.7	0	0	0	0	0	0	69.6	76.7	**526.5**
		4.5	2030	109.1	105.1	98.2	95.7	0	0	0	0	0	0	84.2	64.9	**557.2**
			2050	110.1	106.2	96.7	70.8	0	0	0	0	0	0	84.3	64.9	**533**
			2080	111.8	107.6	99.5	106.8	0	0	0	0	0	0	73.3	58.6	**557.6**
		8.5	2030	109.1	105.1	98.2	95.7	0	0	0	0	0	0	84.2	64.9	**557.2**
			2050	110.1	106.2	96.7	70.8	0	0	0	0	0	0	84.3	64.9	**533**
			2080	111.8	107.6	99.5	106.8	0	0	0	0	0	0	73.3	58.6	**557.6**

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4.5. CROP WEATHER CALENDER OF RICE BASED CROPPING SYSTEM

The figures (fig.6 to 12) illustrates the present and projected changes of rice crop in Northern coastal plain (AEU2), Northern laterites (AEU11) and Northern high hills (AEU15) of Kozhikode, Wayanad, Kannur Kasaragod calendar under anticipated climate. The general tendency in different AEUs is that the length of growing period of the cropping season in the major rice growing areas is that there is no much difference in the growing period among various agro-ecological units, inferring a suitable operating under projected climate as per RCP 4.5. It is also evident from the figures that the sowing date will be lagged by two weeks in AEU2 of Kozhikode district and three weeks in AEU2 Kasaragod district. Sowing date will be delayed by five weeks in AEU2 of Kozhikode and Kasaragod districts and sowing date is delayed by one week in AEU11 of Kasaragod district due to delay in summer showers. It can be also observed that the crops will have to suffer water stress during the grain filling stage at time of harvest in almost all the studied cases of different AEUs. AEU2 of Kannur district was found to have an increase in the rainfall during grain formation stage with respect to other AEUs.

In general, there will be an adequate amount 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 fulfil 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 lead to high soil erosion and nutrient loss and worsen the crop productivity.

In projected climate of RCP 4.5 there will be no much variation in the number of months having the surplus. The annual surplus values will have a fluctuating trend in Wayanad, Kannur and Kasaragod districts and a decreasing trend in Kozhikode district. 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 the agro-ecological unit. At present, adjustments to the agricultural calendar do not seem consistent across locations. Due to climate change, the length of growing period 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.

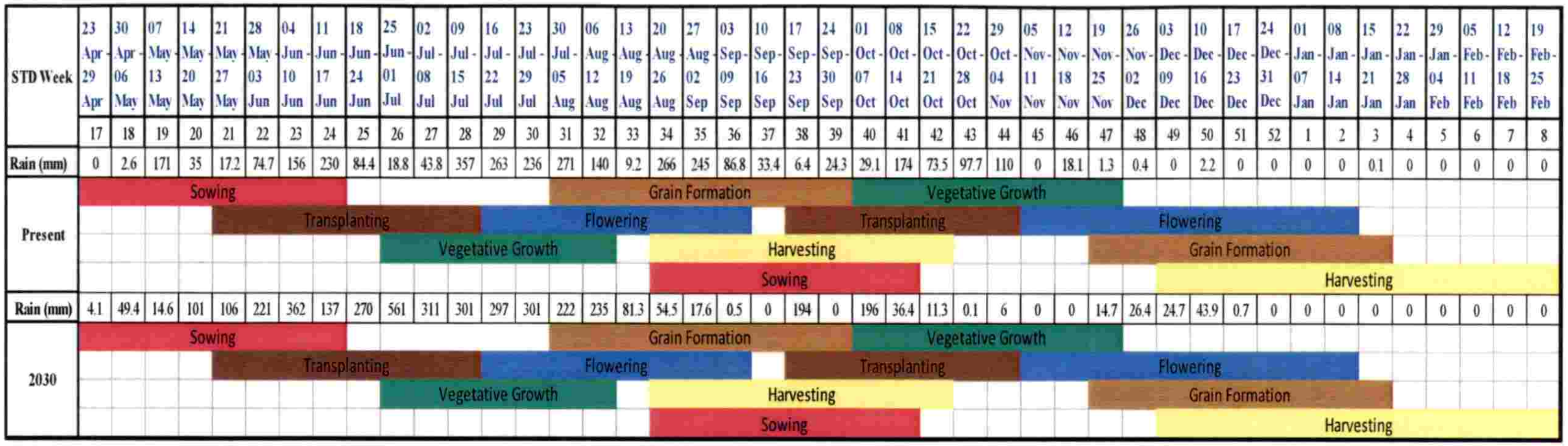

Fig.7. Crop weather calendar of northern coastal plain (AEU2) of Kannur district

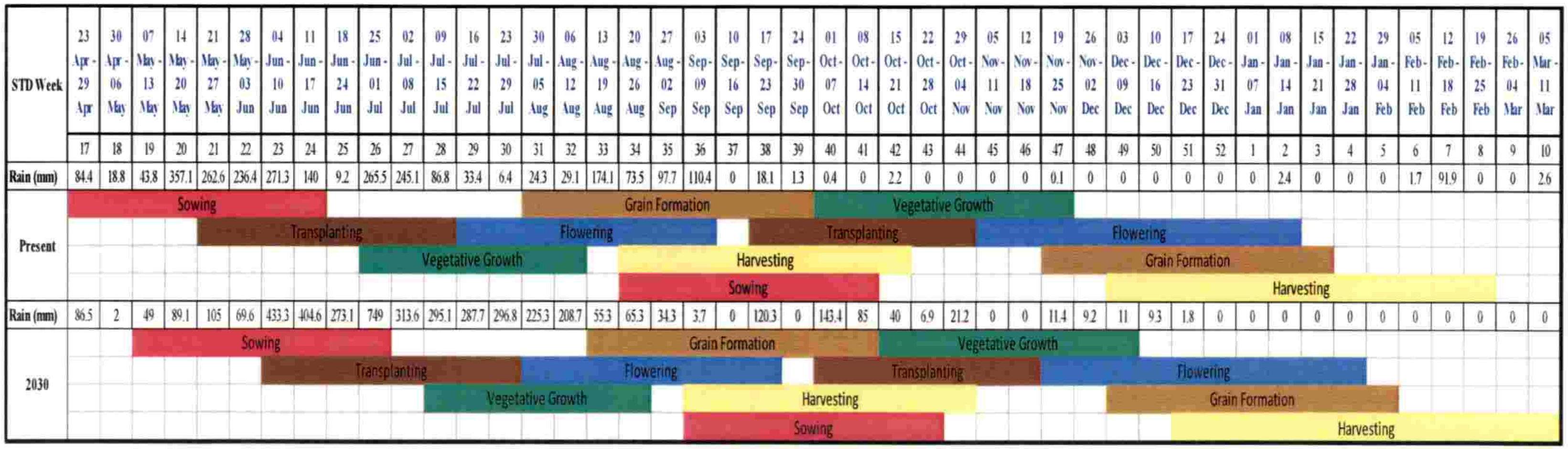

Fig.8. Crop weather calendar of northern coastal plain (AEU2) of Kozhikode district

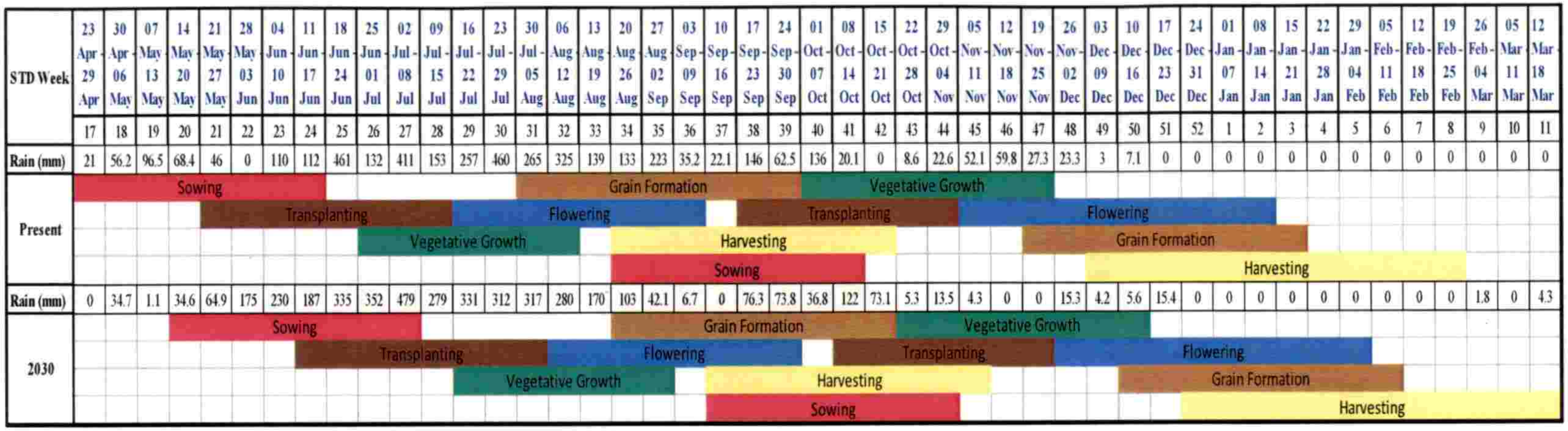

Fig.9. Crop weather calendar of northern coastal plain (AEU2) of Kasargode district

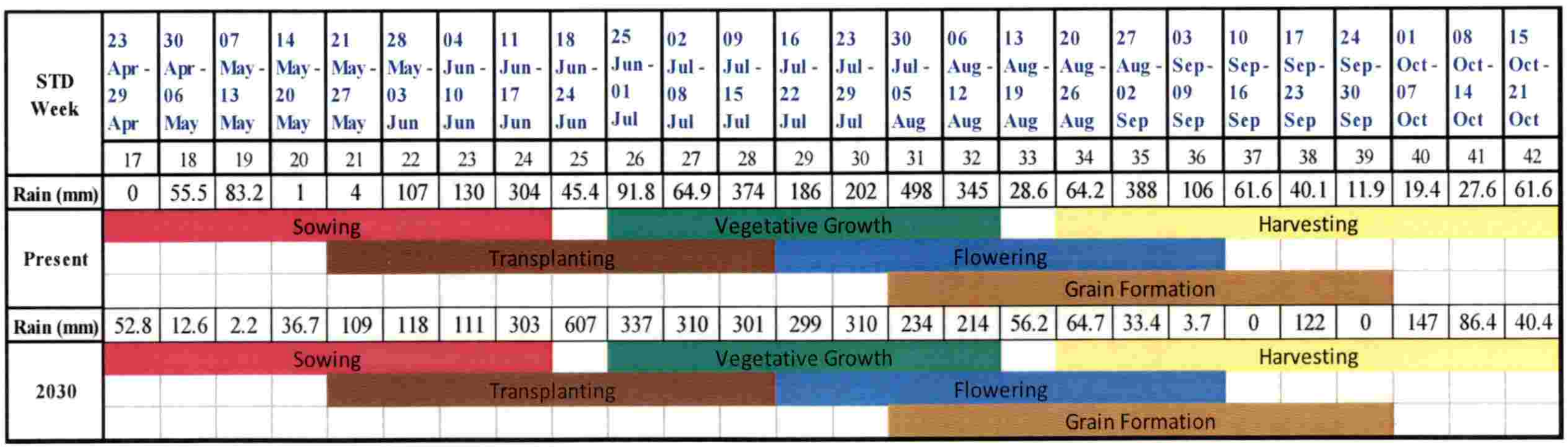

Fig. 10. Crop weather calendar of Kaipad land (AEU7) of Kannur district

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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	55.5	83.2	1	4	107	130	304	45.4	91.8	64.9	374	186	202	498	345	28.6	64.2	388	106	61.6	40.1
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
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Transplanting
															Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation
																		Sowing	Sowing	Sowing	Sowing	Sowing
Rain (mm)	14.4	84	22.1	38.4	130	263	189	196	656	537	326	313	307	314	238	222	60	68.2	35.5	4.3	0	127
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
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Transplanting
															Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation
																		Sowing	Sowing	Sowing	Sowing	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	19 Feb - 25 Feb
	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8
Rain (mm)	11.9	19.4	27.6	61.6	76.2	1.8	0	20.6	15.2	0	0	59.8	0	0	0	0	0	0	0	0	0	0
Present	Harvesting	Harvesting	Harvesting	Harvesting			Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering						
	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting																
	Grain Formation	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
	Sowing	Sowing	Sowing						Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation					
Rain (mm)	0	144	86.1	39.4	7	22.6	0	0	10.3	9.4	10.2	18.1	2	0	0	0	0	0	0	0	0	0
2030	Harvesting	Harvesting	Harvesting	Harvesting			Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering						
	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting																
	Grain Formation	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
	Sowing	Sowing	Sowing						Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation					

Fig. 11. Crop weather calendar of Kaipad land (AEU7) of Kasargode 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	55.5	83.2	1	4	107	130	304	45.4	91.8	64.9	374	186	202	498	345	28.6	64.2	388	106	61.6	40.1
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
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Transplanting
															Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation
																		Sowing	Sowing	Sowing	Sowing	Sowing
Rain (mm)	11.5	163	0	49.9	247	90.4	243	229	455	225	563	320	337	465	259	165	198	46.2	14.2	7.3	0	220
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
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering		Transplanting
															Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation
																		Sowing	Sowing	Sowing	Sowing	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	19 Feb - 25 Feb
	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8
Rain (mm)	11.9	19.4	27.6	61.6	76.2	1.8	0	20.6	15.2	0	0	59.8	0	0	0	0	0	0	0	0	0	0
Present	Harvesting	Harvesting	Harvesting	Harvesting			Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering						
	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting																
	Grain Formation	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
	Sowing	Sowing	Sowing						Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation					
Rain (mm)	0	156	101	43.4	5.9	14.7	4.9	0	17.8	10.1	6.7	5.2	3.7	0	0	0	0	7.9	0	0	0	0
2030	Harvesting	Harvesting	Harvesting	Harvesting			Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering						
	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting																
	Grain Formation	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth		Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
	Sowing	Sowing	Sowing						Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation					

Fig 12. Crop weather calendar of Kaipad land (AEU7) in Kozhikode district

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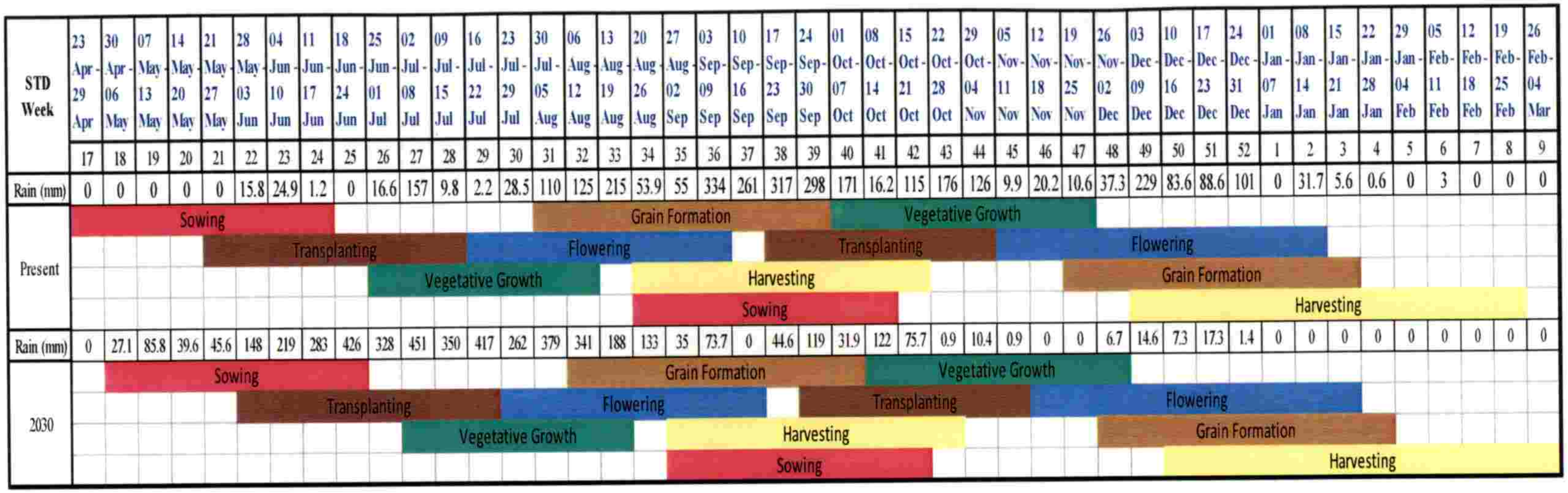

Fig 13. Crop weather calendar of northern laterites (AEU11) in Kasargode district

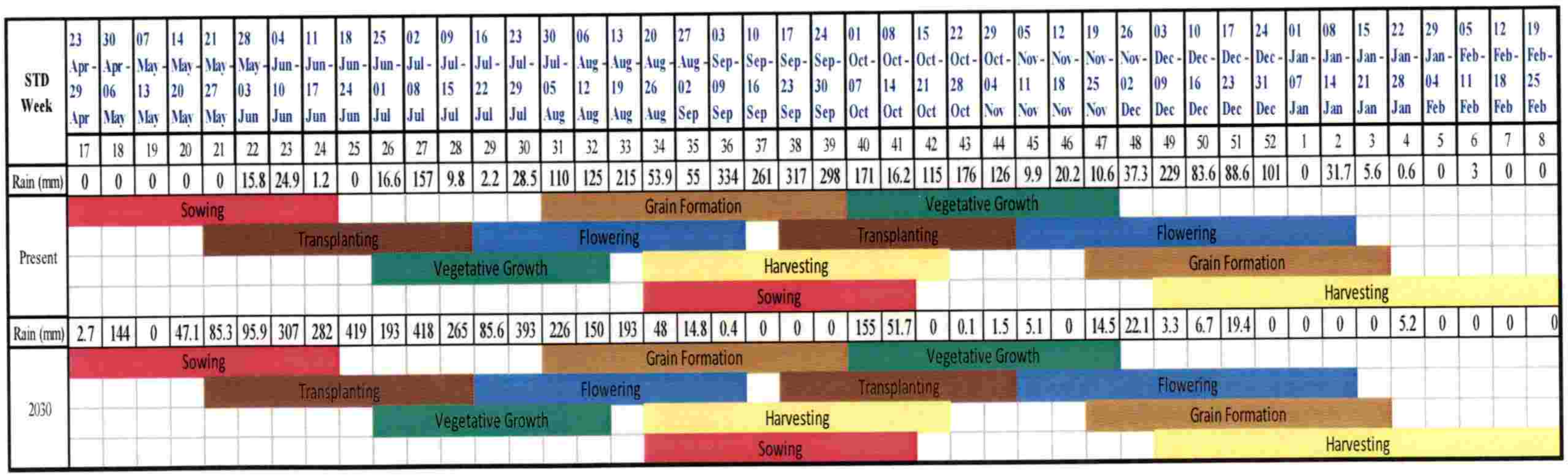

Fig 14. Crop weather calendar of northern laterites (AEU11) in Kozhikode district

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)	10.2	0	0	0	0	45.4	0	22.6	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
Present	Sowing														Grain Formation									Vegetative Growth																				
Present					Transplanting								Flowering									Transplanting							Flowering															
Present										Vegetative Growth								Harvesting													Grain Formation													
Present																		Sowing															Harvesting											
Rain (mm)	28.1	23.7	45.1	105.7	87.3	151.6	289.2	263.5	212	248.4	542.6	272.3	354.6	299.6	314.2	236.1	123.1	77.6	22.7	33.5	0	0	0	16	177.1	0	0.2	14.9	2.5	0	0	24.4	3.1	5.9	21.7	0	0	0	0	0	0	0	0	0
2030	Sowing														Grain Formation									Vegetative Growth																				
2030					Transplanting								Flowering									Transplanting							Flowering															
2030										Vegetative Growth								Harvesting													Grain Formation													
2030																		Sowing															Harvesting											

Fig 15. Crop weather calendar of northern high hills (AEU15) in Kannur 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)	10.2	0	0	0	0	45.4	0	22.6	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
Present	Sowing														Grain Formation									Vegetative Growth																				
Present					Transplanting								Flowering									Transplanting							Flowering															
Present										Vegetative Growth								Harvesting													Grain Formation													
Present																		Sowing															Harvesting											
Rain (mm)	4.7	59.2	0.1	54.2	73.2	152.9	235.8	92.4	213.3	308.9	488.7	272.1	305.8	334.6	277.4	227.9	140.6	112.9	0	52.3	0	0	0	11	141.7	91.3	0.1	9.6	4.2	0	0	15.3	26.4	28.1	22.1	0	0	0	0	0	0	0	0	0
2030	Sowing														Grain Formation									Vegetative Growth																				
2030					Transplanting								Flowering									Transplanting							Flowering															
2030										Vegetative Growth								Harvesting													Grain Formation													
2030																		Sowing															Harvesting											

Fig 16. Crop weather calendar of northern high hills (AEU15) in Wayanad district

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Chapter 5. Summary

Climate change have become an important limiting factor for agricultural development. The risk of climate inconsistency 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 alleviate the negative effects of climate change, researchers have generally stressed incremental adaptation to current cropping systems, such as the adjustment of planting window, appropriate variety and enhanced agronomic practices. The concept of AEZ delineation is a good approach for diverse farming actions performed by the farmers and is a beneficial tool for the study of the impact of climate change.

The objectives of the study are:

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

Method of analysis

CROPWAT model was used for the computations of crop evapotranspiration, crop water requirements and irrigation requirements for the improvement of irrigation scheduling under various management environments 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 figure PET and Thornthwaite water balances.

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Major finding of the study

- The monthly rainfall of various Agro ecological units of Northern Kerala indicate an 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 month of March 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
- Most of the agro ecological units in Northern Kerala indicate a decreasing pattern in the length of growing period in projected climate as per RCP 4.5
- In projected climate the maximum amount of potential evapotranspiration can be observed during the months March, May and July 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
- The number of periods where deficit will happen indicate a stable trend whereas the annual amount of deficit shows an increasing pattern in projected climate
- The crop evapotranspiration indicates an increasing trend in the rice-based cropping system during the projected climate
- The cropping systems like coconut based and Rubber based shows a decreasing trend in the crop evapotranspiration in projected climate whereas in coffee and cardamom-based cropping system indicate an increasing trend
- The irrigation 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
- 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 northern Kerala

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ABSTRACT OF THE THESIS

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ABSTRACT

Climate change poses a developing threat to sustainability of social and economic development, livelihoods, and environmental management across the globe. Characterizing 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 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 southern 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 northern Kerala.

Daily rainfall data for the period 1991-2014 were collected from the India Meteorological Department, Thiruvananthapurm. 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. 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.

The annual rainfall availability in most of the AEUs of Kozhikode, Kannur, Kasaragod and Wayanad districts show an increasing trend in the projected climate. The number of annual rainy days generally shows a linear trend. The seasonal rainfall of southwest and summer monsoon will show an increase from the current situation where as northeast monsoon and winter will have a decreasing trend.

In projected climate of both RCP 4.5 and 8.5 the number of months having the surplus and deficit have a similar trend compared to present situation. The crop evapotranspiration values of rice-based cropping system will show a tendency to decrease. In perennial cropping systems of coconut based and rubber the projected crop evapotranspiration will have a reduction from the present

situation whereas in coffee-based cropping system the ETc will have an increasing trend.

The irrigation requirement of all the major cropping systems will increase from the present situation except in the case of rice-fallow-fallow. The length of growing period of the cropping season 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 sowing date will be delayed up to three to five weeks. 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 time of harvest in almost all the considered cases.

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