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

By

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(2012-20-113)

THESIS

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DECLARATION

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

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SYMBOLS AND ABBREVIATIONS

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

P	-Precipitation
PET	-Potential Evapotranspiration
RCP	-Representative Concentration Pathway
WD	-Water Deficit
WS	- Water Surplus
W/m^2	- Watts per square Meter

CHAPTER 1. INTRODUCTION

Climate change challenges current and future global food production due to the direct effects of changes in mean climatic conditions, increasing risks from extreme weather events, increased atmospheric carbon dioxide (CO_2) concentration and increasing pest damage. Direct drivers of climate impacts on crop yields include long-term change in average temperature and precipitation conditions, and the increasing occurrence of extreme weather events such as extreme temperatures, droughts, floods and tropical storms. In addition, crop yields are sensitive to indirect effects of climate change on freshwater resources, pests and diseases, and sea level rise. Finally, changes in atmospheric composition resulting from GHG emissions, chiefly carbon dioxide (CO_2) and ozone (O_3) concentrations, also play a crucial role in photosynthesis and crop yield.

Impacts of climate change on the agriculture are projected to steadily manifest directly from changes in land and water regimes, the likely primary channels of change. Changes in the frequency and intensity of droughts, flooding, and storm damage are expected. Climate change is likely to result in long-term water and other resource scarcities, worsening soil conditions, drought and desertification, disease and pest outbreaks on crops and livestock, sea-level rise, and so on. Vulnerable areas are expected to experience losses in agricultural productivity, primarily due to reductions in crop yields.

To stabilize the negative effects of climate change, researchers have generally emphasized incremental adaptation to existing cropping systems, such as the adjustment of planting window, suitable variety and improved agronomic practices. Although these adaptations might indeed be effective in terms of improved grain yield, a growing sensitivity of crop production to water shortages has also been observed. Considering the possibility of further reductions in water availability for agriculture, such incremental adjustments are unlikely to provide long-term solutions to the problems of inadequate food and water supplies. Thus, more extensive changes in cropping systems should be considered.

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

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

Climate change, especially changes in rainfall patterns, is particularly important for rainfed agriculture. Soil moisture limitations reduce crop productivity and increase the risk of rainfed farming systems. Although the risk of climate variability is reduced by the use of irrigation, irrigated farming systems are dependent on reliable water resources; therefore they may be exposed to changes in the spatial and temporal distribution of rainfall in a location. So purpose of this study is to delineate the effects of climate change on regional water availability, changes in the cropping pattern and water requirement at agro ecological unit level of southern 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 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 southern Kerala under different climate change scenarios.
2. 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 southern Kerala.

Climate change is aggravating challenge faced by the agriculture sector. Climate change-induced increases in temperatures, rainfall variation and the frequency and intensity of extreme weather events are adding to pressure on the global agriculture system, which is already struggling to meet the rising demands for food and renewable energy. The changing climate is also contributing to resource problems beyond food security, such as water scarcity, pollution and soil degradation. Climate change is expected to negatively affect both crop and livestock production systems in most regions, although some countries may actually benefit from the changing conditions. 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 southern 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 globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85°C, over the period 1880 to 2012. Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP 2.6. It is likely to exceed 2.0°C for RCP 6.0 and RCP 8.5, and more likely than not to exceed 2.0°C for RCP 4.5. Warming will continue beyond 2100 under all RCP scenarios except RCP 2.6. Warming will continue to exhibit inter annual-to-decadal variability and will not be regionally uniform (IPCC, 2013).

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.

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.

Lobell (2011) and Nelson (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 evapotranspiration (ET_0) of wheat for 2020–2021 and 2050–2051 years.

2.2.1 Climate change impact on Indian agriculture

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

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

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2.3. Climate change and agro ecological zones

Most Indian workers have adopted the classification strategies based on techniques developed by Koeppen (1936), Thornthwaite (1931, 1948), Thornthwaite and Mather (1955), Cochevne and Franquien (1967), Papadakis (1970), 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 (1972); 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.

Raman and Murthy (1971) worked out water availability periods for 200 Indian stations using Cocheme and Franquine (1967) method.

The National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) has classified India into agro-ecological regions based on climatic and ecological conditions (Murthy and Panday 1978).

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.

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

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

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

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.

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

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

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.

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

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.

Month is a fairly long period for critical crop growth phases which are usually of a week or ten days duration. The soil water holding capacity can usually 7 buffer moisture availability for one week or more, so that weekly rainfall models can be used (Sarker, 1978).

Sarker *et al.,* (1978) have analyzed weekly rainfall in the dry farming tract of Karnataka by fitting gamma distribution probability model. Dickinson (1983) concluded that Climate change will affect the terrestrial biosphere through changes in the regional energy balance.

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

According to Pisharoty (1986), annual rainfall over the plains of India based on the data of 2800 stations is 117 cm and this is the highest value anywhere in the world for a country of the same size of India.

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

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

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

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

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

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

2.4.3. Potential evapotranspiration (PET)

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

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

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

Matejka (1972) mapped and tabulated Thornthwaite's potential evapotranspiration estimates calculated for 141 meteorological stations throughout Czechoslovakia, discussing their distribution in relation to bioclimatic zones and altitudinal zones of forest associations.

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 ET_0 (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.

Changes in soil moisture and evapotranspiration are likely to have large impacts on water and forest resources, since the distribution and abundance of these resources are controlled to a large extent by the volume and seasonality of available moisture (Neilson *et al.*, 1992).

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

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

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

2.5. Climate change and water requirement

Crop water requirement is defined as the depth of water needed to meet the water loss through evapotranspiration of a disease free crop, growing in large field under non-restricting soil conditions including soil water and fertility and achieving full production potential under given growing environment. Crop water demand is calculated as the product of the estimated reference evapotranspiration (ET_0) and the crop factor (K_c) (Doorenbos, 1984).

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

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

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

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

2.5.1. Crop water estimation

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

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

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

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

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

Kar and Verma (2005) computed the crop water requirement of rice using CROPWAT 4.0 model as 450- 550 mm, 600-720 mm, 775-875 mm for autumn rice, winter rice and summer rice respectively in different agro-ecological sub-regions. Sheng-Feng Kuo (2006) conducted field experiments to calculate the reference and actual crop evapotranspiration, derived the crop coefficient, and collected requirements input data for the CROPWAT irrigation management model to estimate the irrigation water requirements of paddy and upland crops. In the paddy fields, the irrigation water requirements and deep percolation were 962 and 295 mm, respectively, for the first rice crop, and 1114 and 296 mm for the second rice crop. For the irrigated single and double rice cropping patterns the CROPWAT model simulated results indicate that the annual crop water demands are 507 and 1019 mm, respectively, and the monthly water requirements peaked in October at 126 mm and in January at 192 mm, respectively.

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

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

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

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); Hundal *et al.,* (1993).

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

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 (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 (ET_c) 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 (ET_0) 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) and Raman and Murthy (1971) attempted for assessing the water availability periods based on climatic and soil conditions. Murthy (1973, 1976) determined water availability periods using actual evapotranspiration (AET) and potential evapotranspiration (PET), all these methods utilized monthly or weekly mean rainfall.

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

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

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

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

2.7. Crop planning

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

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

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

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

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

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

Budhar *et al.,* (1991) suggested rainfall based cropping system in Palacode Taluk of North Western region of Tamil Nadu, Kulandaivelu and Jayachandran (1992) classified drought and developed a crop plan for Tamil Nadu. The severity of drought was determined by the prevalent soil type in various regions. Drought prone areas were classified based on precipitation (P), potential evapotranspiration (PET) and soil type to provide more precise information in rainfall and to develop suitable crop plan. The P/PET ratio provides a measure of whether certain crops can be grown at a place or not. Based on the ratio, a climatic index was developed and the values were super imposed on a soil map to identify local drought prone areas, and to classify them as mild, moderate or severe.

Shranker *et al.,* (1992) analyzed rainfall data for 1981-89 recorded at Jabalpur, Madhya Pradesh to suggest strategies for crop planning during the rainy season. Budhar and Gopalaswamy (1992) presented annual, seasonal, monthly and weekly rainfall data and suitable cropping systems for the 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 combined effect of greenhouse gases CH_4, N_2O, CFC_{11}, CFC_{12} and O_3 is equivalent to an additional 40-50 ppm increase of CO_2 (Bach, 1989). The increased level of carbon dioxide from 340 to 680 ppm could increase the yield of major crops by 10- 15 per cent especially in C_3 plants like rice (Allen, 1990).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

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

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

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

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

The present work was undertaken with the objective of studying 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 southern Kerala. Agro-Ecological Units Maps of Kerala shows the location of weather stations in the State (Fig. 1).

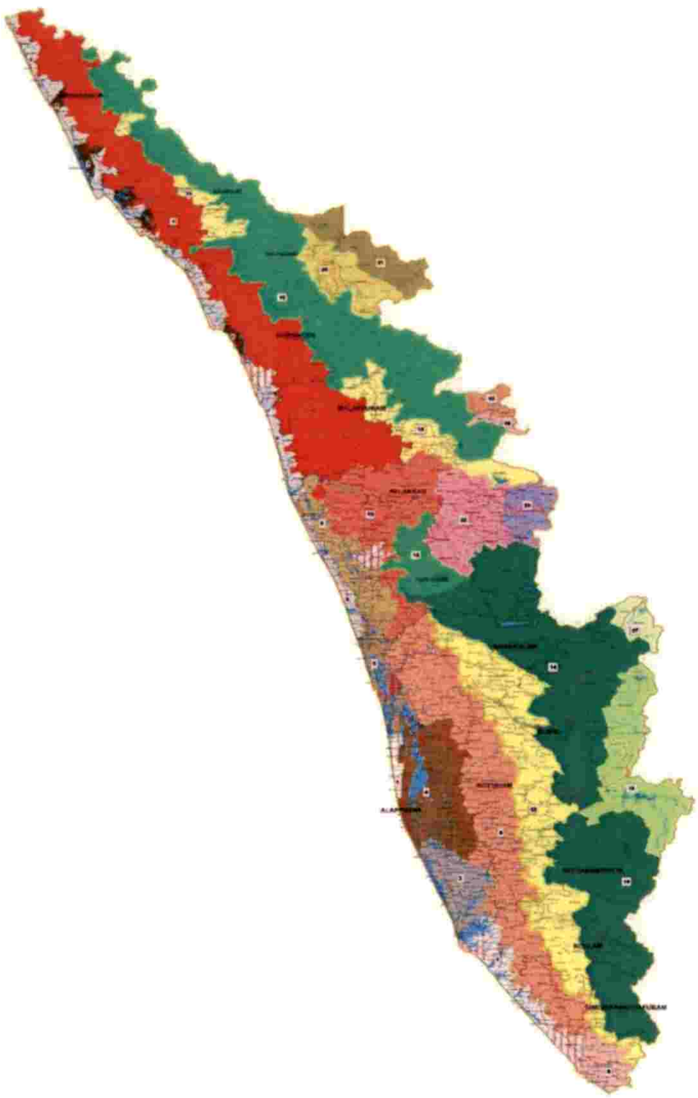

Fig. 1. Agro-Ecological Unit wise map of Kerala

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	Alappuzha	Alappuzha	09^{0}33'N	76^{0}25'E
02		Chengannur	09^{0}19'N	76^{0}37'E
03		Cherthala	09^{0}42'N	76^{0}20'E
04		Haripad	09^{0}15'N	76^{0}25'E
05		Kayamkulam (RARS)	09^{0}30'N	76^{0}20'E
06		Mancompu	09^{0}05'N	76^{0}05'E
07		Mavelikkara	09^{0}14'N	76^{0}31'E
08	Idukki	Devikulam	10^{0}04'N	77^{0}06'E
09		Idukki	09^{0}50'N	76^{0}55'E
10		Munnar	10^{0}00'N	77^{0}09'E
11		Peermede	09^{0}34'N	76^{0}59'E
12		Thodupuzha	09^{0}50'N	76^{0}40'E
13	Kollam	Aryankavu	08^{0}59'N	76^{0}10'E
14		Kollam	08^{0}53'N	76^{0}37'E
15		Punalur	09^{0}00'N	76^{0}55'E
16	Kottayam	Kottayam	09^{0}35'N	76^{0}31'E
17		Kozha	12^{0}03'N	76^{0}34'E
18		Kumarakom	09^{0}40'N	76^{0}30'E
19		Kanjirappally	09^{0}33'N	76^{0}47'E
20		Vaikom	09^{0}46'N	76^{0}24'E
21	Pathanamthitta	Konni	09^{0}15'N	76^{0}50'E
22		Thiruvalla	09^{0}24'N	76^{0}35'E
23	Thiruvananthapuram	AP	08^{0}28'N	76^{0}57'E
24		Nedumangad	08^{0}36'N	77^{0}00'E
25		Neyyattinkara	08^{0}23'N	77^{0}05'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. Reference crop Evapotranspiration (ET_0)

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

$$ET_0 = c\ [W.\ Rn + (1\text{-}w).\ f(u).\ (ea\text{-}ed)]$$

Where,

ET_0 = Reference crop evapotranspiration in mm/day

W = Temperature - related weighting factor

Rn = Net radiation in equivalent evaporation in mm/day

f(u) = Wind related function

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

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

ET_0 for all the rain gauge stations has been interpolated based on Agro Ecological Units.

3.2.3. Water Balance Studies

Water balances have been computed following the book-keeping method of Thornthwaite and Mather (1955). The field capacity of the soil to hold moisture was assumed considering the type of soil and vegetation. 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

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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 that AE is the sum of P and St without considering the sign of St.

Step 9. Moisture deficit (D)

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

Step 10. Moisture surplus (S)

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

Step 11. Water Run-off (RO)

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

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

It is computed in areas of snow fall.

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

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

Step 14. Total Moisture Detention (*DT*)

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

3.2.4. Length of growing period

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

- Humid period: AET ≥ 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

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

The potential evapotranspiration (ET_0) was computed by Penman-Monteith Model. In this model, most of the equation parameters are directly measured or can be readily calculated from weather data. The equation can be utilized for the direct calculation of any crop evapotranspiration (ET_c).The FAO Penman-Monteith method suggested by Verhoef and Feddes (1991) to estimate ET_0 is given as

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

ET_0	- Reference evapotranspiration [mm day-1]
R_n	-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]
u_2	-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]
γ	-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
RCP2.6	Its radiative forcing level first reaches a value around 3.1 Wm^{-2} mid-century, returning to 2.6 Wm^{-2} by 2100. Under this scenario greenhouse gas (GHG) emissions and emissions of air pollutants are reduced substantially over time.
RCP4.5	It is a stabilization scenario where total radiative forcing is stabilized before 2100 by employing a range of technologies and strategies for reducing GHG emissions.
RCP6.0	It is a stabilization scenario where total radiative forcing is stabilized after 2100 without overshoot by employing a range of technologies and strategies for reducing GHG emissions.
RCP8.5	It is characterized by increasing GHG emissions over time representative of scenarios in the literature leading to high GHG concentration levels.

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 have been 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 are presented in this chapter. The changes in rainfall pattern and water balance due to changes in climate and its impact on irrigation water requirement and crop growing periods were studied.

4.1. Rainfall analysis

The data collected from India Meteorological Department, Thiruvananthapuram from 1991 to 2014 and the data from General Circulation Models based on RCP 4.5 and 8.5 were analyzed. The rainfall parameters or indices like seasonal and monthly rainfall, rainy days, high rainfall events, length of growing period etc. were calculated for the six districts viz. Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Kottayam, and Alappuzha comprises southern Kerala.

4.1.1 Rainfall analysis of various AEUs of Thiruvananthapuram district

The Thiruvananthapuram district has divided into five agro ecological units (fig.2) comprising southern coastal plain (AEU1), southern laterites (AEU8), south central laterites (AEU9), southern and central foothills (AEU12), and south high hills (AEU14).

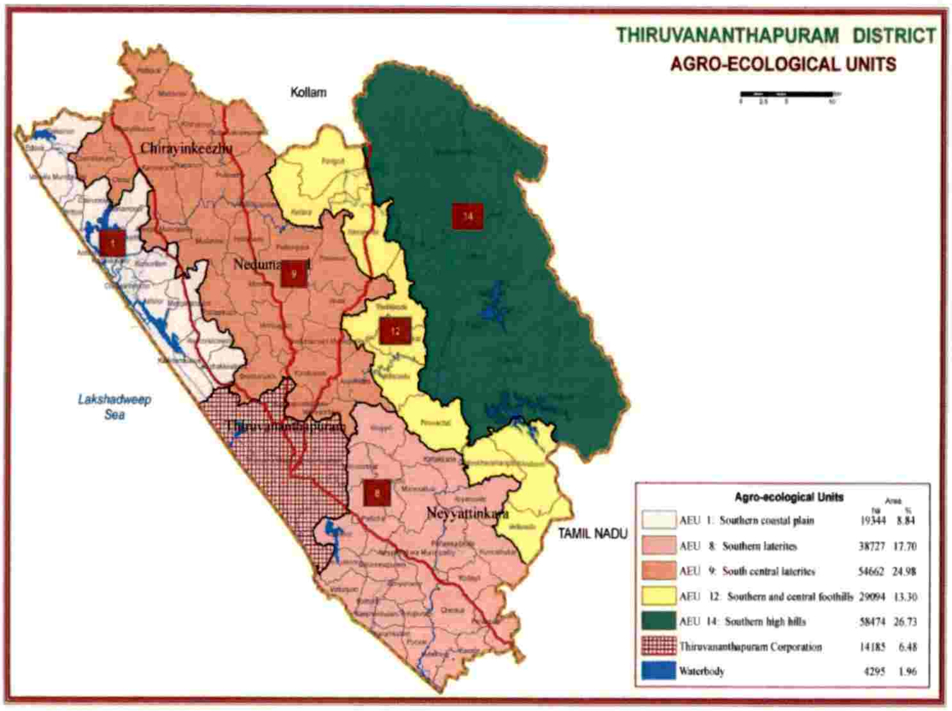

Fig.2 Agro-Ecological Unit wise map of Thiruvananthapuram District

Each AEU occupies 19344 ha (8.84%), 38727 ha (17.70%), 54662 ha (24.98%), 29094 ha (13.30%) and 58474 ha (26.73%) respectively.

4.1.1.1 Rainfall analysis of southern coastal plain (AEU1) and impact of projected climate change in Thiruvananthapuram district

The southern coastal plain agro-ecological unit is delineated to represent the nearly level coastal lands where sands are the dominant soil type. The unit comprises 42 panchayats along the coast from Thiruvananthapuram to Ernakulum district. The unit covers 56,782 ha (1.46 %) in the state.

4.1.1.1.1 Rainfall and Rainy days of southern coastal plain (AEU1) in Thiruvananthapuram district

The monthly rainfall distribution of southern coastal plain (AEU1) for the present and projected climate according to RCP 4.5 and RCP 8.5 were studied and presented in the table 3.

Table 3. Monthly rainfall distribution under projected climate of southern coastal plain (AEU1) in Thiruvananthapuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	18.4	60	27.5	23.2	58.6	19.2	11.5
February	45.3	1.2	39.1	25.5	2.3	30	4.6
March	61	20.3	21	23.2	30.5	22.6	24.6
April	144.9	51.1	51.8	53.1	58.1	54.3	54.8
May	271.7	184.1	165.9	167.1	164.3	150.4	157.6
June	597.7	540	573.9	586.7	575.3	484.3	574.7
July	501.3	485.6	385.4	407.9	468.3	503.4	451.1
August	339.6	399.2	454.8	416.5	406.6	390.3	406.5
September	294	0.6	8.7	8.8	0.6	33.5	82.7
October	364.6	234.8	239.9	252.5	236.1	251.9	266.1
November	191.9	174.1	185.7	119.1	184.7	194.9	59.3
December	40.3	103.5	108.1	122.9	107.2	91.2	6.7
Total	**2870.7**	**2254.5**	**2261.8**	**2206.5**	**2292.6**	**2226**	**2100.2**

Presently, the annual rainfall is around (2870.7 mm). June (597.7 mm) and July (501.3 mm) are the wettest months. January (18.4 mm) and December (40.3 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be lower whereas January, February and march there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, March, April, May, September and October. As per the projections based on RCP 4.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The monthly rainy days in southern coastal plain (AEU1) for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in the table 4.

Table 4. Monthly rainy days under projected climate of southern coastal plain (AEU1) in Thiruvananthapuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	1	2	1	1
February	2	0	1	1	0	1	1
March	3	3	3	3	4	3	2
April	7	3	3	3	3	3	7
May	11	14	12	11	13	10	8
June	21	23	24	24	23	23	23
July	22	27	24	24	27	25	24
August	17	18	19	17	19	17	17
September	13	0	1	1	0	2	3
October	15	10	9	9	9	9	9
November	9	4	5	4	5	5	6
December	2	5	5	5	5	5	1
Total	**123**	**109**	**108**	**103**	**110**	**104**	**102**

Currently, annually there is around 123 rainy days June (21 days) and July (22 days) months have the highest number of rainy days and the most reduced is in January, February and December (1-2 days). 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 highest rainy days will be 27 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of southern coastal plain. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and corresponding rainfall of southern coastal plain (AEU1) for the current and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 5.

Table 5. Seasonal rainfall distribution under projected climate of southern coastal plain (AEU1) in Thiruvananthapuram district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	63.73	22	477.66	73	1732.53	26	596.72
4.5	2030	2	61.2	20	255.5	68	1425.4	19	512.4
	2050	3	66.6	18	238.7	68	1422.8	19	533.7
	2080	2	48.7	17	243.4	66	1419.9	18	494.5
8.5	2030	2	60.9	20	252.9	69	1450.8	19	528
	2050	2	49.2	16	227.3	67	1411.5	19	538
	2080	2	16.1	17	237	67	1515	16	332.1

At present, the highest number of rainy days happens in south west monsoon period (73 days) followed by north east (26 days), summer season (22 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by summer rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in most seasons.

4.1.1.1.2 High rainfall events of southern coastal plain (AEU1) in Thiruvananthapuram district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 6.

Table 6. High rainfall events under projected climate of southern coastal plain (AEU1) in Thiruvananthapuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	1	0	0	0	0	1	0	0
	Summer	3	5	2	1	0	3	5	2	1	0
	SW monsoon	27	12	4	2	1	27	12	4	2	1
	NE monsoon	6	4	1	0	0	6	4	1	0	0
	Total	**36**	**21**	**8**	**3**	**1**	**36**	**21**	**8**	**3**	**1**
2030	Winter	1	1	0	0	0	0	2	0	0	0
	Summer	8	2	0	0	0	7	2	0	0	0
	SW monsoon	22	17	5	1	0	24	18	4	1	0
	NE monsoon	8	3	1	2	0	8	3	1	1	1
	Total	**39**	**23**	**6**	**3**	**0**	**39**	**25**	**5**	**2**	**1**
2050	Winter	1	1	0	0	0	1	1	0	0	0
	Summer	7	2	0	0	0	6	2	0	0	0
	SW monsoon	22	18	3	1	0	23	16	5	1	0
	NE monsoon	8	4	1	1	1	7	4	1	1	1
	Total	**38**	**25**	**4**	**2**	**1**	**37**	**23**	**6**	**2**	**1**
2080	Winter	2	0	0	0	0	0	0	0	0	0
	Summer	7	2	0	0	0	6	1	1	0	0
	SW monsoon	22	16	5	1	0	29	16	2	2	1
	NE monsoon	9	3	0	2	0	6	2	0	0	1
	Total	**40**	**21**	**5**	**3**	**0**	**41**	**19**	**3**	**2**	**2**

As per the present condition, more precipitation occurs in low rainfall events within the range of 10-25 mm and 25-50 mm having 36 and 21 days respectively with less number of high rainfall events having rainfall greater than 50 mm. Climatic projection under both RCP 4.5 and RCP 8.5 also have an increase in the number of low rainfall events having rainfall greater than 50 mm and an decrease in the number of low rainfall events too.

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4.1.1.2 Rainfall analysis of southern laterites (AEU8) and impact of projected climate change in Thiruvananthapuram district

The southern laterites agro-ecological unit spread over 24 panchayats in south-western part of Thiruvananthapuram district is delineated to represent the uniqueness of climate and soils. The unit covers 38,727 ha (1.0 %) in the state.

4.1.1.2.1 Rainfall and Rainy days of southern laterites (AEU8) in Thiruvananthapuram district

The monthly rainfall distribution of southern laterites (AEU8) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 7.

Table 7. Monthly rainfall distribution under projected climate of southern laterites (AEU8) in Thiruvananthapuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	32.1	12.6	47.1	49.9	58.6	19.2	11.5
February	0	4.5	22.4	5.3	2.3	30	4.6
March	17	27.4	27.2	41.8	30.5	22.6	24.6
April	177.5	38.2	42.1	90.7	58.1	54.3	54.8
May	354	121.2	118	116.2	164.3	150.4	157.6
June	102	445	375.7	383.9	575.3	484.3	574.7
July	97.5	236.6	108.4	226.3	468.3	503.4	451.1
August	483.7	225.7	261	267.6	406.6	390.3	406.5
September	175.9	118.3	136.9	126.2	0.6	33.5	82.7
October	183.9	165.5	217.8	193.7	236.1	251.9	266.1
November	103.4	116.4	94.7	168.6	184.7	194.9	59.3
December	130.8	26.4	31.1	60.2	107.2	91.2	6.7
Total	**1857.8**	**1537.8**	**1482.4**	**1730.4**	**2292.6**	**2226**	**2100.2**

Presently, annual rainfall is around (1857.8 mm). May (354 mm) and August (483.7 mm) are the wettest months. February (0 mm) and March (17 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month whereas January and February are the driest. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months April, May, September and December. As per the projections based on RCP 4.5 there is chance of reduction in the total annual rainfall whereas, projections based on RCP 8.5 the total rainfall shows a continuous increase by 2030s, 2050s and 2080s.

From the analysis of monthly rainy days in southern laterites (AEU8) for present and projected climate (RCP 4.5 and RCP 8.5) were analyzed and represented in table 8.

Table 8. Monthly rainy days under projected climate of southern laterites (AEU8) in Thiruvananthapuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	2	2	3	4	3	3	3
February	1	1	1	1	2	2	3
March	2	3	3	4	3	3	2
April	4	4	4	5	5	5	4
May	6	7	8	7	8	8	6
June	21	17	19	21	20	18	19
July	19	18	11	9	9	13	14
August	13	13	14	14	14	14	14
September	5	7	8	8	8	9	9
October	8	7	6	8	6	5	7
November	2	7	7	7	7	9	11
December	4	2	5	3	5	4	1
Total	**87**	**88**	**89**	**91**	**90**	**93**	**93**

Currently, annually there was around 87 rainy days. June (21 days) and July (19 days) months have the highest number of rainy days and the most reduced is in January (2 days) and February (1 day). 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 highest rainy days will be 20 days and the base will be 1 to 2 day. The projected climate demonstrates increasing trend in the yearly rainy days of southern laterites.

The seasonal rainy days and rainfall of southern laterites (AEU8) for the present and projected climate were studied and are presented in table 9.

Table 9. Seasonal rainfall distribution under projected climate of southern laterites (AEU8) in Thiruvananthapuram district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	65.7	12	180.6	58	998.8	14	321.6
4.5	2030	3	17.1	14	186.8	55	1025.6	16	308.3
	2050	4	69.5	15	187.3	52	882	18	343.6
	2080	5	55.2	16	248.7	52	1004	18	422.5
8.5	2030	5	62	16	183.1	51	889.8	18	330.6
	2050	5	59.1	16	252	54	948.4	18	442.4
	2080	6	39.3	12	118.8	56	986.3	19	469

At present, the highest number of rainy days happens in south west monsoon period (58 days) followed by north east (14 days), summer season (12 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east contrasted with the current condition. The lowest number of rainy days and precipitation will be getting in summer and winter season.

4.1.1.2.2 High rainfall events of southern laterites (AEU8) in Thiruvananthapuram district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 10.

Table 10. High rainfall events under projected climate of southern laterites (AEU8) in Thiruvananthapuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	7	7	1	1	0	7	7	1	1	0
	SW monsoon	12	9	2	1	0	12	9	2	1	0
	NE monsoon	6	2	1	1	0	6	2	1	1	0
	Total	**27**	**18**	**4**	**3**	**0**	**27**	**18**	**4**	**3**	**0**
2030	Winter	0	0	0	0	0	2	1	0	0	0
	Summer	6	0	1	0	0	7	1	0	0	0
	SW monsoon	25	9	1	0	1	21	6	4	0	0
	NE monsoon	6	3	1	0	0	6	2	0	0	1
	Total	**37**	**12**	**3**	**0**	**1**	**36**	**10**	**4**	**0**	**1**
2050	Winter	2	1	0	0	0	1	1	0	0	0
	Summer	7	1	0	0	0	10	2	0	0	0
	SW monsoon	23	8	1	1	0	27	2	2	1	1
	NE monsoon	5	3	0	0	1	6	4	1	1	0
	Total	**37**	**13**	**1**	**1**	**1**	**44**	**9**	**3**	**2**	**1**
2080	Winter	1	1	0	0	0	1	0	0	0	0
	Summer	10	2	0	0	0	1	1	0	0	0
	SW monsoon	24	7	1	1	1	24	9	2	0	0
	NE monsoon	7	3	0	2	0	7	3	3	0	0
	Total	**42**	**13**	**1**	**3**	**1**	**33**	**13**	**5**	**0**	**0**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (27 days) and 25 to 50 mm (18 days) and heavy rainfall which is in the range 50 to more than 100 mm (7 days) the number of rainfall events is less. Comparing the present to the projected climate there will be an increasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an decreasing trend.

4.1.1.3 Rainfall analysis of south central laterites (AEU9) and impact of projected climate change in Thiruvananthapuram district

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

4.1.1.3.1 Rainfall and Rainy days of south central laterites (AEU9) in Thiruvananthapuram district

The monthly rainfall distribution of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in table 11.

Table 11. Monthly rainfall distribution under projected climate of south central laterites (AEU9) in Thiruvananthapuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	9.3	13.3	14	14.1	13.9	11.9
February	2	12.2	12.3	10.7	11.7	10.7	4.9
March	1	24.2	15.9	27.5	25.7	20.8	64.2
April	103	55.9	72.3	83.9	56.5	84.5	96.3
May	191	110.4	127.5	122.6	160.1	104.3	135.5
June	518.5	400.3	484.5	526.4	399.4	521.4	530.7
July	641.5	463.3	428.8	443.9	481.4	447.7	501.8
August	891	301.7	296.3	312.7	294.4	280.9	254.6
September	381	78.4	83.9	86	78.6	115.4	199.8
October	357	173.4	183.2	191.5	180.3	194.8	171.7
November	72	106.8	110.7	115.1	109.1	114.4	144.3
December	144	55.9	53.7	58.1	53.4	52.7	4.3
Total	**3302**	**1791.8**	**1882.4**	**1992.4**	**1864.7**	**1961.5**	**2120**

Presently, annual rainfall is around (3302 mm). June (518.5 mm) and July (641.5 mm) are the wettest months. January (0 mm) February (2 mm) and March (1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month whereas January and February are the driest months. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months April, May, July, August, September October and November. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in south central laterites (AEU9) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 12.

Table 12. Monthly rainy days under projected climate of south central laterites (AEU9) in Thiruvananthapuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	3	3	3	3	1
February	1	2	2	2	2	2	1
March	2	2	1	3	2	1	4
April	8	4	5	6	4	6	6
May	9	9	9	9	11	8	6
June	22	18	20	20	19	20	20
July	25	19	22	22	20	23	23
August	19	14	13	13	14	12	11
September	15	3	3	3	3	4	6
October	15	9	9	9	9	9	7
November	8	6	6	6	6	6	7
December	2	8	7	7	7	7	1
Total	**127**	**96**	**100**	**103**	**100**	**101**	**93**

Currently, there was about 127 rainy days under the present condition June (22 days) and July (25 days) months have the highest number of rainy days and the most reduced is in January and February (1 day each). 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 February and March. The highest rainy days will be 23 days and the base will be 1 to 2 days. The projected climate demonstrates a decreasing trend in the annual rainy days of South Central Laterites. In nut shell the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of south central laterites (AEU9) for the present and projected climate were considered and represented in table 13.

Table 13. Seasonal rainfall distribution under projected climate of south central laterites (AEU9) in Thiruvananthapuram district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	2	37.84	19	399.41	81	2249.3	25	565.38
4.5	2030	4	21.5	15	190.5	54	1243.7	23	336.1
	2050	5	25.6	15	215.7	58	1293.5	22	347.6
	2080	5	24.7	18	234	58	1369	22	364.7
8.5	2030	5	25.8	17	242.3	56	1253.8	22	342.8
	2050	5	24.6	15	209.6	59	1365.4	22	361.9
	2080	2	16.8	16	296	60	1486.9	15	320.3

At present, the highest number of rainy days happens in south west monsoon period (81 days) followed by north east (25 days), summer season (19 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 period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in every season contrasted with the current condition.

4.1.1.3.2 High rainfall events of south central laterites (AEU9) in Thiruvananthapuram district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 14.

Table 14. High rainfall events under projected climate of south central laterites (AEU9) in Thiruvananthapuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	2	2	0	0	4	2	2	0	0
	SW monsoon	28	25	7	4	2	28	25	7	4	2
	NE monsoon	11	7	2	0	0	11	7	2	0	0
	Total	**43**	**34**	**11**	**4**	**2**	**43**	**34**	**11**	**4**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	2	0	0	0	7	3	0	0	0
	SW monsoon	32	11	2	2	0	30	11	4	1	0
	NE monsoon	6	0	2	0	0	7	0	1	1	0
	Total	**44**	**13**	**4**	**2**	**0**	**44**	**14**	**5**	**2**	**0**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	9	1	0	0	0	10	0	0	0	0
	SW monsoon	26	9	4	2	0	28	7	6	1	1
	NE monsoon	6	0	1	1	0	5	1	1	1	0
	Total	**41**	**10**	**5**	**3**	**0**	**43**	**8**	**7**	**2**	**1**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	11	0	0	0	0	10	1	1	0	0
	SW monsoon	27	8	6	1	1	33	9	3	1	2
	NE monsoon	7	0	1	1	0	5	5	1	0	0
	Total	**45**	**8**	**7**	**2**	**1**	**48**	**15**	**5**	**1**	**2**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (43 days) and 25 to 50 mm (34 days) and heavy rainfall which is in the range 50 to

more than 100 mm (17 days) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in both the number of rainfall events below 50 mm and heavy rainfall events.

4.1.1.3 Rainfall analysis of southern and central foothills (AEU12) and impact of projected climate change in Thiruvananthapuram district

The southern and central foothills agro-ecological unit is delineated to represent the undulating lands with low hills, between midland laterites and the high hills of Western Ghats. It covers 90 panchayats from Thiruvananthapuram to Trissur districts. The unit covers 3, 15,893 ha (8.13 %) in the state.

4.1.1.3.1 Rainfall and Rainy days of southern and central foothills (AEU12) in Thiruvananthapuram district

The monthly rainfall distribution of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and RCP 8.5) were prepared in the table 15.

Table 15. Monthly rainfall distribution under projected climate of southern and central foothills (AEU12) in Thiruvananthapuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	37.4	13.9	12.9	17.2	13.3	24.4	6.9
February	12.4	10.5	10.5	36.8	10	34.7	30.7
March	2.6	19.2	19.2	19.7	19.5	37.8	43.2
April	102.2	77.6	80.2	31.1	78.1	40.9	49.6
May	387.6	68.7	62.4	83.7	67.7	104.9	86.9
June	174	386.1	426.3	619.2	381.9	446.4	458
July	120	294	327.6	319.5	304.8	231.6	337.6
August	424.2	296.6	299.6	306.1	275	286.8	311.3
September	720.6	110.1	139.2	106.8	111.4	81.3	192.7
October	553.7	196.1	168.4	183.6	176	190.3	95.9
November	194.6	103.1	143.1	143.5	131.5	87.6	214.5
December	318.2	37	37.9	56	48	11.1	14
Total	**3047.5**	**1612.9**	**1727.3**	**1923.2**	**1617.2**	**1577.8**	**1841.3**

Presently, annual rainfall is around (3047.5 mm) and the wettest months of year comes around August (424.2 mm), September (720.6 mm) and October (553.7 mm) and the driest months are February (12.4 mm) and march (2.6 mm) with enough annual distribution of rainfall. The projected climate will likely to decrease the annual rainfall availability by the years 2030, 2050 and 2080.The wettest months of projected climate will be in June, July and August with driest months in January and February. Rainfall distribution will be affected and become more intense in June and July months.

The analysis of monthly rainy days in southern and central foothills (AEU12) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 16.

Table 16. Monthly rainy days under projected climate of southern and central foothills (AEU12) in Thiruvananthapuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3	3	3	4	3	2	2
February	3	2	2	2	2	1	1
March	5	1	1	1	1	3	4
April	10	5	5	5	5	5	4
May	12	7	5	6	6	6	7
June	18	18	19	18	18	17	16
July	22	19	19	14	20	14	15
August	21	11	11	12	10	12	17
September	17	4	5	4	4	5	9
October	18	10	8	8	9	5	2
November	13	6	8	8	7	5	9
December	8	4	4	6	6	2	1
Total	**150**	**90**	**90**	**88**	**91**	**77**	**87**

In the present-day conditions, annually, there was around 150 rainy days where in July (22 days) and August (21 days) are the wettest months. January (14.6 mm) and December (15.9 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas February and march there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months March, April, May, August, September, October and November. As per the projections based on RCP 4.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The seasonal rainy days and rainfall of southern and central foothills (AEU12) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are presented in table 17.

Table 17. Seasonal rainfall distribution under projected climate of southern and central foothills (AEU12) in Thiruvananthapuram district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	6	108.33	27	582.23	78	1817.19	40	997.09
4.5	2030	5	24.4	13	165.5	52	1086.8	20	336.2
	2050	5	23.4	11	161.8	54	1192.7	20	349.4
	2080	6	54	12	134.5	48	1351.6	22	383.1
8.5	2030	5	23.3	12	165.3	52	1073.1	22	355.5
	2050	3	59.1	14	183.6	48	1046.1	12	289
	2080	3	37.6	15	179.7	57	1299.6	12	324.4

At present, the highest number of rainy days happens in south west monsoon period (78 days) followed by north east (40 days), summer season (27 days) and winter season (6 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in most of the months contrasted with the current condition.

4.1.1.3.2 High rainfall events of southern and central foothills (AEU12) in Thiruvananthapuram district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 18.

Table 18. High rainfall events under projected climate of Southern and Central Foothills (AEU12) in Thiruvananthapuram district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	12	5	1	0	0	12	5	1	0	0
	SW monsoon	31	9	5	0	1	31	9	5	0	1
	NE monsoon	18	8	3	1	1	18	8	3	1	1
	Total	**63**	**22**	**9**	**1**	**2**	**63**	**22**	**9**	**1**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	0	0	0	0	6	1	0	0	0
	SW monsoon	19	15	2	1	0	19	15	2	1	0
	NE monsoon	4	2	2	0	0	3	3	2	0	0
	Total	**30**	**17**	**4**	**1**	**0**	**28**	**19**	**4**	**1**	**0**
2050	Winter	0	0	0	0	0	1	1	0	0	0
	Summer	6	1	0	0	0	5	0	1	0	0
	SW monsoon	19	15	3	0	1	12	15	2	1	0
	NE monsoon	3	3	2	0	0	2	2	0	0	1
	Total	**28**	**19**	**5**	**0**	**1**	**20**	**18**	**3**	**1**	**1**
2080	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	3	1	0	0	0	8	0	0	0	0
	SW monsoon	13	16	5	0	1	14	20	3	0	1
	NE monsoon	5	3	2	0	0	4	2	1	0	1
	Total	**21**	**21**	**7**	**0**	**1**	**26**	**23**	**4**	**0**	**2**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (63 days) and 25 to 50 mm (22 days) and heavy rainfall which is in the range 50 to more than 100 mm (12 days) the number of rainfall events is less. Comparing the present

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to the projected climate there will be a decreasing trend in the number of high rainfall events and low rainfall events.

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

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

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

The monthly rainfall distribution of southern high hills (AEU14) for the present and projected climate including RCP 4.5 and RCP 8.5 were studied and are presented in table 19.

Table 19. Monthly rainfall distribution under projected climate of southern high hills (AEU14) in Thiruvananthapuram district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	14.3	13.9	17.4	14.2	21.8	25.1
February	22	10.7	11.1	37.9	10.5	10.5	39.2
March	58.6	27.3	29.5	44.9	29.7	43.3	24.7
April	64.4	79.5	79.3	31.5	77.1	56.4	20.9
May	262.2	65.6	64.1	84.6	61.4	87	62.9
June	308.8	393.5	388.5	572.8	383.5	435.9	285.5
July	350.2	311.4	229.8	189.7	244.6	128.3	264
August	536	284.9	245.7	256.2	232.1	278.1	315.9
September	243	111.4	145.1	141.7	135.3	149.1	107.5
October	335.4	174.9	179.1	188.6	175.1	155	67.5
November	205.2	138.4	150.7	64	148.6	98.5	250.5
December	36.4	38.2	41.2	57.8	40.9	32.5	16.4
Total	**2423.2**	**1650.1**	**1578**	**1687.1**	**1553**	**1496.4**	**1480.1**

Presently, annual rainfall is around (2423.2 mm). July (350.2 mm) and august (536 mm) are the wettest months. January (1 mm) and February (22 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest months but the amount of rainfall will be much higher whereas January and February are the driest months. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, March, May, August, September and October. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in southern high hills (AEU14) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 20.

Table 20. Monthly rainy days under projected climate of southern high hills (AEU14) in Thiruvananthapuram district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	3	3	4	3	4	2
February	2	2	2	2	2	2	3
March	4	3	3	3	3	4	1
April	7	5	5	5	5	4	3
May	8	6	5	6	5	6	7
June	19	19	19	16	19	18	16
July	20	19	15	10	15	9	18
August	15	10	11	11	11	13	17
September	12	4	5	5	5	5	7
October	16	9	7	7	7	5	2
November	12	7	9	6	9	8	8
December	4	4	4	6	4	3	4
Total	**120**	**91**	**88**	**81**	**88**	**81**	**88**

Currently, there was around 120 annual rainy days. June (19 days) and July (20 days) months have the highest number of rainy days and the most reduced is in January (1 day) and February (2 days). According to RCP 4.5 and 8.5, the greatest number of rainy

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days will be happening in June and July and the base will be in January and February. The highest rainy days will be 19 days and the base will be 1 to 2 days. The projected climate demonstrates a decreasing trend in the annual rainy days of southern high hills. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of southern high hills (AEU14) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are presented in table 21.

Table 21. Seasonal rainfall distribution under projected climate of southern high hills (AEU14) in Thiruvananthapuram district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain	Rainy Days	Rain	Rainy Days	Rain	Rainy Days	Rain
	Present	3	62.13	19	370.36	66	1286.18	33	760.79
4.5	2030	5	25	14	172.4	52	1101.2	20	351.5
	2050	5	25	13	172.9	50	1009.1	20	371
	2080	6	55.3	14	161	42	1160.4	19	310.4
8.5	2030	5	24.7	13	168.2	50	995.5	20	364.6
	2050	6	32.3	14	186.7	45	991.4	16	286
	2080	5	64.3	11	108.5	58	972.9	14	334.4

At present, the highest number of rainy days happens in south west monsoon period (66 days) followed by north east (33 days), summer season (19 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in most of the seasons when contrasted with the current condition.

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

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were considered and presented in table 22.

Table 22. High rainfall events under projected climate of southern high hills (AEU14) in Thiruvananthapuram district

Year	Rainfall (mm)	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	RCP 4.5					RCP 8.5				
		Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	4	0	1	0	6	4	0	1	0
	SW monsoon	31	14	3	0	1	31	14	3	0	1
	NE monsoon	10	6	1	0	0	10	6	1	0	0
	Total	**48**	**24**	**4**	**1**	**1**	**48**	**24**	**4**	**1**	**1**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	7	0	0	0	0	6	1	0	0	0
	SW monsoon	19	13	3	1	0	21	11	2	1	0
	NE monsoon	4	2	2	0	0	3	3	2	0	0
	Total	**30**	**15**	**5**	**1**	**0**	**30**	**15**	**4**	**1**	**0**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	6	1	0	0	0	7	1	0	0	0
	SW monsoon	19	14	1	1	0	16	14	1	0	1
	NE monsoon	4	3	2	0	0	3	3	0	1	0
	Total	**29**	**18**	**3**	**1**	**0**	**26**	**18**	**1**	**1**	**1**
2080	Winter	0	1	0	0	0	1	1	0	0	0
	Summer	4	1	0	0	0	4	0	0	0	0
	SW monsoon	13	11	5	0	1	22	12	1	0	0
	NE monsoon	4	3	0	1	0	2	2	0	0	1
	Total	**21**	**16**	**5**	**1**	**1**	**29**	**15**	**1**	**0**	**1**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (48 days) and 25 to 50 mm (24 days) and heavy rainfall which is in the range 50 to more than 100 mm (6 days) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in both the number of high rainfall events and low rainfall events.

4.1.2 Rainfall analysis of various AEUs of Kollam district

The Kollam district has divided into five agro ecological units (fig.3) comprising southern coastal plain (AEU1), onattukara sandy plain (AEU3), south central laterites (AEU9), southern and central foothills (AEU12), and south high hills (AEU14). Each AEU occupies 27408 ha (11.02%), 23794 ha (9.56%), 47023 ha (18.90%), 68845 ha (27.67%) and 72091 ha (28.98%) respectively.

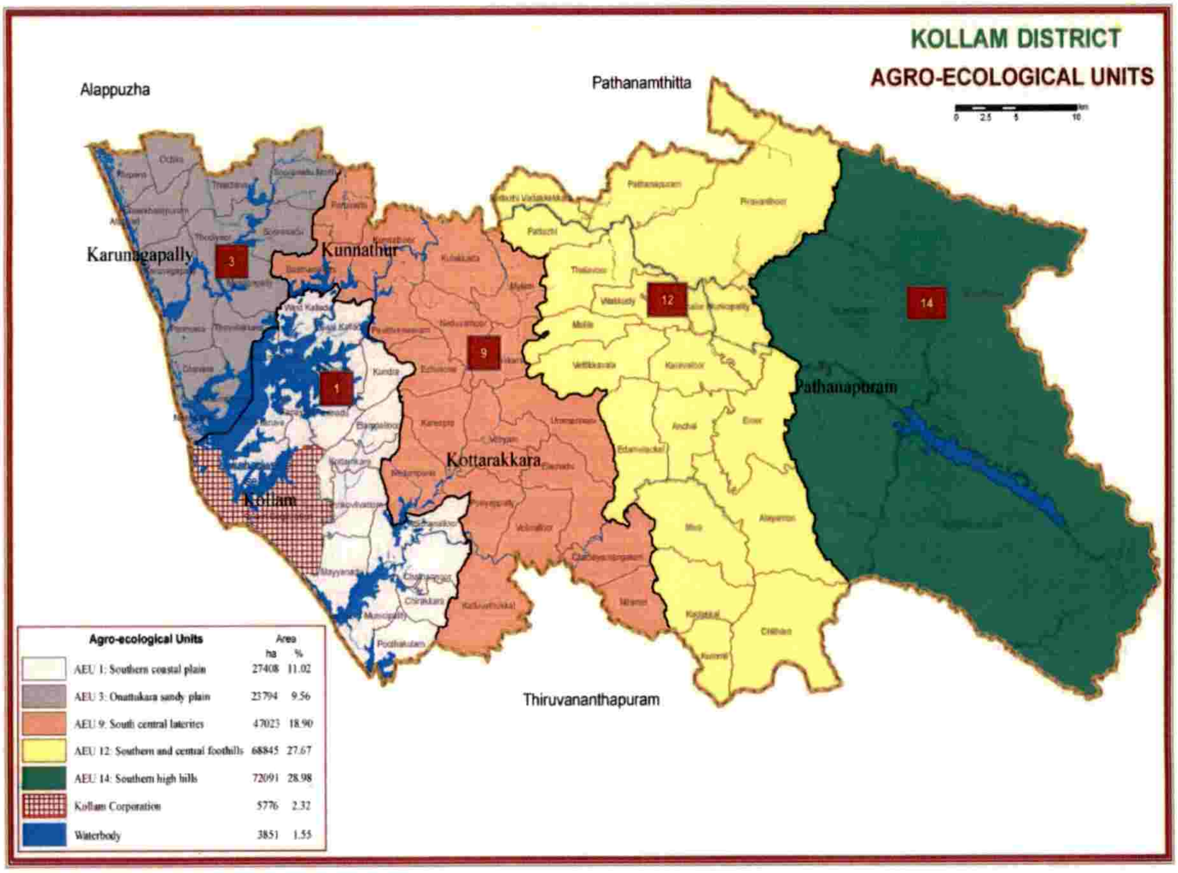

Fig.3 Agro-Ecological Unit wise map of Kollam District

4.1.2.1 Rainfall analysis of southern coastal plain (AEU1) and impact of projected climate change in Kollam district

The southern coastal plain agro-ecological unit is delineated to represent the nearly level coastal lands where sands are the dominant soil type. The unit comprises 42 panchayats along the coast from Thiruvananthapuram to Ernakulum district. The unit covers 56,782 ha (1.46 %) in the state.

4.1.2.1.1 Rainfall and Rainy days of southern coastal plain (AEU1) in Kollam district

The monthly rainfall distribution of southern coastal plain (AEU1) for the present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 23.

Table 23. Monthly rainfall distribution under projected climate of southern coastal plain (AEU1) in Kollam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	18.4	41	39.5	14.2	32.5	32.5	10.7
February	45.3	0.2	1.3	1.2	0.7	0.8	4.6
March	61	42.6	31	50.2	27.2	30.9	32.6
April	144.9	97.7	67.3	91.3	81.4	72.6	53.2
May	271.7	344.8	180.6	217	302	199.5	196.2
June	597.7	818.5	662.5	700.9	807.9	675.7	627.3
July	501.3	719.2	771.6	616.8	781	638.8	616.6
August	339.6	432.2	527.6	467.1	472.7	473.1	514.8
September	294	15.3	13.9	62.1	15	65.7	124.5
October	364.6	281.6	250.3	248.5	290.1	251.8	360.8
November	191.9	126.9	179.4	187.5	129.3	189.9	51.5
December	40.3	72.4	43.2	43.2	78.3	101.2	17.2
Total	**2870.7**	**2992.4**	**2768.2**	**2700**	**3018.1**	**2732.5**	**2610**

Presently, total annual rainfall is around (2870.7 mm). June (597.7 mm) and July (501.3 mm) are the wettest months. January (18.4 mm) and December (40.3 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas February and march there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, March, April, September and October. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2050s and 2080s but an increase during 2030s.

The monthly rainy days in southern coastal plain (AEU1) for present and projected climate as per RCP 4.5 and RCP 8.5 were presented and represented in the table 24.

Table 24. Monthly rainy days under projected climate of southern coastal plain (AEU1) in Kollam district

Rainy days(mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	3	3	2
February	2	0	0	0	0	0	1
March	3	4	4	4	4	4	4
April	7	6	6	6	7	6	6
May	11	16	14	13	15	14	10
June	21	20	23	23	21	23	24
July	22	22	24	25	23	25	24
August	17	16	16	18	17	18	19
September	13	2	2	3	2	4	6
October	15	11	11	12	11	12	13
November	9	3	4	4	4	4	4
December	2	4	3	4	4	5	2
Total	**123**	**106**	**109**	**114**	**111**	**118**	**115**

Currently, there is around 123 annual rainy days. June (21 days) and July (22 days) have the highest number of rainy days and 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 highest rainy days will be 25 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of southern coastal plain. In nut shell the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and corresponding rainfall of southern coastal plain (AEU1) for the current and projected climate according to RCP 4.5 and RCP 8.5 were studied in the table 25.

Table 25. Seasonal rainfall distribution under projected climate of southern coastal plain (AEU1) in Kollam district

RCP	Winter		Summer		South west		North east	
	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	3	63.73	22	477.66	73	1732.53	26	596.72
	2	41.2	26	485.1	60	1985.2	18	480.9
4.5	2	40.8	24	278.9	65	1975.6	18	472.9
	2	15.4	23	358.5	69	1846.9	20	479.2
	3	33.2	26	410.6	63	2076.6	19	497.7
8.5	3	33.3	24	303	70	1853.3	21	542.9
	3	15.3	20	282	73	1883.2	19	429.5

At present, the highest number of rainy days happens in south west monsoon period (73 days) followed by north east (26 days), summer season (22 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in south west.

4.1.2.1.2 High rainfall events of southern coastal plain (AEU1) in Kollam district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in the table 26.

Table 26. High rainfall events under projected climate of southern coastal plain (AEU1) in Kollam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	1	0	0	0	0	1	0	0
	Summer	3	5	2	1	0	3	5	2	1	0
	SW monsoon	27	12	4	2	1	27	12	4	2	1
	NE monsoon	6	4	1	0	0	6	4	1	0	0
	Total	**36**	**21**	**8**	**3**	**1**	**36**	**21**	**8**	**3**	**1**
2030	Winter	0	1	0	0	0	2	0	0	0	0
	Summer	16	3	0	0	1	11	2	0	0	1
	SW monsoon	17	18	8	2	1	17	21	6	3	2
	NE monsoon	8	4	0	2	0	8	4	0	2	0
	Total	**41**	**26**	**8**	**4**	**2**	**38**	**27**	**6**	**5**	**3**
2050	Winter	0	1	0	0	0	2	0	0	0	0
	Summer	9	1	0	0	0	10	2	0	0	0
	SW monsoon	12	23	7	5	0	23	19	6	2	1
	NE monsoon	6	3	2	0	1	10	3	2	0	1
	Total	**27**	**28**	**9**	**5**	**1**	**45**	**24**	**8**	**2**	**2**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	15	2	0	0	0	8	2	0	0	0
	SW monsoon	26	16	6	1	2	26	20	5	2	1
	NE monsoon	6	3	2	0	1	7	3	0	0	1
	Total	**47**	**21**	**8**	**1**	**3**	**41**	**25**	**5**	**2**	**2**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (36 days) and 25 to 50 mm (21 days) and heavy rainfall which is in the range 50 to more than 100 mm (12 days) the number of rainfall events is less. Comparing the present to the projected climate of RCP 4.5 and RCP 8.5 there will be an increasing trend in both heavy and low rainfall events.

4.1.2.2 Rainfall analysis of onattukara sandy plain (AEU3) and impact of projected climate change in Kollam district

The special agro-ecological unit onattukara sandy plain is delineated for the sandy plains extending into the midlands from coast and covering 43 panchayats in Kollam and Kollam districts. The unit covers 67,447 ha (1.74 %) in the state.

4.1.2.2.1 Rainfall and Rainy days of onattukara sandy plain (AEU3) in Kollam district

The monthly rainfall distribution of onattukara sandy plain (AEU3) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in the table 27.

Table 27. Monthly rainfall distribution under projected climate of onattukara sandy plain (AEU3) in Kollam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	21.2	39.9	29.7	30.5	34	39.4	14.8
February	32.4	0.3	1	1	0.7	1	20.4
March	45	34.1	27.6	29.5	26.7	49.8	29.1
April	142.1	67.5	61.6	61.4	82.7	81	58.2
May	260.7	255.9	277.7	275.8	334.1	235.1	203.3
June	535.6	706.6	653.2	645.6	858.6	728.5	758.5
July	492.9	782.5	633.7	665.5	678.8	686.3	637.6
August	339.9	397.8	507.1	528	420	523.3	566.2
September	271.3	87.3	121.7	118.6	115.7	120.1	177.4
October	335.2	325.6	297.1	304	366.7	261.1	290.3
November	177.6	13.9	113.2	112.5	12.4	195	52.4
December	47.9	24.1	72.1	79.1	67.4	104.7	71.7
Total	**2701.8**	**2735.5**	**2795.7**	**2851.5**	**2997.8**	**3025.3**	**2879.9**

Presently, annual rainfall is around (2701.8 mm). June (535.6 mm) and July (492.9 mm) are the wettest months. January (21.2 mm) and February (32.4 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas February and March there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, March, April, September and November. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

From the analysis of monthly rainy days in onattukara sandy plain (AEU3) for present and projected climate (RCP 4.5 and RCP 8.5) were analyzed and presented in the table 28.

Table 28. Monthly rainy days of onattukara sandy plain (AEU3) and the projected climate in Kollam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	3	3	3	3	2	1
February	2	0	0	0	0	0	1
March	3	4	2	2	4	4	4
April	7	5	5	5	7	6	6
May	11	17	14	14	17	13	12
June	21	22	22	22	22	22	26
July	22	24	22	22	24	23	24
August	17	17	18	18	17	18	19
September	13	4	5	5	5	5	8
October	15	12	11	11	9	12	11
November	9	2	3	3	2	4	4
December	3	4	7	7	6	5	7
Total	**124**	**114**	**112**	**112**	**116**	**114**	**123**

Currently, there was around 124 annual rainy days. June (21 days) and July (22 days) months have the highest number of rainy days and the most reduced is in January and February (1-2 days). 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 highest rainy days will be 26 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the yearly rainy days of onattukara sandy plain.

The seasonal rainy days and rainfall of onattukara sandy plain (AEU3) for the present and projected climate were studied and are presented in the table 29.

Table 29. Seasonal rainfall distribution under projected climate of onattukara sandy plain (AEU3) in Kollam district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	53.6	21	447.75	72	1639.69	26	560.65
4.5	2030	3	40.2	26	357.5	67	1974.2	18	363.6
	2050	3	30.7	21	366.9	67	1915.7	21	482.4
	2080	3	31.5	21	366.7	67	1957.7	21	495.6
8.5	2030	3	34.7	28	443.5	68	2073.1	17	446.5
	2050	2	40.4	23	365.9	68	2058.2	21	560.8
	2080	2	35.2	22	290.6	77	2139.7	22	414.4

At present, the highest number of rainy days happens in south west monsoon period (72 days) followed by north east (26 days), summer season (21 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be an extreme abatement in precipitation in summer and north east when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in south west.

4.1.2.2.2 High rainfall events of onattukara sandy plain (AEU3) in Kollam district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in the table 30.

Table 30. High rainfall events under projected climate of onattukara sandy plain (AEU3) in Kollam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	8	2	1	1	0	8	2	1	1	0
	SW monsoon	24	15	1	3	1	24	15	1	3	1
	NE monsoon	7	6	1	1	0	7	6	1	1	0
	Total	**39**	**24**	**3**	**5**	**1**	**39**	**24**	**3**	**5**	**1**
2030	Winter	0	1	0	0	0	2	0	0	0	0
	Summer	15	2	0	0	0	10	3	0	0	1
	SW monsoon	24	17	9	1	2	22	23	8	1	2
	NE monsoon	5	2	0	0	1	5	2	2	0	1
	Total	**44**	**22**	**9**	**1**	**3**	**39**	**28**	**10**	**1**	**4**
2050	Winter	1	0	0	0	0	1	1	0	0	0
	Summer	11	1	0	1	0	13	2	0	0	0
	SW monsoon	21	23	5	2	1	22	18	9	1	2
	NE monsoon	5	4	0	1	1	8	5	2	0	1
	Total	**38**	**28**	**5**	**4**	**2**	**44**	**26**	**11**	**1**	**3**
2080	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	11	1	0	1	0	8	3	0	0	0
	SW monsoon	20	22	7	3	0	28	15	7	4	2
	NE monsoon	5	4	0	0	2	7	3	0	0	1
	Total	**38**	**27**	**7**	**4**	**2**	**45**	**21**	**7**	**4**	**3**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (39 days) and 25 to 50 mm (24 days) and heavy rainfall which is in the range 50 to more than 100 mm (9 days) the number of rainfall events is less. Comparing the present to the projected climate of RCP 4.5 and RCP 8.5 there will be an increasing trend in both heavy and low rainfall events.

4.1.2.3 Rainfall analysis of south central laterites (AEU9) and impact of projected climate change in Kollam district

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

4.1.2.3.1 Rainfall and Rainy days of south central laterites (AEU9) in Kollam district

The monthly rainfall distribution of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in the table 31.

Table 31. Monthly rainfall distribution under projected climate of south central laterites (AEU9) in Kollam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	29.4	29	39.1	29.5	37.7	14.7
February	2	1.1	1.3	1.1	1.3	2.6	20.8
March	1	29.5	34.9	64.3	31.1	34.3	35.4
April	103	84.8	71.4	96.9	81.4	75.5	57
May	191	289.4	178.3	203.3	192.9	142.8	192.1
June	518.5	745.7	622.5	627.3	823	655	593.5
July	641.5	778.2	772.4	645.3	816.5	621.4	610.4
August	891	490.2	536.6	483	481.8	493	520.9
September	381	15.6	14.1	66.3	61.7	67.1	127.1
October	357	286.8	253.3	250.3	248	274.6	363.8
November	72	126	177.3	185.9	185.1	50.4	50.8
December	144	71.5	100.2	108.6	102.9	20.8	65.6
Total	**3302**	**2948.2**	**2791.3**	**2771.4**	**3055.2**	**2475.2**	**2652.1**

Presently, annual rainfall is around (3302 mm). July (641.5 mm) and August (891 mm) are the wettest months. January (0 mm) February (2 mm) and March (1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months April, August, September and December. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in south central laterites (AEU9) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 32.

Table 32. Monthly rainy days under projected climate of south central laterites (AEU9) in Kollam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	3	3	2	3	2	1
February	1	0	0	0	0	0	1
March	2	4	4	5	4	4	5
April	8	7	6	6	6	6	6
May	9	15	14	12	15	12	10
June	22	21	23	23	21	23	24
July	25	23	24	25	23	25	24
August	19	17	16	18	17	19	19
September	15	2	2	4	3	4	6
October	15	11	11	12	12	11	13
November	8	3	4	4	4	4	4
December	2	4	5	6	5	3	7
Total	**127**	**110**	**112**	**117**	**113**	**113**	**120**

Currently, there is about 127 annual rainy days. June (22 days) and July (25 days) months have the highest number of rainy days and 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 highest rainy days will be 25 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of south central laterites. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of south central laterites (AEU9) for the present and projected climate were analyzed and presented in the table 33.

Table 33. Seasonal rainfall distribution under projected climate of south central laterites (AEU9) in Kollam district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	2	37.84	19	399.41	81	2249.3	25	565.38
4.5	2030	3	30.5	26	403.7	63	2029.7	18	484.3
	2050	3	30.3	24	284.6	65	1945.6	20	530.8
	2080	2	40.2	23	364.5	70	1821.9	22	544.8
8.5	2030	3	30.8	25	305.4	64	2183	21	536
	2050	2	40.3	22	252.6	71	1836.5	18	345.8
	2080	2	35.5	21	284.5	73	1851.9	24	480.2

At present, the highest number of rainy days happens in south west monsoon period (81 days) followed by north east (25 days), summer season (19 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 period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be an extreme abatement in precipitation in south west and north east when contrasted with the current condition.

4.1.2.3.2 High rainfall events of south central laterites (AEU9) in Kollam district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 34.

Table 34. High rainfall events under projected climate of south central laterites (AEU9) in Kollam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	2	2	0	0	4	2	2	0	0
	SW monsoon	28	25	7	4	2	28	25	7	4	2
	NE monsoon	11	7	2	0	0	11	7	2	0	0
	Total	**43**	**34**	**11**	**4**	**2**	**43**	**34**	**11**	**4**	**2**
2030	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	10	2	0	0	1	11	2	0	0	0
	SW monsoon	15	21	7	4	1	14	22	7	4	2
	NE monsoon	8	4	0	2	0	9	4	2	0	1
	Total	**35**	**27**	**7**	**6**	**2**	**35**	**28**	**9**	**4**	**3**
2050	Winter	1	0	0	0	0	1	1	0	0	0
	Summer	8	1	0	0	0	9	1	0	0	0
	SW monsoon	16	19	8	5	0	24	19	7	2	0
	NE monsoon	8	5	2	1	0	6	2	0	0	1
	Total	**33**	**25**	**10**	**6**	**0**	**40**	**23**	**7**	**2**	**1**
2080	Winter	1	1	0	0	0	2	0	0	0	0
	Summer	14	2	0	0	0	8	2	0	0	0
	SW monsoon	27	17	5	2	1	26	20	5	2	1
	NE monsoon	9	4	2	0	1	8	3	1	0	1
	Total	**51**	**24**	**7**	**2**	**2**	**44**	**25**	**6**	**2**	**2**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (43 days) and 25 to 50 mm (34 days) and heavy rainfall which is in the range 50 to more than 100 mm (17 days) the number of rainfall events is less. Comparing the present

to the projected climate there will be a decreasing trend in the number of low rainfall events and heavy rainfall events.

4.1.2.4 Rainfall analysis of southern and central foothills (AEU 12) and impact of projected climate change in Kollam district

The southern and central foothills agro-ecological unit is delineated to represent the undulating lands with low hills, between midland laterites and the high hills of Western Ghats. It covers 90 panchayats from Thiruvananthapuram to Thrissur districts. The unit covers 3, 15,893 ha (8.13 %) in the state.

4.1.2.4.1 Rainfall and Rainy days of southern and central foothills (AEU 12) in Kollam district

The monthly rainfall distribution of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are analyzed in the table 35.

Table 35. Monthly rainfall distribution under projected climate of southern and central foothills (AEU12) in Kollam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	37.4	28.5	4.2	4.6	39.7	7.4	9.2
February	12.4	1.3	15.1	13.1	5.8	13.1	23.6
March	2.6	27	27.2	35.5	50.6	35.3	49.9
April	102.2	47	48.2	62.2	22.8	62.7	56.8
May	387.6	219.7	151	151.5	171.5	139.8	177.2
June	174	550	712.3	608.6	649.9	569	578.6
July	120	575.8	470.9	515.6	536.3	545	613
August	424.2	441	515.7	543.8	448.6	508.2	418.2
September	720.6	0.2	10	10.1	0.2	45.1	79.4
October	553.7	223.4	279.1	289.5	275.2	293	326.6
November	194.6	146.9	143.6	148.9	141.6	149.7	229.6
December	318.2	71	72.7	80.6	73.8	69.2	73
Total	**3047.5**	**2331.8**	**2450**	**2464**	**2416**	**2437.5**	**2635.1**

In the existing condition the annual rainfall is around (3047.5 mm). September (720.6 mm) and October (553.7 mm) are the wettest months. February (12.4 mm) and March (2.6 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months January, February, April, May, August, September and December. As per the projections based on RCP 4.5 there will be a chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in southern and central foothills (AEU12) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied in the table 36.

Table 36. Monthly rainy days under projected climate of southern and central foothills (AEU12) in Kollam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3	3	0	1	1	2	1
February	3	0	2	2	1	2	1
March	5	2	2	2	5	2	5
April	10	3	3	5	2	5	7
May	12	13	10	12	11	11	9
June	18	22	22	23	22	22	22
July	22	25	25	25	24	25	25
August	21	13	14	14	14	14	17
September	17	0	1	1	0	2	5
October	18	10	9	9	9	9	11
November	13	3	4	4	4	4	6
December	8	8	8	8	8	7	5
Total	**150**	**102**	**100**	**106**	**101**	**105**	**114**

Currently, annually there is around 150 rainy days. July (22 days) and August (21 days) months have the highest number of rainy days and 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 highest rainy days will be 25 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of southern and central foothills. In nut shell the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of southern and central foothills (AEU12) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are presented in the table 37.

Table 37. Seasonal rainfall distribution under projected climate of southern and central foothills (AEU12) in Kollam district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	6	108.33	27	582.23	78	1817.19	40	997.09
4.5	2030	3	29.8	18	293.7	60	1567	21	441.3
	2050	2	19.3	15	226.4	62	1708.9	21	495.4
	2080	3	17.7	19	249.2	63	1678.1	21	519
8.5	2030	2	45.5	18	244.9	60	1635	21	490.6
	2050	4	20.5	18	237.8	63	1667.3	20	511.9
	2080	2	32.8	21	283.9	69	1689.2	22	629.2

At present, the highest number of rainy days happens in south west monsoon period (78 days) followed by north east (40 days), summer season (27 days) and winter season (6 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in north east, summer and winter season when contrasted with the current condition.

4.1.2.4.2 High rainfall events of southern and central foothills (AEU12) in Kollam district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 38.

Table 38. High rainfall events under projected climate of southern and central foothills (AEU12) in Kollam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	12	5	1	0	0	12	5	1	0	0
	SW monsoon	31	9	5	0	1	31	9	5	0	1
	NE monsoon	18	8	3	1	1	18	8	3	1	1
	Total	**63**	**22**	**9**	**1**	**2**	**63**	**22**	**9**	**1**	**2**
2030	Winter	1	0	0	0	0	0	1	0	0	0
	Summer	7	2	1	0	0	8	2	0	0	0
	SW monsoon	20	15	5	3	0	20	16	5	1	2
	NE monsoon	6	1	0	0	2	5	4	0	1	1
	Total	**34**	**18**	**6**	**3**	**2**	**33**	**23**	**5**	**2**	**3**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	9	1	0	0	0	10	1	0	0	0
	SW monsoon	25	17	3	3	1	26	17	4	2	1
	NE monsoon	6	3	0	1	1	5	4	0	0	2
	Total	**40**	**21**	**3**	**4**	**2**	**41**	**22**	**4**	**2**	**3**
2080	Winter	0	0	0	0	0	1	0	0	0	0
	Summer	11	1	0	0	0	9	0	1	0	0
	SW monsoon	24	17	4	2	1	28	18	3	1	1
	NE monsoon	5	4	0	0	2	6	4	0	1	2
	Total	**40**	**22**	**4**	**2**	**3**	**44**	**22**	**4**	**2**	**3**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (63 days) and 25 to 50 mm (22 days) and heavy rainfall which is in the range 50 to more than 100 mm (12 days) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in both the number of low rainfall events and heavy rainfall events.

4.1.2.5 Rainfall analysis of southern high hills (AEU14) and impact of projected climate change in Kollam district

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

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

The monthly rainfall distribution of southern high hills (AEU14) for the present and projected climate including RCP 4.5 and RCP 8.5 were studied and are presented in table 39.

Table 39. Monthly rainfall distribution under projected climate of southern high hills (AEU14) in Kollam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	6	9.7	9.6	10.2	5.7	20.6
February	22	42.6	43.9	43	41	35.2	32.7
March	58.6	42.4	40.5	54.6	42	52.1	58.6
April	64.4	74.2	78.8	79.9	76.3	77.2	47.9
May	262.2	109.1	95.7	93.6	94.2	46.9	98.1
June	308.8	384.1	414	401.1	414.9	516.3	465.3
July	350.2	363	345.4	372.3	336.5	312.5	354.4
August	536	283.5	287.4	273.8	246.8	315.1	298.5
September	243	68.1	92.8	92.5	86.6	110.8	198.3
October	335.4	214.4	224.8	236.2	219.6	223.2	138.3
November	205.2	16.4	19.5	20.3	19.2	77.1	170.2
December	36.4	26.6	22.7	24.9	22.9	57.1	27.7
Total	**2423.2**	**1630.4**	**1675.2**	**1701.8**	**1610.2**	**1829.2**	**1910.6**

Presently, the annual rainfall is around (2423.2 mm). July (350.2 mm) and August (536 mm) are the wettest months. January (1 mm) and February (22 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and December there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months May, August, September, October, November and December. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in southern high hills (AEU14) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 40.

Table 40. Monthly rainy days under projected climate of southern high hills (AEU14) in Kollam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	2	2	2	1	4
February	2	2	2	2	2	1	1
March	4	4	4	5	4	5	5
April	7	5	5	5	5	5	4
May	8	9	7	7	7	5	7
June	19	18	20	18	20	20	17
July	20	13	13	13	13	11	17
August	15	15	15	14	12	13	15
September	12	3	4	4	4	4	10
October	16	8	7	7	7	8	5
November	12	1	2	2	2	5	11
December	4	4	3	3	3	4	3
Total	**120**	**83**	**84**	**82**	**81**	**82**	**99**

Currently, annually there was around 120 rainy days. June (19 days) and July (20 days) months have the highest number of rainy days and the most reduced is in January (1 day) and February (2 days). 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 highest rainy days will be 20 days and the base will be 1 to 2 day. The projected climate demonstrates a decreasing trend in the annual rainy days of Southern High Hills. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of southern high hills (AEU14) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are presented in table 41.

Table 41. Seasonal rainfall distribution under projected climate of southern high hills (AEU14) in Kollam district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain	Rainy Days	Rain	Rainy Days	Rain	Rainy Days	Rain
	Present	3	62.13	19	370.36	66	1286.18	33	760.79
4.5	2030	3	48.6	18	225.7	49	1098.7	13	257.4
	2050	4	53.6	16	215	52	1139.6	12	267
	2080	4	52.6	17	228.1	49	1139.7.	12	281.4
8.5	2030	4	51.2	16	212.5	49	1084.8	12	261.7
	2050	2	40.9	15	176.2	48	1254.7	17	357.4
	2080	5	53.3	16	204.6	59	1316.5	19	336.2

At present, the highest number of rainy days happens in south west monsoon period (66 days) followed by north east (33 days), summer season (19 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be an extreme abatement in precipitation in north east and summer when contrasted with the current condition.

4.1.2.5.2 High rainfall events of southern high hills (AEU14) in Kollam district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 42.

Table 42. High rainfall events under projected climate of southern high hills (AEU14) in Kollam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	4	0	1	0	6	4	0	1	0
	SW monsoon	31	14	3	0	1	31	14	3	0	1
	NE monsoon	10	6	1	0	0	10	6	1	0	0
	Total	**48**	**24**	**4**	**1**	**1**	**48**	**24**	**4**	**1**	**1**
2030	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	10	1	0	0	0	10	0	0	0	0
	SW monsoon	24	7	3	2	0	24	7	3	2	0
	NE monsoon	3	2	0	1	0	3	2	0	1	0
	Total	**37**	**11**	**3**	**3**	**0**	**37**	**10**	**3**	**3**	**0**
2050	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	9	1	0	0	0	7	1	0	0	0
	SW monsoon	25	7	3	2	0	17	10	4	2	1
	NE monsoon	3	2	0	0	1	7	3	0	1	0
	Total	**37**	**11**	**3**	**2**	**1**	**31**	**15**	**4**	**3**	**1**
2080	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	10	1	0	0	0	8	1	0	0	0
	SW monsoon	22	7	3	3	0	21	13	2	1	1
	NE monsoon	2	3	0	0	1	3	3	2	0	0
	Total	**34**	**12**	**3**	**3**	**1**	**32**	**18**	**4**	**1**	**1**

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

4.1.2 Rainfall analysis of various AEUs of Pathanamthitta district

The Pathanamthitta district has divided into four agro ecological units (fig.4) comprising kuttanad (AEU4), south central laterites (AEU9), southern and central foothills (AEU12) and southern high hills (AEU14). Each AEU occupies 8999 ha (3.39%), 67223 ha (25.34%), 43742 ha (16.49%) and 142136 ha (53.58%) respectively.

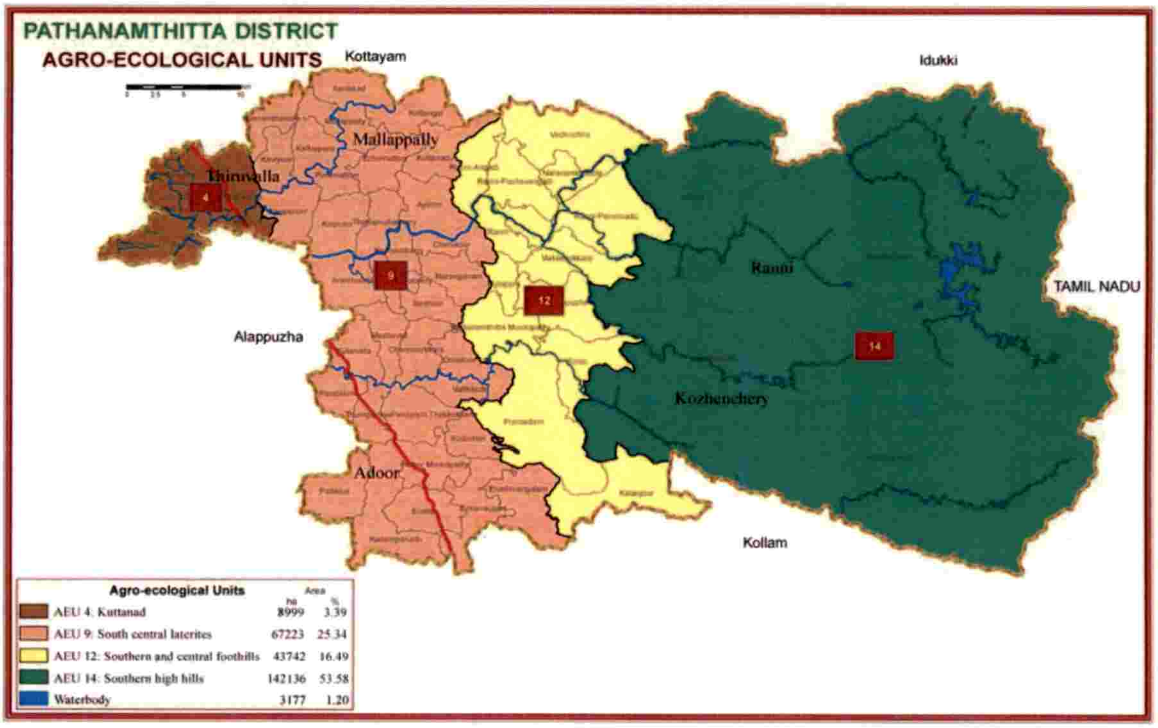

Fig.4 Agro-Ecological Unit wise map of Pathanamthitta District

4.1.3.1 Rainfall analysis of Kuttanad (AEU4) and impact of projected climate change in Pathanamthitta district

Kuttanad is a special agro-ecological unit delineated to represent the waterlogged lands spread over 69 panchayats of Alappuzha, Kottayam and Pathanamthitta districts.

Large parts of these lands are below, at or just above sea level. The unit covers 1, 26,931 ha (3.27%) in the state.

4.1.3.1.1 Rainfall and Rainy days of Kuttanad (AEU4) in Pathanamthitta district

The monthly rainfall distribution of kuttanad (AEU4) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 43.

Table 43. Monthly rainfall distribution under projected climate of kuttanad (AEU4) in Pathanamthitta district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	7.2	15.7	14.1	47.4	49	47.6	16.8
February	15.1	0.4	0.4	1.2	0.3	1.1	14.7
March	44.5	45.8	44.1	32.2	29	32.1	29.7
April	133.6	88.8	93.2	66.9	76.8	66.3	57.9
May	237.4	407.4	418.9	232.4	248.8	230.5	201.7
June	481.9	788.7	860.8	846.8	780.6	836.9	707.8
July	510.2	721.5	781.9	773.5	736.2	765	557.2
August	326.6	559.7	536.2	601.7	523.6	622.8	559.7
September	259.5	23.9	27.4	239.3	91.2	240.5	267.1
October	365.3	373.6	371	265.5	352.8	267.5	300.9
November	206.2	24.1	25.9	189.2	50.6	191.8	138.7
December	49.1	13	16.6	109.3	71.2	103.1	75.5
Total	**2636.6**	**3062.6**	**3190.5**	**3405.4**	**3010.1**	**3405.2**	**2927.7**

Presently, annual rainfall is around (2636.6 mm). June (481.9 mm) and July (510.2 mm) are the wettest months January (7.2 mm) and February (15.1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, April, September and November. As per the projections based on RCP 4.5 there is chance of increase in the total annual rainfall during 2030s, 2050s and 2080s.

The monthly rainy days in kuttanad (AEU4) for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in the table 44.

Table 44. Monthly rainy days under projected climate of kuttanad (AEU4) in Pathanamthitta district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	2	1
February	1	0	0	0	0	0	2
March	3	4	4	4	4	4	2
April	9	6	6	6	7	6	4
May	11	17	17	14	16	13	16
June	19	22	22	24	23	24	24
July	22	23	23	23	23	23	24
August	17	19	19	18	18	19	19
September	14	3	4	7	4	7	9
October	15	11	13	12	12	12	9
November	10	3	3	4	3	4	4
December	3	2	2	6	4	5	8
Total	**125**	**112**	**115**	**120**	**116**	**119**	**122**

Currently, annually there was around 125 rainy days. June (19 days) and July (22 days) months have the highest number of rainy days and 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 highest rainy days will be 24 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of kuttanad lands. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and corresponding rainfall of kuttanad (AEU4) for the current and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 45.

Table 45. Seasonal rainfall distribution under projected climate of kuttanad (AEU4) in Pathanamthitta 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	22.23	23	415.47	72	1578.17	28	620.55
4.5	2030	2	16.1	27	542	67	2093.8	16	410.7
	2050	2	14.5	27	556.2	68	2206.3	18	413.5
	2080	2	48.6	24	331.5	72	2461.3	22	564
8.5	2030	2	49.3	27	354.6	68	2131.6	19	474.6
	2050	2	48.7	23	328.9	73	2465.2	21	562.4
	2080	3	31.5	22	289.3	76	2091.8	21	515.1

At present, the highest number of rainy days happens in south west monsoon period (72 days) followed by north east (28 days), summer season (23 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 period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be an extreme abatement in precipitation in north east when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in south west.

4.1.3.1.2 High rainfall events of kuttanad (AEU4) in Pathanamthitta district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in the table 46.

Table 46. High rainfall events under projected climate of kuttanad (AEU4) in Pathanamthitta district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	5	2	2	0	0
	SW monsoon	23	10	3	1	0	23	10	3	1	0
	NE monsoon	4	3	1	0	0	4	3	1	0	0
	Total	**32**	**15**	**6**	**1**	**0**	**32**	**15**	**6**	**1**	**0**
2030	Winter	1	0	0	0	0	1	1	0	0	0
	Summer	13	4	0	0	1	8	3	1	0	0
	SW monsoon	19	20	9	3	2	17	20	10	3	2
	NE monsoon	3	3	1	0	1	8	4	1	1	0
	Total	**36**	**27**	**10**	**3**	**4**	**34**	**28**	**12**	**4**	**2**
2050	Winter	0	0	0	0	0	1	1	0	0	0
	Summer	14	4	0	0	1	6	5	0	0	0
	SW monsoon	19	19	12	2	3	17	25	8	4	3
	NE monsoon	6	3	0	0	1	7	6	2	0	1
	Total	**39**	**26**	**12**	**2**	**5**	**31**	**37**	**10**	**4**	**4**
2080	Winter	1	1	0	0	0	1	0	0	0	0
	Summer	7	4	0	0	0	11	1	0	0	0
	SW monsoon	18	24	8	4	3	24	22	7	3	1
	NE monsoon	7	6	2	0	1	5	4	0	0	2
	Total	**33**	**35**	**10**	**4**	**4**	**41**	**27**	**7**	**3**	**3**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (32 days) and 25 to 50 mm (15 days) and heavy rainfall which is in the range 50 to more than 100 mm (7 days) the number of rainfall events is less. Comparing the present to

the projected climate there will be an increasing trend in both the number of rainfall events below 50 mm per day and heavy rainfall events.

4.1.3.2 Rainfall analysis of south central laterites (AEU9) and impact of projected climate change climate change in Pathanamthitta district

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

4.1.3.2.1 Rainfall and Rainy days of south central laterites (AEU9) in Pathanamthitta district

The monthly rainfall distribution of south central laterites (AEU9) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and presented in the table 47.

Table 47. Monthly rainfall distribution under projected climate of south central laterites (AEU9) in Pathanamthitta district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	37.5	12.4	37	38.3	10.4	15.6
February	2	0.8	1.7	0.7	0.6	5.3	21.4
March	1	33.1	50.4	35.5	34.9	56	26.6
April	103	45.3	97.9	46.5	45.9	89.5	62.1
May	191	249.4	268	229.4	267.4	229.7	239.7
June	518.5	654.3	841.5	601.2	685.4	725	670.8
July	641.5	772.5	767.8	617	764.5	567.2	709.4
August	891	532.7	539.5	530.4	545.1	527.9	574.9
September	381	20.7	129.6	71.7	162.2	130.7	135.9
October	357	394.8	254.2	279.6	381.4	253.2	371.2
November	72	23.5	183.3	47.9	26.3	193.4	50.7
December	144	77.3	39.5	77.9	75.7	40.3	69.9
Total	**3302**	**2841.9**	**3185.8**	**2574.8**	**3027.7**	**2828.6**	**2948.2**

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Presently, annual rainfall is around (3302 mm). June (518.5 mm), July (641.5 mm) are the wettest months. January (0 mm), february (2 mm) and March (1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February are the driest. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months April, August, September, November and December. As per the projections based on RCP 4.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

From the analysis of monthly rainy days in south central laterites (AEU9) for present and projected climate of RCP 4.5 and RCP 8.5 were studied and are presented in the table 48.

Table 48. Monthly rainy days under projected climate of south central laterites (AEU9) in Pathanamthitta district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	1	1
February	1	0	0	0	0	1	1
March	2	3	4	3	4	4	4
April	8	5	6	5	5	6	6
May	9	15	16	13	17	12	14
June	22	23	20	24	23	23	25
July	25	24	23	25	24	22	25
August	19	18	20	18	17	21	19
September	15	3	5	5	6	5	7
October	15	12	12	11	12	11	13
November	8	2	4	4	2	5	4
December	2	7	3	7	5	3	7
Total	**127**	**114**	**115**	**117**	**117**	**114**	**126**

Currently, annually there was around 127 rainy days. June (22 days) and July (25 days) months have the highest number of rainy days and the most reduced is in January and February (1 day each). 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 highest rainy days will be 25 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of south central laterites. In general, the wet months will be wetter and dry periods will be drier.

The seasonal rainy days and rainfall of south central laterites (AEU9) for the present and projected climate were studied and are represented in the table 49.

Table 49. Seasonal rainfall distribution under projected climate of south central laterites (AEU9) in Pathanamthitta district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	2	37.84	19	399.41	81	2249.3	25	565.38
4.5	2030	2	38.3	23	327.8	68	1980.2	21	495.6
	2050	2	14.1	26	416.3	68	2278.4	19	477
	2080	2	37.7	21	311.4	72	1820.3	22	405.4
8.5	2030	2	38.9	26	348.2	70	2157.2	19	483.4
	2050	2	15.7	22	375.2	71	1950.8	19	486.9
	2080	2	37	24	328.4	76	2091	24	491.8

At present, the highest number of rainy days happens in south west monsoon period (81 days) followed by north east (25 days), summer season (19 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 period followed by north east. The lowest number of rainy days and precipitation will be getting in summer and winter season.

There will be an extreme abatement in precipitation in north east when contrasted with the current condition.

4.1.3.2.2 High rainfall events of south central laterites (AEU9) in Pathanamthitta district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in the table 50.

Table 50. High rainfall events under projected climate of south central laterites (AEU9) in Pathanamthitta district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	2	2	0	0	4	2	2	0	0
	SW monsoon	28	25	7	4	2	28	25	7	4	2
	NE monsoon	11	7	2	0	0	11	7	2	0	0
	Total	**43**	**34**	**11**	**4**	**2**	**43**	**34**	**11**	**4**	**2**
2030	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	12	2	0	0	0	13	2	0	0	0
	SW monsoon	18	23	5	2	2	17	22	9	2	2
	NE monsoon	5	4	1	0	1	5	4	1	0	1
	Total	**37**	**29**	**6**	**2**	**3**	**37**	**28**	**10**	**2**	**3**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	16	3	0	0	0	13	3	0	0	0
	SW monsoon	23	17	11	1	3	29	20	5	1	2
	NE monsoon	7	2	2	0	1	6	3	2	0	1
	Total	**46**	**22**	**13**	**1**	**4**	**48**	**26**	**7**	**1**	**3**
2080	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	11	2	0	0	0	9	3	0	0	0
	SW monsoon	23	22	3	2	1	25	16	5	6	1
	NE monsoon	7	3	0	0	1	8	3	1	0	1
	Total	**43**	**27**	**3**	**2**	**2**	**44**	**22**	**6**	**6**	**2**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (43 days) and 25 to 50 mm (34 days) and heavy rainfall which is in the range 50 to

more than 100 mm (17 days) the number of rainfall events is less. Comparing the present to the projected climate there will be an increasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an decreasing trend.

4.1.3.3 Rainfall analysis of southern and central foothills (AEU12) and impact of projected climate change in Pathanamthitta district

The southern and central foothills agro-ecological unit is delineated to represent the undulating lands with low hills, between midland laterites and the high hills of Western Ghats. It covers 90 panchayats from Thiruvananthapuram to Thrissur districts. The unit covers 3, 15,893 ha (8.13 %) in the state.

4.1.3.3.1 Rainfall and Rainy days of southern and central foothills (AEU12) in Pathanamthitta district

The monthly rainfall distribution of southern and central foothills (AEU12) for the present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 51.

Table 51. Monthly rainfall distribution under projected climate of southern and central foothills (AEU12) in Pathanamthitta district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	37.4	45.9	48	39.3	24.7	10.4	16
February	12.4	1.6	2.1	2.1	6.5	5.6	22.3
March	2.6	28.9	69.1	68.5	33.5	31.1	35.6
April	102.2	67.1	86.8	94.1	78.6	51.6	56.7
May	387.6	173.6	195.6	184.9	160.9	161.9	188.2
June	174	637.5	596.6	624.3	778.3	570.5	549.4
July	120	850	802.6	654.1	858.8	598.7	660.3
August	424.2	533.2	588.8	515	545.3	545.7	546.3
September	720.6	66.2	68.4	68.2	66.1	140.9	53.9
October	553.7	266	248.5	273.6	243.3	324.5	441.8
November	194.6	124.2	179.9	48.8	187.3	49.1	49.2
December	318.2	69.9	99.3	21.7	102	20	67.3
Total	**3047.5**	**2864.1**	**2985.7**	**2594.6**	**3085.3**	**2510**	**2687**

Presently, annual rainfall is around (3047.5 mm). September (720.6 mm) and October (553.7 mm) are the wettest months. February (12.4 mm) and March (2.6 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, April, May, September, October and November. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s and 2050s and 2080s except in 2030s of RCP 8.5.

The analysis of monthly rainy days in southern and central foothills (AEU12) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 52.

Table 52. Monthly rainy days under projected climate of southern and central foothills (AEU12) in Pathanamthitta district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3	3	2	2	2	1	1
February	3	0	0	0	1	1	1
March	5	2	5	5	4	3	5
April	10	5	6	6	6	6	6
May	12	15	11	11	13	10	10
June	18	21	23	22	22	23	23
July	22	24	24	24	23	23	24
August	21	18	18	19	19	19	20
September	17	4	3	4	4	7	5
October	18	9	10	11	10	12	14
November	13	4	5	4	5	4	4
December	8	7	5	3	5	2	7
Total	**150**	**112**	**112**	**111**	**114**	**111**	**120**

Currently, annually there is around 150 rainy days. July (22 days) and August (21 days) months have the highest number of rainy days and the most reduced is in January

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and February (3 day each). 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 highest rainy days will be 24 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of southern and central foothills lands. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of southern and central foothills (AEU12) for the present and projected climate were studied and are presented in table 53.

Table 53. Seasonal rainfall distribution under projected climate of southern and central foothills (AEU12) in Pathanamthitta district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	6	108.33	27	582.23	78	1817.19	40	997.09
4.5	2030	3	47.5	22	269.6	67	2086.9	20	460.1
	2050	2	50.1	22	351.5	68	2056.4	20	527.7
	2080	2	41.4	22	347.5	69	1861.6	18	344.1
8.5	2030	3	31.2	23	273	68	2248.5	20	532.6
	2050	2	16	19	244.6	72	1855.8	18	393.6
	2080	2	38.3	21	280.5	72	1809.9	25	558.3

At present, the highest number of rainy days happens in south west monsoon period (78 days) followed by north east (40 days), summer season (27 days) and winter season (6 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in north east, summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West.

4.1.3.3.2 High rainfall events of southern and central foothills (AEU12) in Pathanamthitta district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 54.

Table 54. High rainfall events under projected climate of southern and central foothills (AEU12) in Pathanamthitta district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	12	5	1	0	0	12	5	1	0	0
	SW monsoon	31	9	5	0	1	31	9	5	0	1
	NE monsoon	18	8	3	1	1	18	8	3	1	1
	Total	**63**	**22**	**9**	**1**	**2**	**63**	**22**	**9**	**1**	**2**
2030	Winter	0	1	0	0	0	1	0	0	0	0
	Summer	12	0	0	0	0	9	2	0	0	0
	SW monsoon	19	19	10	3	0	19	22	7	4	2
	NE monsoon	5	4	0	2	0	9	4	2	0	1
	Total	**36**	**24**	**10**	**5**	**0**	**38**	**28**	**9**	**4**	**3**
2050	Winter	1	1	0	0	0	0	0	0	0	0
	Summer	12	2	0	0	0	9	1	0	0	0
	SW monsoon	21	17	10	3	1	27	18	5	3	0
	NE monsoon	8	5	2	1	0	6	3	0	0	1
	Total	**42**	**25**	**12**	**4**	**1**	**42**	**22**	**5**	**3**	**1**
2080	Winter	0	1	0	0	0	2	0	0	0	0
	Summer	13	2	0	0	0	8	2	0	0	0
	SW monsoon	28	17	5	2	1	27	19	4	2	1
	NE monsoon	6	2	0	0	1	8	3	2	0	1
	Total	**47**	**22**	**5**	**2**	**2**	**45**	**24**	**6**	**2**	**2**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (63 days) and 25 to 50 mm (22 days) and heavy rainfall which is in the range 50 to more than 100 mm (12 days) the number of rainfall events is less. Comparing the present

to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.3.4 Rainfall analysis of southern high hills (AEU14) and impact of projected climate change in Pathanamthitta district

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

4.1.3.4.1 Rainfall and Rainy days of southern high hills (AEU14) in Pathanamthitta district

The monthly rainfall distribution of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in the table 55.

Table 55. Monthly rainfall distribution under projected climate of southern high hills (AEU14) in Pathanamthitta district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	4.6	5.5	5.2	6	5.3	39
February	22	42.4	43.9	42.7	38.4	42.8	10
March	58.6	38.3	38.7	39.3	45.5	40.3	28.1
April	64.4	74.6	76.5	77.8	64	77	71
May	262.2	183	142.3	156.8	165.6	135.9	128.4
June	308.8	475.1	457.5	438.5	525.1	466.3	604.3
July	350.2	622.2	668.6	677.5	638.1	661.9	434.7
August	536	425.5	420.7	426.1	379.9	422.3	492.1
September	243	89.6	93.5	93.3	85.6	94.7	72.4
October	335.4	227.1	239.4	249.7	235.9	252.4	304.7
November	205.2	17.7	18.4	19	18	19	207.2
December	36.4	28.1	27.5	35.3	27.2	27.3	43.5
Total	**2423.2**	**2228.2**	**2232.5**	**2261.2**	**2229.3**	**2245.2**	**2435.4**

Presently, annual rainfall is around (2423.2mm). July (350.2 mm) and august (536 mm) are the wettest months. January (1 mm) and February (22 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and December there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months March, May, September and November. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s except in the case of RCP 8.5 of 2080s.

The analysis of monthly rainy days in southern high hills (AEU14) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are represented in the table 56.

Table 56. Monthly rainy days under projected climate of southern high hills (AEU14) in Pathanamthitta district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	1	1	1	1	2
February	2	2	2	2	2	2	2
March	4	4	4	4	4	4	3
April	7	5	5	5	5	5	8
May	8	13	12	13	11	10	8
June	19	21	21	20	20	20	24
July	20	20	21	20	22	21	15
August	15	17	17	17	14	18	18
September	12	4	4	4	4	4	3
October	16	8	8	8	8	7	9
November	12	1	1	1	1	1	9
December	4	4	4	6	4	4	4
Total	**120**	**100**	**100**	**101**	**96**	**97**	**105**

Currently, annually there was around 120 rainy days. July (20 days) and August (15 days) months have the highest number of rainy days and the most reduced is in January

(1 day) and February (2 days). 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 highest rainy days will be 24 days and the base will be 1 to 2 days. The projected climate demonstrates a decreasing trend in the annual rainy days of southern high hills. In nut shell the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of southern high hills (AEU14) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are presented in the table 57.

Table 57. Seasonal rainfall distribution under projected climate of southern high hills (AEU14) in Pathanamthitta district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	62.13	19	370.36	66	1286.18	33	760.79
4.5	2030	3	47	22	295.9	62	1612.4	13	272.9
	2050	3	49.4	21	257.5	63	1640.3	13	285.3
	2080	3	47.9	22	273.9	61	1635.4	15	304
8.5	2030	3	44.4	20	275.1	60	1628.7	13	281.1
	2050	3	48.1	19	253.2	63	1645.2	12	298.7
	2080	4	49	19	227.5	60	1603.5	22	555.4

At present, the highest number of rainy days happens in south west monsoon period (66 days) followed by north east (33 days), summer season (19 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in north east, summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in south west.

4.1.3.4.2 High rainfall events of southern high hills (AEU14) in Pathanamthitta district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are represented in table 58.

Table 58. High rainfall events under projected climate of southern high hills (AEU14) in Pathanamthitta district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	4	0	1	0	6	4	0	1	0
	SW monsoon	31	14	3	0	1	31	14	3	0	1
	NE monsoon	10	6	1	0	0	10	6	1	0	0
	Total	**48**	**24**	**4**	**1**	**1**	**48**	**24**	**4**	**1**	**1**
2030	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	12	2	0	0	0	6	3	0	0	0
	SW monsoon	22	16	5	3	0	18	17	6	0	2
	NE monsoon	3	2	0	0	1	2	3	0	0	1
	Total	**37**	**21**	**5**	**3**	**1**	**26**	**24**	**6**	**0**	**3**
2050	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	11	2	0	0	0	11	1	0	0	0
	SW monsoon	26	14	6	1	1	25	13	6	1	2
	NE monsoon	2	3	0	0	1	2	3	0	0	1
	Total	**39**	**20**	**6**	**1**	**2**	**38**	**18**	**6**	**1**	**3**
2080	Winter	0	1	0	0	0	2	0	0	0	0
	Summer	10	1	0	0	0	8	2	0	0	0
	SW monsoon	24	13	6	2	1	20	14	5	3	0
	NE monsoon	2	3	0	0	1	6	4	2	0	1
	Total	**36**	**18**	**6**	**2**	**2**	**36**	**20**	**7**	**3**	**1**

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

4.1.4 Rainfall analysis of various AEUs of Idukki district

The Idukki district has been divided into four agro ecological units (fig.5) comprising southern and central foot hills (AEU12), southern high hills (AEU14), kumily hills (AEU16) and marayur hills (AEU17). Each AEU occupies 38200 ha (8.75%), 209695 ha (48.06%), 150984 ha (34.60%) and 28968 ha (6.64%) respectively.

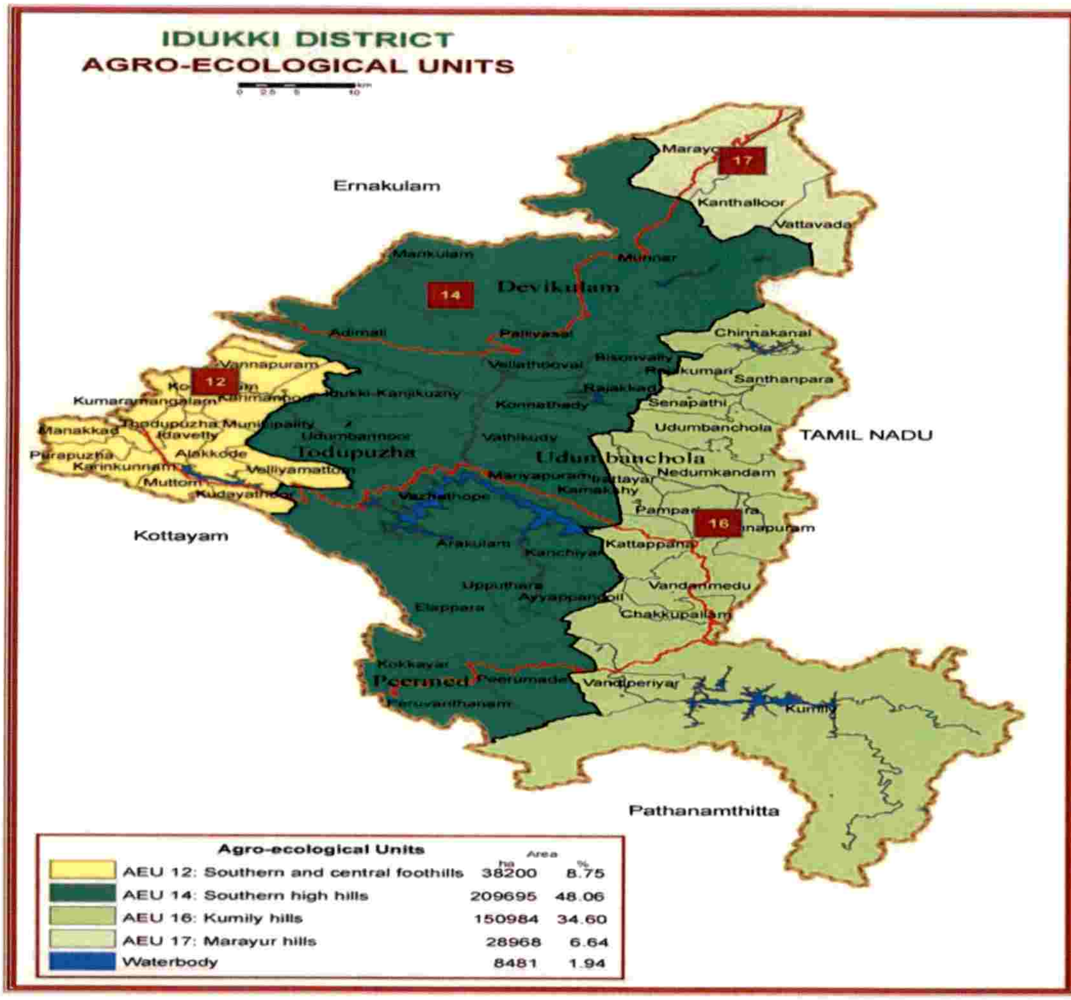

Fig.5 Agro-Ecological Unit wise map of Idukki District

4.1.4.1 Rainfall analysis of southern and central foothills (AEU12) and impact of projected climate change of Idukki district

The southern and central Foothills agro-ecological unit is delineated to represent the undulating lands with low hills, between midland laterites and the high hills of Western

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

4.1.4.1.1 Rainfall and Rainy days of southern and central foothills (AEU12) in Idukki district

The monthly rainfall distribution of southern and central foothills (AEU12) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in the table 59.

Table 59. Monthly rainfall distribution under projected climate of southern and central foothills (AEU12) in Idukki district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	37.4	16.3	14.6	32.5	16.6	32.4	7.7
February	12.4	0.4	1.6	0.6	0.4	0.6	4.3
March	2.6	56.4	56.5	38	57.5	37.8	46.7
April	102.2	74.7	75.3	41.9	75.7	40.8	48.6
May	387.6	497.4	345.8	349.4	502.2	351.6	328.8
June	174	924.9	916.9	789	955.5	795.3	1026.2
July	120	1100.4	1257.5	1170.1	1108.7	1168.2	1032.8
August	424.2	960.4	797.1	777.8	970.3	783.4	749.8
September	720.6	34.5	28.6	133.5	34.7	132.8	141.2
October	553.7	369.3	424.2	368	380	369.5	365.4
November	194.6	24.2	21	187.6	24.6	189.5	205.7
December	318.2	12.9	17.6	99.3	13.4	94.9	85.3
Total	**3047.5**	**4071.8**	**3956.7**	**3987.7**	**4139.6**	**3996.8**	**4042.5**

Presently, annual rainfall is around (3047.5 mm). August (424.2 mm), September (720.6 mm) and October (553.7 mm) are the wettest months. February (12.4 mm) and March (2.6 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, April, September, October, November and December. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of increase in the total annual rainfall during 2030s, 2050s and 2080s.

The monthly rainy days in southern and central foothills (AEU12) for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in table 60.

Table 60. Monthly rainy days under projected climate of southern and central foothills (AEU12) in Idukki district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3	2	2	2	2	2	1
February	3	0	0	0	0	0	1
March	5	5	5	4	5	4	5
April	10	3	3	6	3	6	5
May	12	18	18	18	18	18	17
June	18	22	24	25	22	25	24
July	22	28	25	25	28	25	27
August	21	17	18	20	17	20	20
September	17	4	3	6	4	6	8
October	18	11	11	12	11	12	10
November	13	3	1	4	3	4	6
December	8	1	2	7	1	7	6
Total	**150**	**114**	**112**	**129**	**114**	**129**	**130**

Currently, annually there was around 150 rainy days. July (22 days) and August (21 days) months have the highest number of rainy days and 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 July and August and the base will be in January and February. The highest rainy days will be 28 days and the base value will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of southern and central foothills. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and corresponding rainfall of southern and central foothills (AEU12) for the current and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 61.

Table 61. Seasonal rainfall distribution under projected climate of southern and central foothills (AEU12) in Idukki district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	6	108.33	27	582.23	78	1817.19	40	997.09
4.5	2030	2	16.7	26	628.5	71	3020.2	15	406.4
	2050	2	16.2	26	477.6	70	3000.1	14	462.8
	2080	2	33.1	28	429.3	76	2870.4	23	654.9
8.5	2030	2	17	26	635.4	71	3069.2	15	418
	2050	2	33	28	430.2	76	2879.7	23	653.9
	2080	2	12	27	424.1	79	2950	22	656.4

At present, the highest number of rainy days happens in south west monsoon period (78 days) followed by north east (40 days), summer season (27 days) and winter season (6 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by summer rains and north east. The lowest number of rainy days and precipitation will be getting in winter season. There will be an extreme abatement in precipitation in north east and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in south west.

4.1.4.1.2 High rainfall events of southern and central foothills (AEU12) in Idukki district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in the table 62.

Table 62. High rainfall events under projected climate of southern and central foothills (AEU12) in Idukki district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	12	5	1	0	0	12	5	1	0	0
	SW monsoon	31	9	5	0	1	31	9	5	0	1
	NE monsoon	18	8	3	1	1	18	8	3	1	1
	Total	**63**	**22**	**9**	**1**	**2**	**63**	**22**	**9**	**1**	**2**
2030	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	13	5	1	0	1	13	5	1	0	1
	SW monsoon	19	18	15	3	7	19	18	15	3	7
	NE monsoon	4	3	1	0	1	4	3	1	0	1
	Total	**37**	**26**	**17**	**3**	**9**	**37**	**26**	**17**	**3**	**9**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	17	4	0	0	0	13	3	1	0	0
	SW monsoon	18	18	17	3	5	20	21	9	9	4
	NE monsoon	5	3	1	0	1	6	3	0	3	1
	Total	**41**	**25**	**18**	**3**	**6**	**40**	**27**	**10**	**12**	**5**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	13	3	1	0	0	14	1	1	0	0
	SW monsoon	20	20	11	8	4	22	22	14	6	3
	NE monsoon	6	3	1	2	1	11	2	1	2	1
	Total	**40**	**26**	**13**	**10**	**5**	**47**	**25**	**16**	**8**	**4**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (63 days) and 25 to 50 mm (22 days) and heavy rainfall which is in the range 50 to

more than 100 mm (12 days) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.4.2 Rainfall analysis of southern high hills (AEU14) and impact of projected climate change in Idukki district

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

4.1.4.2.1 Rainfall and Rainy days of southern high hills (AEU14) in Idukki district

The monthly rainfall distribution of southern high hills (AEU 14) for the present and projected climate as per RCP 4.5 and RCP 8.5 were presented and studied in the table 63.

Table 63. Monthly rainfall distribution under projected climate of southern high hills (AEU14) in Idukki district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	13.5	11.5	11.4	11.6	11.4	6.8
February	22	26.3	17.3	16.7	16.5	16.7	22
March	58.6	27.3	27.4	28.6	33.5	28.7	36
April	64.4	48.6	41.8	41.1	34.9	40.1	47.5
May	262.2	151.9	169.4	173.4	149	146.5	144.2
June	308.8	490.7	457.4	439.6	458.3	444.8	431
July	350.2	512.8	512.2	548.7	522.7	555.4	505
August	536	459.2	452.1	437.9	447.3	429.8	409.5
September	243	55.5	76.6	75.5	54.8	75.9	92.9
October	335.4	240.2	261.7	240.3	252.6	243.4	366
November	205.2	25.2	26.5	26.4	25.8	26.9	169.3
December	36.4	41.1	41.3	50.6	43.6	34.6	50.1
Total	**2423.2**	**2092.3**	**2095.2**	**2090.2**	**2050.6**	**2054.2**	**2280.3**

Presently, annual rainfall is around (2423.2 mm). June (308.8 mm), July (350.2 mm) and August (536 mm) are the wettest months January (1 mm) and February (22 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June, July and August will be the wettest month but the amount of rainfall will be much higher whereas January and February are the driest months. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months March, April, May, September and November. As per the projections based on RCP 4.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

From the analysis of monthly rainy days in southern high hills (AEU14) for present and projected climate of RCP 4.5 and RCP 8.5 were studied and are presented in table 64.

Table 64. Monthly rainy days under projected climate of southern high hills (AEU14) in Idukki district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	1	1	1	1	1
February	2	1	1	1	1	1	1
March	4	3	3	3	4	3	4
April	7	6	5	5	4	5	6
May	8	13	12	12	11	10	10
June	19	23	23	23	23	23	21
July	20	22	21	21	22	22	24
August	15	15	15	19	15	19	19
September	12	2	3	4	2	4	5
October	16	11	11	9	11	9	14
November	12	3	3	3	3	3	5
December	4	4	3	4	4	2	4
Total	**120**	**104**	**101**	**105**	**101**	**102**	**114**

Currently, annually there was around 120 rainy days. June (19 days) and July (20 days) months have the highest number of rainy days and 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 highest rainy days will be 24 days and the base will be 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of southern high hills. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of southern high hills (AEU14) for the present and projected climate were studied and are presented in the table 65.

Table 65. Seasonal rainfall distribution under projected climate of southern high hills (AEU14) in Idukki district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	62.13	19	370.36	66	1286.18	33	760.79
4.5	2030	2	39.8	22	227.8	62	1518.2	18	306.5
	2050	2	28.8	20	238.6	62	1498.3	17	329.5
	2080	2	28.1	20	243.1	67	1501.7	16	317.3
8.5	2030	2	28.1	19	217.4	62	1483.1	18	322
	2050	2	28.1	18	215.3	68	1505.9	14	304.9
	2080	2	28.8	20	227.7	69	1438.4	23	585.4

At present, the highest number of rainy days happens in south west monsoon period (66 days) followed by north east (33 days), summer season (19 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in north east, summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West.

4.1.4.2.2 High rainfall events of southern high hills (AEU14) in Idukki district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in the table 66.

Table 66. High rainfall events under projected climate of southern high hills (AEU14) in Idukki district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	4	0	1	0	6	4	0	1	0
	SW monsoon	31	14	3	0	1	31	14	3	0	1
	NE monsoon	10	6	1	0	0	10	6	1	0	0
	Total	**48**	**24**	**4**	**1**	**1**	**48**	**24**	**4**	**1**	**1**
2030	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	10	0	0	0	0	6	2	0	0	0
	SW monsoon	20	18	5	1	0	21	20	3	2	0
	NE monsoon	7	2	1	0	0	6	3	1	0	0
	Total	**39**	**20**	**6**	**1**	**0**	**35**	**25**	**4**	**2**	**0**
2050	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	7	2	0	0	0	7	2	0	0	0
	SW monsoon	21	20	3	2	0	25	20	2	2	0
	NE monsoon	5	4	1	0	0	4	3	1	1	0
	Total	**35**	**26**	**4**	**2**	**0**	**38**	**25**	**3**	**3**	**0**
2080	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	9	2	0	0	0	7	2	0	0	0
	SW monsoon	26	18	3	2	0	27	16	3	1	0
	NE monsoon	4	3	1	1	0	6	4	3	1	0
	Total	**41**	**23**	**4**	**3**	**0**	**41**	**22**	**6**	**2**	**0**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (48 days) and 25 to 50 mm (24 days) and heavy rainfall which is in the range 50 to more than 100 mm (6 days) the number of rainfall events is less. Comparing the present to

the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.4.3 Rainfall analysis of kumily hills (AEU16) and climate change impacts in Idukki district

The kumily high hills agro-ecological unit is delineated to represent low-rainfall parts of the High Hills zone. The unit differs from Southern High Hills not only in the lower rainfall, but also the extensive occurrence of very deep, non-gravelly clay soils. Thirteen panchayats distributed in Peerumedu and Udumbanchola taluks of Idukki district constitute this unit. The unit covers around 1, 50,984 ha (3.81 %) in the state.

4.1.4.3.1 Rainfall and Rainy days of kumily hills (AEU16) in Idukki district

The monthly rainfall distribution of kumily hills (AEU16) for the present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 67.

Table 67. Monthly rainfall distribution under projected climate of kumily hills (AEU16) in Idukki district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	16.8	22.5	20.6	20.4	21.7	20.1	8.4
February	12.1	15.5	10.3	10.2	9.2	10.2	22.3
March	33.4	30	33.7	34.9	33.9	35.2	27.7
April	79	45.2	51.4	50.6	41.2	49.4	50.6
May	87.8	164.8	152.5	137.4	157.7	134.3	115.2
June	336.5	509.8	466.9	449.4	540.2	450.2	441.4
July	358.6	516.4	527.9	564.5	502.1	562.1	571.7
August	282.9	466.5	458.8	429.9	398.6	428.7	378.5
September	184.8	34.7	37	35.6	33.6	35.9	93.1
October	242.4	263.7	285.2	257.8	277.6	261	324.3
November	187.4	18.1	19.1	19.4	18.5	19.3	206
December	57.8	94.5	98.8	110.6	98.2	90.8	46.4
Total	**1879.5**	**2181.7**	**2162.2**	**2120.7**	**2132.5**	**2097.2**	**2285.6**

Presently, annual rainfall is around (1879.5 mm). June (336.5 mm) and July (358.6 mm) are the wettest months. January (16.8 mm) and february (12.1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February are the driest months. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months April, September and November. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of increase in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in kumily hills (AEU16) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are represented in table 68.

Table 68. Monthly rainy days under projected climate of kumily hills (AEU16) in Idukki district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	1	1	1	1	1	1
February	1	2	1	1	1	1	1
March	2	4	4	4	3	4	3
April	5	3	6	6	6	6	6
May	6	10	12	11	10	10	8
June	20	22	22	23	22	22	22
July	22	24	24	24	24	25	24
August	19	14	14	18	12	19	19
September	13	2	2	3	2	3	5
October	13	11	11	9	11	9	13
November	10	2	2	2	2	2	6
December	4	7	7	7	7	5	4
Total	**116**	**102**	**106**	**109**	**101**	**107**	**112**

Currently, annually there was around 116 rainy days. June (20 days) and July (22 days) months have the highest number of rainy days and it is around 22 days and the most reduced is in January and February (1 day each). 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 highest rainy days will be 25 days and the base will be 1 to 2 days. The projected climate demonstrates a decreasing trend in the yearly rainy days of kumily hills.

The seasonal rainy days and rainfall of kumily hills (AEU16) for the present and projected climate were studied and are represented in the table 69.

Table 69. Seasonal rainfall distribution under projected climate of kumily hills (AEU16) in Idukki 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	28.88	13	200.3	74	1162.83	27	487.63
4.5	2030	3	38	17	240	62	1527.4	20	376.3
	2050	2	30.9	22	237.6	62	1490.6	20	403.1
	2080	2	30.6	21	222.9	68	1479.4	18	387.8
8.5	2030	2	30.9	19	232.8	60	1474.5	20	394.3
	2050	2	30.3	20	218.9	69	1476.9	16	371.1
	2080	2	30.7	17	193.5	70	1484.7	23	576.7

At present, the highest number of rainy days happens in south west monsoon period (74 days) followed by north east (27 days), summer season (13 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 period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an increase in precipitation in south west, summer and winter season when contrasted with the current condition.

4.1.4.3.2 High rainfall events of kumily hills (AEU16) in Idukki district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 70.

Table 70. High rainfall events under projected climate of kumily hills (AEU16) in Idukki district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	1	0	1	0	0	1	0	1	0	0
	Summer	5	1	0	0	0	5	1	0	0	0
	SW monsoon	33	4	1	0	0	33	4	1	0	0
	NE monsoon	15	5	0	1	0	15	5	0	1	0
	Total	**54**	**10**	**2**	**1**	**0**	**54**	**10**	**2**	**1**	**0**
2030	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	8	2	0	0	0	9	1	0	0	0
	SW monsoon	20	17	3	3	0	19	15	3	3	0
	NE monsoon	5	3	0	0	1	7	3	0	0	1
	Total	**35**	**22**	**3**	**3**	**1**	**36**	**19**	**3**	**3**	**1**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	11	1	0	0	0	10	0	0	0	0
	SW monsoon	19	17	5	1	0	22	16	6	0	0
	NE monsoon	7	3	0	0	1	5	3	1	0	1
	Total	**38**	**21**	**5**	**1**	**1**	**38**	**19**	**7**	**0**	**1**
2080	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	10	0	0	0	0	6	2	0	0	0
	SW monsoon	22	15	7	0	0	27	19	2	2	0
	NE monsoon	5	3	1	0	1	6	4	3	1	0
	Total	**38**	**18**	**8**	**0**	**1**	**40**	**25**	**5**	**3**	**0**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (54 days) and 25 to 50 mm (10 days) and heavy rainfall which is in the range 50 to more than 100 mm (3 days) the number of rainfall events is less. Comparing the present to

the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.4.4 Rainfall analysis of marayur hills (AEU17) and impact of projected climate change in Idukki district

The marayur dry hills agro-ecological unit is delineated to represent the low rainfall region (rain-shadow) of the high hill zone and comprises only three panchayats of Idukki district. The unit covers 28,968 ha (0.75 %) in the state.

4.1.4.4.1 Rainfall and Rainy days of marayur hills (AEU17) in Idukki district

The monthly rainfall distribution of marayur hills (AEU17) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in the table 71.

Table 71. Monthly rainfall distribution under projected climate of marayur hills (AEU17) in Idukki district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	55.3	16.6	16.6	18.2	17.1	18.5	19.3
February	75.8	14.4	14.9	14.6	14.1	14.7	14.9
March	194.3	26.2	26.6	18.9	26.9	26.6	30.2
April	136.5	49.1	50.2	47.8	49.3	34.1	38.1
May	118.9	111.6	114.3	123.2	110.3	130.9	149.7
June	99.3	483.5	488.9	568.2	494.6	503.7	498.4
July	151.2	602.3	614	675.7	589.8	794.2	650.2
August	279.4	512.2	495.4	502	496.6	537.7	567.1
September	483.6	69.9	53.3	128.7	71.5	94	35.2
October	385.3	258.2	315	212.9	261	280.6	262
November	239.4	206.8	212.5	37	207.5	35.2	41.7
December	81.5	104.2	106.4	81.2	106.8	77	80
Total	**2300.5**	**2455**	**2508.1**	**2428.4**	**2445.5**	**2547.2**	**2386.8**

Presently, annual rainfall is around (2300.5 mm). September (483.6 mm) and October (385.3 mm) are the wettest months January (55.3 mm) and February (75.8 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June, July and August months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months January, February, March, April and September. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of increase in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in marayur hills (AEU17) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 72.

Table 72. Monthly rainy days under projected climate of marayur hills (AEU17) in Idukki district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	4	1	1	1	1	1	1
February	5	2	2	2	2	2	2
March	12	4	4	2	4	2	2
April	10	5	5	3	5	3	3
May	9	10	10	11	10	10	9
June	8	21	21	22	22	20	21
July	10	25	24	24	25	21	22
August	15	13	13	20	13	17	21
September	19	5	5	5	5	4	2
October	17	10	11	10	10	12	11
November	11	7	7	4	7	3	4
December	6	5	5	7	6	7	7
Total	**126**	**108**	**108**	**111**	**110**	**102**	**105**

Currently, annually there was around 126 rainy days. September (19 days) and October (17 days) months have the highest number of rainy days and 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 highest rainy days will be 25 days and the base will be 1 to 2 days. The projected climate demonstrates a decreasing trend in the annual rainy days of marayur hills. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of marayur hills (AEU17) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are presented in the table 73.

Table 73. Seasonal rainfall distribution under projected climate of marayur hills (AEU17) in Idukki 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	10	131.13	30	449.71	52	1013.46	34	706.21
4.5	2030	3	31	19	186.9	64	1667.9	22	569.2
	2050	3	31.5	19	191.1	63	1651.6	23	633.9
	2080	3	32.8	16	189.9	71	1874.6	21	331.1
8.5	2030	3	31.2	19	186.5	65	1652.5	23	575.3
	2050	3	33.2	15	191.6	62	1929.6	22	392.8
	2080	3	34.2	14	218	66	1750.9	22	383.7

At present, the highest number of rainy days happens in south west monsoon period (54 days) followed by north east (34 days), summer season (30 days) and winter season (10 days). As indicated by projected climate, the most elevated number of rainy days and high measure of precipitation will be in south west monsoon period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in north east, summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West.

4.1.4.4.2 High rainfall events of marayur hills (AEU17) in Idukki district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are represented in table 74.

Table 74. High rainfall events under projected climate of marayur hills (AEU17) in Idukki district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	4	0	0	0	0	4	0	0	0	0
	Summer	8	1	0	0	0	8	1	0	0	0
	SW monsoon	13	15	6	1	1	13	15	6	1	1
	NE monsoon	0	0	1	0	0	0	0	1	0	0
	Total	**25**	**16**	**7**	**1**	**1**	**25**	**16**	**7**	**1**	**1**
2030	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	6	1	0	0	0	6	1	0	0	0
	SW monsoon	17	20	6	2	0	17	19	5	2	0
	NE monsoon	8	6	1	2	0	8	6	1	2	0
	Total	**32**	**27**	**7**	**4**	**0**	**32**	**26**	**6**	**4**	**0**
2050	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	6	1	0	0	0	8	1	0	0	0
	SW monsoon	18	19	6	2	0	13	19	12	1	1
	NE monsoon	8	7	1	2	0	6	3	0	1	0
	Total	**34**	**27**	**7**	**4**	**0**	**28**	**23**	**12**	**2**	**1**
2080	Winter	1	0	0	0	0	2	0	0	0	0
	Summer	7	1	0	0	0	8	1	0	0	0
	SW monsoon	22	18	9	2	0	22	18	6	3	0
	NE monsoon	6	2	0	1	0	7	3	0	0	1
	Total	**36**	**21**	**9**	**3**	**0**	**39**	**22**	**6**	**3**	**1**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (25 days) and 25 to 50 mm (16 days) and heavy rainfall which is in the range 50 to more than 100 mm (9 days) the number of rainfall events is less. Comparing the present to

the projected climate there will be an increasing trend in the number of low rainfall events below 50 mm per day and high rainfall events.

4.1.5 Rainfall analysis of various AEUs of Kottayam district

The Kottayam district has been divided into three agro ecological units (fig.6) comprising kuttanad (AEU4), south central laterites (AEU9) and south and central foothills (AEU12). Each AEU occupies 59695 ha (27.08%), 80330 ha (36.44%) and 72611 ha (32.94%) respectively.

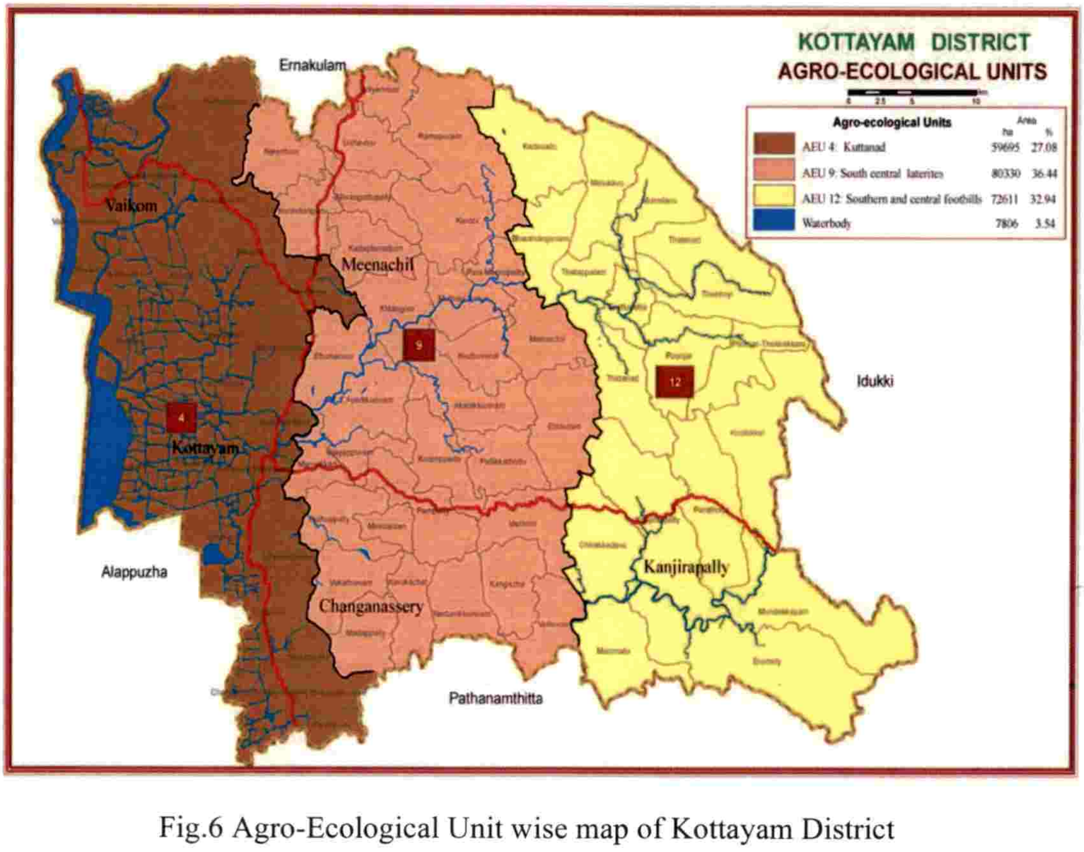

Fig.6 Agro-Ecological Unit wise map of Kottayam District

4.1.5.1 Rainfall analysis of kuttanad (AEU4) and impact of projected climate change in Kottayam district

Kuttanad is a special agro-ecological unit delineated to represent the waterlogged lands spread over 69 panchayats of Alappuzha, Kottayam and Pathanamthitta districts. Large parts of these lands are below, at or just above sea level. The unit covers 1, 26,931 ha (3.27%) in the state.

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4.1.5.1.1 Rainfall and Rainy days of kuttanad (AEU4) in Kottayam district

The monthly rainfall distribution of kuttanad (AEU4) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 75.

Table 75. Monthly rainfall distribution under projected climate of kuttanad (AEU4) in Kottayam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	7.2	14.9	16.2	14.7	15.4	14.5	37
February	15.1	0.5	0.4	0.5	0.4	0.4	0.8
March	44.5	45.6	53.8	53.8	46.9	53.8	25.7
April	133.6	92.1	81.8	81.3	93.3	80.5	59
May	237.4	445.3	386.9	423	423.8	414.8	271.6
June	481.9	969.9	787.8	779.5	977.7	734.2	759.3
July	510.2	796.2	796.3	853.1	794.5	825.2	769.1
August	326.6	474.9	589.1	590.4	513.5	674.4	629.2
September	259.5	18.6	180.4	173.7	26.1	173.4	257.6
October	365.3	367.9	381.1	312.6	378.7	313.2	295.6
November	206.2	23.6	25.5	26.5	24.2	26.8	50.4
December	49.1	15.3	13.6	18.5	15.7	17.5	75.1
Total	**2636.6**	**3264.8**	**3312.9**	**3327.6**	**3310.2**	**3328.7**	**3230.4**

Presently, annual rainfall is around (2636.6 mm). June (481.9 mm) and July (510.2 mm) are the wettest months. January (7.2 mm) and February (15.1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition, the projected climate shows a drastic decrease in the amount of rainfall during the months February, April, September and November. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of increase in the total annual rainfall during 2030s, 2050s and 2080s.

The monthly rainy days in kuttanad (AEU4) for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in the table 76.

Table 76. Monthly rainy days under projected climate of kuttanad (AEU4) in Kottayam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	2	2
February	1	0	0	0	0	0	0
March	3	4	4	4	4	4	3
April	9	6	6	6	6	6	6
May	11	20	16	17	19	16	15
June	19	21	23	23	21	23	24
July	22	23	23	22	23	22	22
August	17	18	18	18	18	19	20
September	14	2	6	6	3	6	8
October	15	11	11	12	11	12	11
November	10	2	3	3	3	3	4
December	3	2	1	3	2	3	7
Total	**125**	**111**	**113**	**116**	**112**	**116**	**122**

Currently, annually there was around 125 rainy days. June (19 days) and July (22 days) months have the highest number of rainy days and the most reduced is in January and February (1 day each). 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 highest rainy days will be 24 days and the base will be 0 to 2 days. The projected climate demonstrates a decreasing trend in the annual rainy days of kuttanad. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and corresponding rainfall of kuttanad (AEU4) for the current and projected climate according to RCP 4.5 and RCP 8.5 were studied and are represented in table 77.

Table 77. Seasonal rainfall distribution under projected climate of kuttanad (AEU4) in Kottayam 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	22.23	23	415.47	72	1578.17	28	620.55
4.5	2030	2	15.4	30	583	64	2259.6	15	406.8
	2050	2	16.6	26	522.5	70	2353.6	15	420.2
	2080	2	15.2	27	558.1	69	2396.7	18	357.6
8.5	2030	2	15.8	29	564	65	2311.8	16	418.6
	2050	2	14.9	26	549.1	70	2407.2	18	357.5
	2080	2	37.8	24	356.3	74	2415.2	22	421.1

At present, the highest number of rainy days happens in south west monsoon period (72 days) followed by north east (28 days), summer season (23 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 period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be an extreme abatement in precipitation in north east and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West and summer.

4.1.5.1.2 High rainfall events of kuttanad (AEU4) in Kottayam district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 78.

Table 78. High rainfall events under projected climate of kuttanad (AEU4) in Kottayam district

Year	Rainfall (mm)	10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
		RCP 4.5					RCP 8.5				
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	5	2	2	0	0
	SW monsoon	23	10	3	1	0	23	10	3	1	0
	NE monsoon	4	3	1	0	0	4	3	1	0	0
	Total	**32**	**15**	**6**	**1**	**0**	**32**	**15**	**6**	**1**	**0**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	16	5	0	0	1	16	4	0	0	1
	SW monsoon	17	20	9	4	2	17	20	10	4	2
	NE monsoon	3	3	1	0	1	3	3	1	0	1
	Total	**36**	**28**	**10**	**4**	**4**	**36**	**27**	**11**	**4**	**4**
2050	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	15	2	0	0	1	14	2	1	0	1
	SW monsoon	14	24	9	5	1	16	20	12	5	1
	NE monsoon	4	3	1	0	1	6	2	0	0	1
	Total	**34**	**29**	**10**	**5**	**3**	**36**	**24**	**13**	**5**	**3**
2080	Winter	0	0	0	0	0	2	0	0	0	0
	Summer	15	2	1	0	1	9	4	0	0	0
	SWmonsoon	16	20	11	6	1	21	23	7	5	3
	NE monsoon	6	2	0	0	1	7	3	0	0	1
	Total	**37**	**24**	**12**	**6**	**3**	**39**	**30**	**7**	**5**	**4**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (32 days) and 25 to 50 mm (15 days) and heavy rainfall which is in the range 50 to more than 100 mm (7 days) the number of rainfall events is less. Comparing the present to the projected climate, there will be an increasing trend in both the number of low rainfall events and heavy rainfall events.

4.1.5.2 Rainfall analysis of south central laterites (AEU9) and impact of projected climate change in Kottayam district

The special agro-ecological unit south central laterites (AEU9) is delineated for the sandy plains extending into the midlands from coast and covering 43 panchayats in Kollam and Kottayam districts. The unit covers 67,447 ha (1.74 %) in the state.

4.1.5.2.1 Rainfall and Rainy days of south central laterites (AEU9) in Kottayam district

The monthly rainfall distribution of south central laterites (AEU9) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in table 79.

Table 79. Monthly rainfall distribution under projected climate of south central laterites (AEU9) in Kottayam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	15.7	34.1	14.3	15.4	14.1	10.5
February	2	0.4	0.7	1.5	0.4	1.5	5.3
March	1	32.3	25.5	36.3	33.6	36.3	36.3
April	103	50.3	49.9	41.5	37.5	40.8	43.5
May	191	394.4	299.2	270.8	412	264.1	271.2
June	518.5	690.7	963.8	661	716.6	699.3	796.3
July	641.5	1049.4	1100.6	1113.2	1052.1	1132.7	928.2
August	891	554.1	589.4	666.1	561.6	665.6	660.8
September	381	39.7	121.5	84.8	118.1	86.8	147.2
October	357	466.5	339.2	352.5	409.5	347.1	349.2
November	72	39	180.5	171.7	129.3	180.9	199.2
December	144	66.2	90.2	98	71.5	92.5	91
Total	**3302**	**3398.7**	**3794.6**	**3511.7**	**3557.6**	**3561.7**	**3538.7**

Presently, annual rainfall is around (3302 mm). July (641.5 mm) and August (891 mm) are the wettest months. January (0 mm), February (2 mm) and March (1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also, June and July will be the wettest months but the amount of rainfall will be much higher whereas January and February will be the driest. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months April, August, September and December. As per the projections based on RCP 4.5 and RCP 8.5, there is chance of increase in the total annual rainfall during 2030s, 2050s and 2080a but an increase during 2080s.

From the analysis of monthly rainy days in south central laterites (AEU9) for present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in the table 80.

Table 80. Monthly rainy days under projected climate of south central laterites (AEU9) in Kottayam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	2	1
February	1	0	0	0	0	0	1
March	2	3	4	3	3	3	4
April	8	6	3	5	4	5	5
May	9	17	19	14	18	13	15
June	22	24	24	25	24	25	26
July	25	25	25	25	25	25	27
August	19	17	17	18	16	18	19
September	15	2	6	4	6	4	7
October	15	11	12	12	13	11	10
November	8	3	4	4	4	5	6
December	2	6	7	7	6	7	7
Total	**127**	**116**	**123**	**119**	**121**	**118**	**128**

Currently, annually there was around 127 rainy days. June (22 days) and July (25 days) months have the highest number of rainy days and the most reduced is in January and February (1 day each). 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 highest rainy days will be 27 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of south central laterites except in the case of 2080s of RCP 8.5. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of south central laterites (AEU9) for the present and projected climate were studied and are presented in table 81.

Table 81. Seasonal rainfall distribution under projected climate of south central laterites (AEU9) in Kottayam district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	2	37.84	19	399.41	81	2249.3	25	565.38
4.5	2030	2	16.1	26	477	68	2333.9	20	571.7
	2050	2	34.8	26	374.6	72	2775.3	23	609.9
	2080	2	15.8	22	348.6	72	2525.1	23	622.2
8.5	2030	2	15.8	25	483.1	71	2448.4	23	610.3
	2050	2	15.6	21	341.2	72	2584.4	23	620.5
	2080	2	15.8	24	351	79	2532.5	23	639.4

At present, the highest number of rainy days happens in south west monsoon period (81 days) followed by north east (25 days), summer season (19 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 period followed by north east rains. The lowest number of rainy days and precipitation will be getting in summer and winter season. There will be an extreme abatement in precipitation in winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in south west and north east.

4.1.5.2.2 High rainfall events of south central laterites (AEU9) in Kottayam district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 82.

Table 82. High rainfall events under projected climate of south central laterites (AEU9) in Kottayam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	2	2	0	0	4	2	2	0	0
	SW monsoon	28	25	7	4	2	28	25	7	4	2
	NE monsoon	11	7	2	0	0	11	7	2	0	0
	Total	**43**	**34**	**11**	**4**	**2**	**43**	**34**	**11**	**4**	**2**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	13	2	0	0	1	14	2	0	0	1
	SW monsoon	20	22	11	4	1	23	22	11	3	2
	NE monsoon	8	4	0	0	2	5	3	1	2	1
	Total	**41**	**28**	**11**	**4**	**4**	**42**	**27**	**12**	**5**	**4**
2050	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	12	4	0	0	0	11	1	1	0	0
	SW monsoon	24	18	13	3	5	25	13	13	5	4
	NE monsoon	5	3	1	2	1	6	3	1	2	1
	Total	**42**	**25**	**14**	**5**	**6**	**42**	**17**	**15**	**7**	**5**
2080	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	12	1	1	0	0	12	1	1	0	0
	SW monsoon	23	19	10	5	3	31	19	9	4	3
	NE monsoon	6	3	1	2	1	6	3	1	2	1
	Total	**41**	**23**	**12**	**7**	**4**	**49**	**23**	**11**	**6**	**4**

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

4.1.5.3 Rainfall analysis of south and central foothills (AEU12) and impact of projected climate change in Kottayam district

The southern and central foothills agro-ecological unit is delineated to represent the undulating lands with low hills, between midland laterites and the high hills of Western Ghats. It covers 90 panchayats from Thiruvananthapuram to Thrissur districts. The unit covers 3, 15,893 ha (8.13 %) in the state.

4.1.5.3.1 Rainfall and Rainy days of south and central foothills (AEU12) in Kottayam district

The monthly rainfall distribution of south and central foothills (AEU12) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in table 83.

Table 83. Monthly rainfall distribution under projected climate of south and central foothills (AEU12) in Kottayam district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	37.4	33.1	34.4	33	33.9	10.4	11.3
February	12.4	0.7	0.8	0.8	0.7	23.4	5.3
March	2.6	30.9	28.8	33.4	30.2	33.1	31.7
April	102.2	64.6	65.9	55.1	65.1	54	51.9
May	387.6	255.7	258.4	221.2	259.7	212.1	248.7
June	174	787.6	863.6	645.8	802.8	665.4	633.3
July	120	984.9	1038.4	1038.3	1009.3	931.6	891.4
August	424.2	600.7	611.4	670.9	574.7	757.4	615.7
September	720.6	82.7	120.1	83.9	116.4	97.5	96
October	553.7	445.3	326.3	339.2	331.2	341.5	422
November	194.6	24.6	189.8	180.8	185.3	182.7	194
December	318.2	75.5	88.2	95.9	88.6	90.4	88.3
Total	**3047.5**	**3386.3**	**3626.1**	**3398.3**	**3497.9**	**3399.5**	**3289.6**

Presently, annual rainfall is around (3047.5 mm). September (720.6 mm) and October (553.7 mm) are the wettest months. February (12.4 mm) and March (2.6 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, April, September, November and December. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of increase in the total annual rainfall during 2030s and 2050s and 2080s.

The analysis of monthly rainy days in south and central foothills (AEU12) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 84.

Table 84. Monthly rainy days under projected climate of south and central foothills (AEU12) in Kottayam district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	3	2	2	2	2	1	1
February	3	0	0	0	0	1	1
March	5	4	4	5	4	5	3
April	10	6	6	6	6	6	6
May	12	17	17	13	17	12	13
June	18	24	24	25	24	26	24
July	22	25	23	25	25	24	29
August	21	18	19	19	18	19	19
September	17	4	6	4	6	5	6
October	18	11	10	10	11	10	12
November	13	2	6	6	5	6	6
December	8	5	7	7	7	7	7
Total	**150**	**118**	**124**	**122**	**125**	**122**	**127**

Currently, annually there was around 150 rainy days. July (22 days) and August (21 days) months have the highest number of rainy days and 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 highest rainy days will be 29 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of south and central foothills. In general, the wet months will be wetter and dry periods will be drier.

The seasonal rainy days and rainfall of south and central foothills (AEU12) for the present and projected climate were studied and are presented in the table 85.

Table 85. Seasonal rainfall distribution under projected climate of south and central foothills (AEU12) in Kottayam district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	6	108.33	27	582.23	78	1817.19	40	997.09
4.5	2030	2	33.8	27	351.2	71	2455.9	18	545.4
	2050	2	35.2	27	353.1	72	2633.5	23	604.3
	2080	2	33.8	24	309.7	73	2438.9	23	615.9
8.5	2030	2	34.6	27	355	73	2503.2	23	605.1
	2050	2	33.8	23	299.2	74	2451.9	23	614.6
	2080	2	16.6	22	332.3	78	2236.4	25	704.3

At present, the highest number of rainy days happens in south west monsoon period (78 days) followed by north east (40 days), summer season (27 days) and winter season (6 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by north east. The lowest number of rainy days and precipitation will be getting in summer and winter season.

There will be an extreme abatement in precipitation in north east, summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West.

4.1.5.3.2 High rainfall events of south and central foothills (AEU12) in Kottayam district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 86.

Table 86. High rainfall events under projected climate of south and central foothills (AEU12) in Kottayam district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	12	5	1	0	0	12	5	1	0	0
	SW monsoon	31	9	5	0	1	31	9	5	0	1
	NE monsoon	18	8	3	1	1	18	8	3	1	1
	Total	**63**	**22**	**9**	**1**	**2**	**63**	**22**	**9**	**1**	**2**
2030	Winter	2	0	0	0	0	1	0	0	0	0
	Summer	13	2	0	0	0	10	4	0	0	0
	SW monsoon	25	19	8	6	3	27	19	8	6	3
	NE monsoon	7	4	0	0	2	5	3	1	2	1
	Total	**47**	**25**	**8**	**6**	**5**	**43**	**26**	**9**	**8**	**4**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	11	3	0	0	0	9	3	0	0	0
	SW monsoon	27	19	9	6	3	25	14	13	6	1
	NE monsoon	5	3	1	2	1	6	3	1	2	1
	Total	**44**	**25**	**10**	**8**	**4**	**41**	**20**	**14**	**8**	**2**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	10	3	0	0	0	11	1	1	0	0
	SW monsoon	23	14	13	6	1	29	24	8	2	1
	NE monsoon	6	3	1	2	1	7	3	2	2	1
	Total	**40**	**20**	**14**	**8**	**2**	**47**	**28**	**11**	**4**	**2**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (63 days) and 25 to 50 mm (22 days) and heavy rainfall which is in the range 50 to more than 100 mm (12 days) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.6 Rainfall analysis of various AEUs of Alappuzha district

The Alappuzha district has been divided into five agro ecological units (fig.7) comprising southern coastal plain (AEU1), onattukara sandy plain (AEU3), kuttanad (AEU4), pokkali lands (AEU5), and south central laterites (AEU9). Each AEU occupies 10030ha (7.11%), 43654ha (30.96%), 58238ha (41.30%), 2049ha (1.45%) and 8058ha (5.71%), respectively.

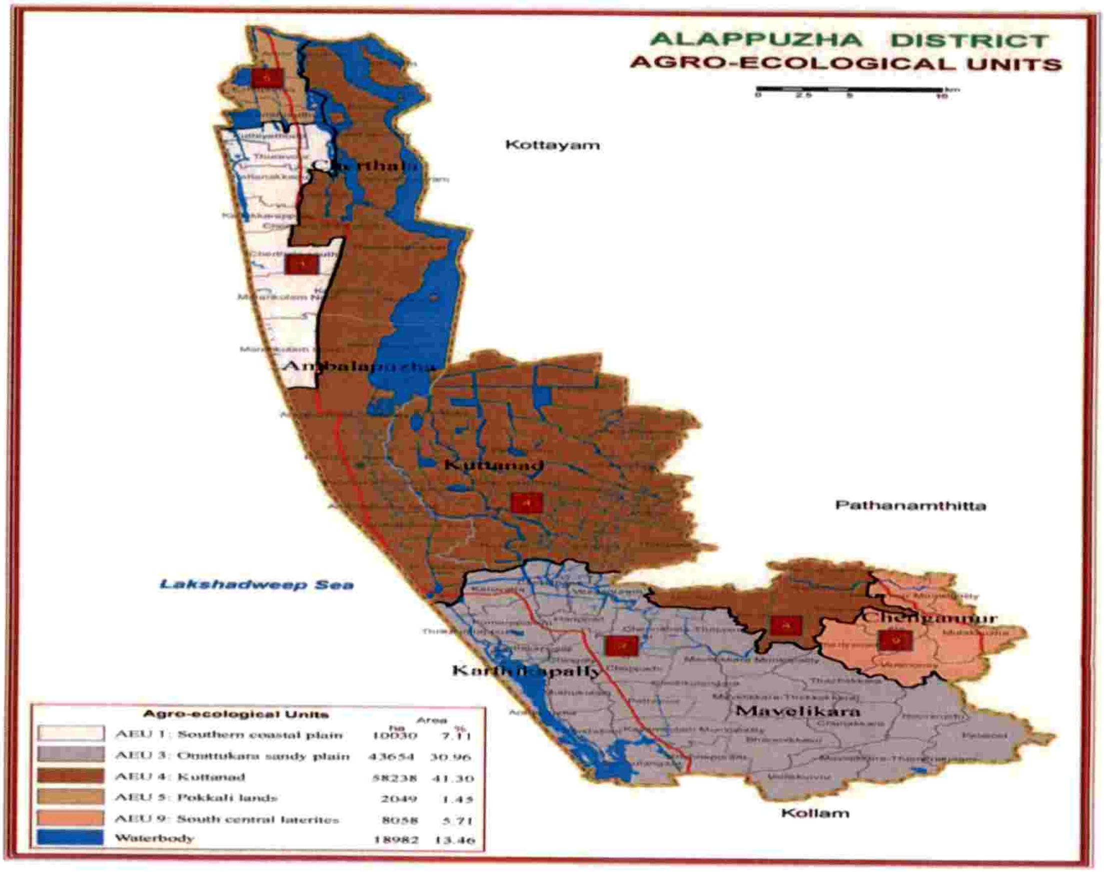

Fig.7 Agro-Ecological Unit wise map of Alappuzha District

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4.1.6.1 Rainfall analysis of southern coastal plain (AEU1) and impact of projected climate in Alappuzha district

The southern coastal plain agro-ecological unit is delineated to represent the nearly level coastal lands where sands are the dominant soil type. The unit comprises 42 panchayats along the coast from Thiruvananthapuram to Ernakulum district. The unit covers 56,782 ha (1.46 %) in the state.

4.1.6.1.1 Rainfall and Rainy days of southern coastal plain (AEU1) in Alappuzha district

The monthly rainfall distribution of southern coastal plain (AEU1) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 87.

Table 87. Monthly rainfall distribution under projected climate of southern coastal plain (AEU1) in Alappuzha district

Rainfall(mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	18.4	10.8	12	10.6	10.6	10.6	14.9
February	45.3	10.6	9.5	12	10.7	1.1	0.4
March	61	24	13.5	16.7	14.5	26.3	31.5
April	144.9	58.4	50.7	53.4	50.2	52.7	44.4
May	271.7	549.5	588.1	485.2	579.6	392.6	411
June	597.7	821.5	889.3	664	824.8	744.2	652.4
July	501.3	1025.4	992.2	1037.9	1018.3	999.5	900.9
August	339.6	510.9	389.7	456.9	457.2	484.7	590.8
September	294	9.3	42.1	118.1	9.3	118	176.7
October	364.6	405.9	371.2	367.3	417.9	368.7	316.2
November	191.9	66.9	78.9	77.8	67.7	50.2	28
December	40.3	43.9	48.9	50.9	45.8	74.5	17.4
Total	**2870.7**	**3537.1**	**3486.1**	**3350.8**	**3506.6**	**3323.1**	**3184.6**

Presently, the annual rainfall is around (2870.7 mm) and June and July are the wettest months, having a rainfall of 597.7 mm and 501.3 mm respectively. January (18.4 mm) and

December (40.3 mm) are the months having lowest rainfall. The rainfall is highly distributed through out the year. As per projected climate based on RCP 4.5 and 8.5 the June and July will be the wettest month but the amount of rainfall will be much higher and the driest months are January and February and there is chances to increase the aridity. Compared to the present condition the projecterd climate shows a drastic decrease in February, March, April, September and November. As per projrction based of RCP 4.5 and 8.5 there is a probability to increase the annual rainfall availability by the year 2030s, 2050s and 2080s

The monthly rainy days in southern coastal plain (AEU1) for present and projected climate as per RCP 4.5 and RCP 8.5 were analyzed and represented in the table 88.

Table 88. Monthly rainy days under projected climate of southern coastal plain (AEU1) in Alappuzha district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	2	2
February	2	1	1	1	1	0	0
March	3	3	2	2	2	3	3
April	7	4	4	7	4	7	6
May	11	20	21	17	21	16	16
June	21	25	24	25	24	25	24
July	22	27	25	25	27	24	25
August	17	13	14	13	13	14	19
September	13	1	2	6	1	6	6
October	15	10	12	12	10	12	12
November	9	4	4	4	4	3	3
December	2	4	4	4	4	5	3
Total	**123**	**114**	**115**	**118**	**113**	**117**	**119**

Currently, annually there is around 123 rainy days. June (21 days) and July (22 days) have the highest number of rainy days and most reduced is in January, February and December (1-2 days). According to RCP 4.5 and 8.5, the highest number of rainy days will be happening in June and July and the base will be in January and February. The highest rainy days will be 27 and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the annual rainy days of southern coastal plain. In nut shell the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and corresponding rainfall of southern coastal plain (AEU1) for the current and projected climate according to RCP 4.5 and RCP 8.5 were analyzed and presented in table 89.

Table 89. Seasonal rainfall distribution under projected climate of southern coastal plain (AEU1) in Alappuzha district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	63.73	22	477.66	73	1732.53	26	596.72
4.5	2030	3	21.4	27	631.9	66	2367.1	18	516.7
	2050	3	21.5	27	652.3	65	2313.3	20	499
	2080	3	22.6	26	555.3	69	2276.9	20	496
8.5	2030	3	21.3	27	644.3	65	2309.6	18	531.4
	2050	2	11.7	26	471.6	69	2346.4	20	493.4
	2080	2	15.3	25	486.9	74	2320.8	18	361.6

Currently, maximum number of rainy days happens in south west monsoon period (73 days) followed by and north east monsoon (26 days), summer (22 days) and winter (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by summer rains. The base number of rainy days and precipitation will be getting in north east and winter.

There will be an extreme abatement in precipitation in summer and winter season when contrasted with the current condition. The projected climate demonstrates an intense precipitation in south west and north east.

4.1.6.1.2 High rainfall events of southern coastal plain (AEU1) in Alappuzha district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 90.

Table 90. High rainfall events under projected climate of southern coastal plain (AEU1) in Alappuzha district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	1	0	0	0	0	1	0	0
	Summer	3	5	2	1	0	3	5	2	1	0
	SW monsoon	27	12	4	2	1	27	12	4	2	1
	NE monsoon	6	4	1	0	0	6	4	1	0	0
	Total	**36**	**21**	**8**	**3**	**1**	**36**	**21**	**8**	**3**	**1**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	10	4	1	0	2	12	4	1	0	2
	SW monsoon	20	18	12	5	2	20	18	12	4	2
	NE monsoon	10	3	0	0	2	10	3	0	0	2
	Total	**40**	**25**	**13**	**5**	**6**	**42**	**25**	**13**	**4**	**6**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	11	4	1	0	2	10	2	1	0	1
	SW monsoon	22	16	9	5	3	25	14	13	4	2
	NE monsoon	9	4	0	1	1	8	4	0	1	1
	Total	**42**	**24**	**10**	**6**	**6**	**43**	**20**	**14**	**5**	**4**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	9	3	0	1	1	12	2	0	0	1
	SW monsoon	28	11	13	5	1	19	28	9	2	2
	NE monsoon	8	4	0	1	1	5	3	0	0	1
	Total	**46**	**18**	**13**	**7**	**3**	**36**	**33**	**9**	**2**	**4**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (36 days) and 25 to 50 mm (21 days) and in case of heavy rainfall which is >50 mm (12 days) the number of rainfall events is less. Comparing the present to the projected climate there will be an increasing trend in the number of high rainfall events above 50 mm per day with an increase in the low rainfall events too.

4.1.6.2 Rainfall analysis of onattukara sandy plain (AEU3) and impact of projected climate change in Alappuzha district

The special agro-ecological unit onattukara sandy plain is delineated for the sandy plains extending into the midlands from coast and covering 43 panchayats in Kollam and Alappuzha districts. The unit covers 67,447 ha (1.74 %) in the state.

4.1.6.2.1 Rainfall and Rainy days of onattukara sandy plain (AEU3) in Alappuzha district

The monthly rainfall distribution of onattukara sandy plain (AEU3) for the present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are represented in the table 91.

Table 91. Monthly rainfall distribution under projected climate of onattukara sandy plain (AEU3) in Alappuzha district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	21.2	14.9	15	30.4	14.7	10.6	2.3
February	32.4	1.1	1	1.1	1.1	1.5	11.4
March	45	24.4	28.1	29.9	25.3	26.9	38.7
April	142.1	65.9	60.4	60.1	66.3	49.3	47.3
May	260.7	286.7	253.6	253.1	277.4	231.2	230.7
June	535.6	763.3	635.1	623.9	797.5	703.1	824.5
July	492.9	827.4	747.5	815.6	777	930	689.1
August	339.9	369.3	476.9	499.1	422.8	568	579.3
September	271.3	84.2	237.9	236.9	83.8	118.6	144.2
October	335.2	378.9	305.9	313.2	392.2	359.4	419.3
November	177.6	11.9	111.8	110.8	12.2	39.5	198.8
December	47.9	68.1	73.4	79.8	71.3	98	80.2
Total	**2701.8**	**2896.1**	**2946.6**	**3053.9**	**2941.6**	**3136.1**	**3265.8**

Presently, the annual rainfall is around (2701.8 mm) and June and July are the wettest months having a rainfall of 535.6 mm and 492.9 mm respectively. January (21.2 mm) and February (32.4 mm) are the months having minimum rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest months but the amount of rainfall will be much higher whereas January and February there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months January, February, March, April and September. As per the projection the annual rainfall availability will likely to increase by 2030s, 2050s and 2080s.

Monthly rainy days in onattukara sandy plain (AEU3) for present and projected climate (RCP 4.5 and RCP 8.5) were analyzed and represented in the table 92.

Table 92. Monthly rainy days under projected climate of onattukara sandy plain (AEU3) in Alappuzha district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	3	3	3	3	2	0
February	2	0	0	0	0	0	2
March	3	2	2	2	2	3	4
April	7	5	5	5	5	6	5
May	11	20	15	15	19	14	13
June	21	23	23	23	23	24	26
July	22	23	22	22	23	25	23
August	17	15	18	18	16	16	19
September	13	4	7	7	4	6	7
October	15	9	11	11	9	11	11
November	9	2	3	3	2	3	6
December	3	7	7	7	7	6	6
Total	**124**	**113**	**116**	**116**	**113**	**116**	**122**

As per present condition, June (21 days) and July (22 days) months have the maximum number of rainy days and the most reduced is in January and December that is about 1 to 2 days. Annually, there is around 124 rainy days under the present condition. As per the climate projection based on RCP 4.5 and RCP 8.5, the greatest number of rainy days will be happening in June and July months and the base will be in February and march. The highest rainy days will be 26 days and the base will be 0 to 2 days. The projected climate demonstrates a decreasing trend in the yearly rainy days of onattukara sandy plain.

The seasonal rainy days and rainfall of onattukara sandy plain (AEU3) for the present and projected climate were studied in the table 93.

Table 93. Seasonal rainfall distribution under projected climate of onattukara sandy plain (AEU3) in Alappuzha district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	53.6	21	447.75	72	1639.69	26	560.65
4.5	2030	3	16	27	377	65	2044.2	18	458.9
	2050	3	16	22	342.1	70	2097.4	21	491.1
	2080	3	31.5	22	343.1	70	2175.5	21	503.8
8.5	2030	3	15.8	26	369	66	2081.1	18	475.7
	2050	2	12.1	23	307.4	71	2319.7	20	496.9
	2080	2	13.7	22	316.7	75	2237.1	23	698.3

At present, the highest number of rainy days happens in south west monsoon period (72 days) followed by north east (26 days), summer season (21 days) and winter season (3 days). As indicated by projected climate the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be a drastic decrease in precipitation in summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in South West.

4.1.6.2.2 High rainfall events of onattukara sandy plain (AEU3) in Alappuzha district

The high rainfall events of four different seasons for present and projected climate as per RCP 4.5 and RCP 8.5 were studied and are presented in table 94.

Table 94. High rainfall events under projected climate of onattukara sandy plain (AEU3) in Alappuzha district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	1	0	0	0	0	1	0	0	0
	Summer	8	2	1	1	0	8	2	1	1	0
	SW monsoon	24	15	1	3	1	24	15	1	3	1
	NE monsoon	7	6	1	1	0	7	6	1	1	0
	Total	**39**	**24**	**3**	**5**	**1**	**39**	**24**	**3**	**5**	**1**
2030	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	13	1	1	0	0	12	1	1	0	0
	SW monsoon	14	23	7	3	2	15	22	8	3	2
	NE monsoon	5	2	2	0	1	4	3	2	0	1
	Total	**32**	**26**	**10**	**3**	**3**	**31**	**26**	**11**	**3**	**3**
2050	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	13	1	1	0	0	7	3	0	0	0
	SW monsoon	16	23	6	5	0	25	14	13	4	1
	NE monsoon	5	4	0	1	1	7	4	0	1	1
	Total	**34**	**28**	**7**	**6**	**1**	**39**	**21**	**13**	**5**	**2**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	13	1	1	0	0	12	1	0	0	0
	SW monsoon	14	23	6	6	1	25	19	9	4	2
	NE monsoon	5	4	0	1	1	7	2	2	2	1
	Total	**33**	**28**	**7**	**7**	**2**	**44**	**22**	**11**	**6**	**3**

In present condition, the number of rainfall events occurring is more in the range of 10 to 25 mm (39 days) and 25 to 50 mm (24 days) and heavy rainfall which is

>50 mm (9 days) the number of rainfall events is less. Comparing the present to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.6.3 Rainfall analysis of kuttanad (AEU4) and climate change impacts in Alappuzha district

Kuttanad is a special agro-ecological unit delineated to represent the waterlogged lands spread over 69 panchayats of Alappuzha, Kottayam and Pathanamthitta districts. Large parts of these lands are below, at or just above sea level. The unit covers 1, 26,931 ha (3.27%) in the state.

4.1.6.3.1 Rainfall and Rainy days of kuttanad (AEU4) in Alappuzha district

The monthly rainfall distribution of kuttanad (AEU4) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in table 95.

Table 95. Monthly rainfall distribution under projected climate of kuttanad (AEU4) in Alappuzha district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	7.2	50.4	34.8	34	50.8	34.1	10.2
February	15.1	4	0.5	3.1	0.3	0.4	6.1
March	44.5	22.7	29.5	30.9	27.1	33.2	28.8
April	133.6	50.1	35.2	43.4	50.7	42.7	33.4
May	237.4	304.7	474.1	414.3	303.4	407.3	240
June	481.9	925.4	995.2	779.3	894	737.9	742.7
July	510.2	855.3	793.7	817.4	752.9	789	802.4
August	326.6	514.4	502	558.8	577.4	635.4	506
September	259.5	2.4	25.4	20	0.7	20.2	247.5
October	365.3	283.9	389.2	309.1	356.5	310.1	297.2
November	206.2	27.1	26.7	29.4	28	29.8	141.1
December	49.1	69	64.5	73.1	71.8	68.5	79.6
Total	**2636.6**	**3109.4**	**3370.8**	**3112.8**	**3113.6**	**3108.6**	**3135**

Presently, annual rainfall is around (2636.6 mm). June and July are the wettest months, having a rainfall of 481.9 mm and 510.2 mm. January (7.2 mm) and December (15.1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas February and March there is chance of increase in aridity. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months February, March, April, September and November. As per the projections based on RCP 4.5 and RCP 8.5 the total annual rainfall will show a continuous increasing trend during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in kuttanad (AEU4) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in table 96.

Table 96. Monthly rainy days under projected climate of kuttanad (AEU4) in Alappuzha district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	2	2
February	1	1	0	1	0	0	1
March	3	3	3	3	4	4	2
April	9	4	4	5	4	5	2
May	11	19	20	16	18	15	17
June	19	23	21	23	23	23	24
July	22	26	23	23	23	23	25
August	17	15	18	18	16	19	20
September	14	0	3	3	0	3	8
October	15	11	11	12	9	12	9
November	10	2	3	4	2	4	4
December	3	4	6	6	4	6	8
Total	**125**	**110**	**114**	**116**	**105**	**116**	**122**

Currently, June (19 days) and July (22 days) months have the highest number of rainy days and the most reduced is in January and February (1 day each). 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 highest rainy days will be 26 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the yearly rainy days of Pokkali lands.

The seasonal rainy days and rainfall of kuttanad (AEU4) for the present and projected climate were studied and are presented in the table 97.

Table 97. Seasonal rainfall distribution under projected climate of kuttanad (AEU4) in Alappuzha 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	22.23	23	415.47	72	1578.17	28	620.55
4.5	2030	3	54.4	26	377.5	64	2297.5	17	380
	2050	2	35.3	27	538.8	65	2316.3	20	480.4
	2080	3	37.1	24	488.6	67	2175.5	22	411.6
8.5	2030	2	51.1	26	381.2	62	2225	15	456.3
	2050	2	34.5	24	483.2	68	2182.5	22	408.4
	2080	3	16.3	21	302.2	77	2298.6	21	517.9

At present, the highest number of rainy days happens in south west monsoon period (72 days) followed by north east (28 days), summer season (23 days) and winter season (2 days). As indicated by projected climate of both RCP 4.5 and RCP 8.5 the most elevated number of rainy days and high measure of precipitation will get in south west monsoon period followed by summer rains. The lowest number of rainy days and precipitation will be getting in north east and winter season. There will be an extreme abatement in precipitation in summer and winter season when contrasted with the current condition. The projected climate demonstrates a strengthened precipitation in south west.

4.1.6.3.2 High rainfall events of kuttanad (AEU4) in Alappuzha district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 98.

Table 98. High rainfall events under projected climate of kuttanad (AEU4) in Alappuzha district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	5	2	2	0	0	5	2	2	0	0
	SW monsoon	23	10	3	1	0	23	10	3	1	0
	NE monsoon	4	3	1	0	0	4	3	1	0	0
	Total	**32**	**15**	**6**	**1**	**0**	**32**	**15**	**6**	**1**	**0**
2030	Winter	1	1	0	0	0	1	1	0	0	0
	Summer	9	3	1	0	0	9	3	1	0	0
	SW monsoon	14	21	11	2	3	13	20	10	2	3
	NE monsoon	6	2	0	0	1	6	2	2	0	1
	Total	**30**	**27**	**12**	**2**	**4**	**29**	**26**	**13**	**2**	**4**
2050	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	11	3	0	0	1	9	2	1	0	1
	SW monsoon	18	20	10	4	2	17	21	10	2	2
	NE monsoon	4	4	1	0	1	7	3	0	0	1
	Total	**34**	**27**	**11**	**4**	**4**	**34**	**26**	**11**	**2**	**4**
2080	Winter	1	0	0	0	0	0	0	0	0	0
	Summer	10	2	1	0	1	11	2	0	0	0
	SW monsoon	16	20	11	3	1	23	23	8	3	2
	NE monsoon	7	3	0	0	1	5	4	0	0	2
	Total	**34**	**25**	**12**	**3**	**3**	**39**	**29**	**8**	**3**	**4**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (32 days) and 25 to 50 mm (15 days) and heavy rainfall which is in the range 50 to more than 100 mm (7 days) the number of rainfall events is less. Comparing the present to

the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.6.4 Rainfall analysis of pokkali lands (AEU5) and impact of projected climate change in Alappuzha district

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

4.1.6.4.1 Rainfall and Rainy days of pokkali lands (AEU5) in Alappuzha district

The monthly rainfall distribution of pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are prepared in the table 99.

Table 99. Monthly rainfall distribution under projected climate of pokkali lands (AEU5) in Alappuzha district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	14.6	47.1	10.6	31.8	32	31.7	24.5
February	50.4	0.3	10.8	3.3	3	3.2	1
March	180.5	22.5	23.3	26.3	22.5	21.7	24
April	401.9	72.9	60.2	24.7	49.8	27.8	45.5
May	530.3	392	518.8	498.5	590.5	543.1	434.9
June	776.8	937.8	963.3	797.7	976.9	767.1	759.1
July	702.9	1093	1129	1042.2	1051.3	1032.1	1029.2
August	455.1	462.1	410	447	459.4	460.1	502.5
September	234.9	72.5	11.3	101	9.6	121.6	203.8
October	315.2	385.3	450.9	493.5	437.7	494.7	426.9
November	96.7	46.4	69.3	46	31.6	45.9	133.7
December	15.9	57.3	47.5	73.8	59.7	70.6	74.2
Total	**3775.2**	**3589.2**	**3705**	**3585.8**	**3724**	**3619.6**	**3659.3**

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

The analysis of monthly rainy days in pokkali lands (AEU5) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are represented in the table 100.

Table 100. Monthly rainy days under projected climate of pokkali lands (AEU5) in Alappuzha district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	2	3
February	2	0	1	1	0	1	0
March	5	4	3	3	3	2	3
April	11	7	4	3	5	4	4
May	16	18	20	17	20	18	19
June	22	25	25	24	23	23	25
July	22	29	28	25	28	25	27
August	18	13	14	13	11	13	15
September	9	3	1	5	1	6	7
October	11	11	10	14	12	14	13
November	5	3	4	4	4	4	4
December	1	3	4	5	4	5	6
Total	**123**	**118**	**116**	**116**	**113**	**117**	**126**

Currently, there is around 123 annual rainy days. June and July months have the highest number of rainy days and it is around 22 days and the most reduced is in January and December. According to RCP 4.5 and 8.5, the greatest number of rainy days will be happening in June and July and the base will be in January and February. The highest rainy days will be 29 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend except in the case of 2080 of RCP 8.5 in the annual rainy days of pokkali lands. In general, the wet months will be wetter and dry periods will be drier in this AEU.

The seasonal rainy days and rainfall of pokkali lands (AEU5) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are presented in the table 101

Table 101. Seasonal rainfall distribution under projected climate of pokkali lands (AEU5) in Alappuzha district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	3	65.06	32	1112.7	71	2169.66	16	427.76
4.5	2030	2	47.4	29	487.4	70	2565.4	17	489
	2050	3	21.4	27	602.3	68	2513.6	18	567.7
	2080	3	35.1	23	549.5	67	2387.9	23	613.3
8.5	2030	2	35	28	662.8	63	2497.2	20	529
	2050	3	34.9	24	592.6	67	2380.9	23	611.2
	2080	3	25.5	26	504.4	74	2494.6	23	634.8

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

4.1.6.4.2 High rainfall events of pokkali lands(AEU5) in Alappuzha district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are represented in the table 102.

Table 102. High rainfall events under projected climate of Pokkali lands (AEU5) in Alappuzha district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	22	17	6	1	0	22	17	6	1	0
	SW monsoon	20	15	7	1	2	20	15	7	1	2
	NE monsoon	2	1	0	0	0	2	1	0	0	0
	Total	**46**	**33**	**13**	**2**	**2**	**46**	**33**	**13**	**2**	**2**
2030	Winter	1	1	0	0	0	1	0	0	0	0
	Summer	10	2	1	0	1	10	4	0	0	2
	SW monsoon	13	24	12	6	2	19	19	11	5	2
	NE monsoon	8	2	2	0	1	8	4	0	0	2
	Total	**32**	**29**	**15**	**6**	**4**	**38**	**27**	**11**	**5**	**6**
2050	Winter	0	0	0	0	0	1	0	0	0	0
	Summer	12	3	2	0	1	11	2	1	1	1
	SW monsoon	20	17	16	2	3	23	16	14	1	3
	NE monsoon	10	3	0	0	2	5	3	1	2	1
	Total	**42**	**23**	**18**	**2**	**6**	**40**	**21**	**16**	**4**	**5**
2080	Winter	1	0	0	0	0	1	0	0	0	0
	Summer	11	1	1	1	1	12	4	0	0	1
	SW monsoon	23	16	14	1	3	28	15	12	7	1
	NE monsoon	5	3	1	2	1	5	3	1	2	1
	Total	**40**	**20**	**16**	**4**	**5**	**46**	**22**	**13**	**9**	**3**

Currently, the number of rainfall events occurring is more in the range of 10 to 25 mm (46 days) and 25 to 50 mm (33 days) and heavy rainfall which is in the range 50 to more than 100 mm (17 days) the number of rainfall events is less. Comparing the present

to the projected climate there will be a decreasing trend in the number of rainfall events below 50 mm per day whereas the heavy rainfall events shows an increasing trend.

4.1.6.5 Rainfall analysis of south central laterites (AEU9) and impact of projected climate change in Alappuzha district

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

4.1.6.5.1 Rainfall and Rainy days of south central laterites (AEU9) in Alappuzha district

The monthly rainfall distribution of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and RCP 8.5) were studied and are presented in the table 103.

Table 103. Monthly rainfall distribution under projected climate of south central laterites (AEU9) in Alappuzha district

Rainfall (mm)		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	0	12.5	10.6	36.6	37.2	37.3	15
February	2	0.6	1.5	0.6	0.8	0.6	21.1
March	1	22.7	36.7	27.2	30.1	25.2	28.7
April	103	68.7	44.2	54.5	47	59.5	50.3
May	191	366.7	254.4	252.5	271.6	259	268.6
June	518.5	686.5	724.5	683.9	727.8	720	698.5
July	641.5	848.8	908.9	1002.3	794.6	772.7	757.8
August	891	472.9	550.5	616.3	516.2	548.9	599.5
September	381	39.2	81.6	71.2	24.6	167.6	164.5
October	357	415.4	340.2	314.6	368.4	282.7	348.2
November	72	116.7	172.2	24.3	22.6	48.8	51.6
December	144	62.4	82.2	81	78	74.3	72.9
Total	**3302**	**3113.1**	**3207.5**	**3165**	**2918.9**	**2996.6**	**3076.7**

Presently, annual rainfall is around (3302 mm) and July and August are the wettest months, having a rainfall of 641.5 mm and 891 mm respectively. January (0 mm) and March (1 mm) are the months having lowest rainfall. As per projected climate based on RCP 4.5 and 8.5 also June and July months will be the wettest month but the amount of rainfall will be much higher whereas January and February will be the driest. Compared to the present condition the projected climate shows a drastic decrease in the amount of rainfall during the months April, August, September and December. As per the projections based on RCP 4.5 and RCP 8.5 there is chance of reduction in the total annual rainfall during 2030s, 2050s and 2080s.

The analysis of monthly rainy days in south central laterites (AEU9) for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 104.

Table 104. Monthly rainy days under projected climate of south central laterites (AEU9) in Alappuzha district

Rainy days		RCP 4.5			RCP 8.5		
Month	Present	2030	2050	2080	2030	2050	2080
January	1	2	2	2	2	2	1
February	1	0	0	0	0	0	1
March	2	3	3	3	3	3	4
April	8	7	4	6	5	6	6
May	9	18	15	15	17	15	15
June	22	22	24	25	21	25	25
July	25	22	25	25	23	25	24
August	19	16	16	16	18	18	19
September	15	2	4	3	3	7	8
October	15	14	12	12	13	11	12
November	8	4	4	3	3	4	4
December	2	5	6	7	7	7	7
Total	**127**	**115**	**115**	**117**	**115**	**123**	**126**

Currently, there is around 127 annual rainy days. June (22 days) and July (25 days) have the highest number of rainy days and the most reduced is in January and December. 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 highest rainy days will be 25 days and the base will be 0 to 1 day. The projected climate demonstrates a decreasing trend in the yearly rainy days of South Central Laterites.

The seasonal rainy days and rainfall of south central laterites (AEU9) for the present and projected climate under RCP 4.5 and RCP 8.5 were studied and are represented in the table 105.

Table 105. Seasonal rainfall distribution under projected climate of south central laterites (AEU9) in Alappuzha district

RCP	Season	Winter		Summer		South west		North east	
	Year	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)	Rainy Days	Rain (mm)
	Present	2	37.84	19	399.41	81	2249.3	25	565.38
4.5	2030	2	13.1	28	458.1	62	2047.4	23	594.5
	2050	2	12.1	22	335.3	69	2265.5	22	594.6
	2080	2	37.2	24	334.2	69	2373.7	22	419.9
8.5	2030	2	38	25	348.7	65	2063.2	23	469
	2050	2	37.9	24	343.7	75	2209.2	22	405.8
	2080	2	36.1	25	347.6	76	2220.3	23	472.7

At present, the highest number of rainy days happens in south west monsoon period (81 days) followed by north east (25 days), summer season (19 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 period followed by north east monsoon. The lowest number of rainy days and precipitation will be getting in summer rains and winter season. The projected climate demonstrates a weakened precipitation in south west and north east.

4.1.6.5.2 High rainfall events of south central laterites (AEU9) in Alappuzha district

The high rainfall events of four different seasons for present and projected climate according to RCP 4.5 and RCP 8.5 were studied and are presented in the table 106.

Table 106. High rainfall events under projected climate of south central laterites (AEU9) in Alappuzha district

Year	Rainfall (mm)	RCP 4.5					RCP 8.5				
		10 <25	25 <50	50 <75	75 <100	>= 100	10 <25	25 <50	50 <75	75 <100	>= 100
	Season	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days
Present	Winter	0	0	0	0	0	0	0	0	0	0
	Summer	4	2	2	0	0	4	2	2	0	0
	SW monsoon	28	25	7	4	2	28	25	7	4	2
	NE monsoon	11	7	2	0	0	11	7	2	0	0
	Total	**43**	**34**	**11**	**4**	**2**	**43**	**34**	**11**	**4**	**2**
2030	Winter	0	0	0	0	0	2	0	0	0	0
	Summer	10	4	0	0	1	12	2	0	0	0
	SW monsoon	22	18	9	0	4	20	18	11	1	2
	NE monsoon	8	2	1	2	1	7	4	0	0	1
	Total	**40**	**24**	**10**	**2**	**6**	**41**	**24**	**11**	**1**	**3**
2050	Winter	0	0	0	0	0	2	0	0	0	0
	Summer	12	1	0	0	0	9	4	0	0	0
	SW monsoon	24	19	9	5	1	27	17	7	5	1
	NE monsoon	7	2	1	2	1	7	3	0	0	1
	Total	**43**	**22**	**10**	**7**	**2**	**45**	**24**	**7**	**5**	**2**
2080	Winter	2	0	0	0	0	2	0	0	0	0
	Summer	10	2	0	0	0	12	1	1	0	0
	SW monsoon	20	16	13	5	1	30	16	6	6	1
	NE monsoon	7	3	0	0	1	7	3	1	0	1
	Total	**39**	**21**	**13**	**5**	**2**	**51**	**20**	**8**	**6**	**2**

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

4.2. The length of growing period of various AEUs of Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Kottayam and Alappuzha

The length of growing period of various AEUs of Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Kottayam and Alappuzha comprises southern Kerala is represented in table 107.

Table 107. The length of growing period of various AEUs of Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Kottayam and Alappuzha

LGP (weeks)	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
THIRUVANANTHAPURAM							
AEU1	29	25	25	26	26	24	23
AEU8	26	21	23	27	23	27	22
AEU9	33	26	23	28	26	24	24
AEU12	27	23	24	24	27	19	23
AEU14	31	24	24	21	24	22	20
KOLLAM							
AEU1	29	25	25	31	26	25	25
AEU3	35	23	28	27	26	29	26
AEU9	33	27	26	27	27	25	28
AEU12	27	23	25	24	25	25	24
AEU14	31	23	23	23	22	26	26
PATHANAMTHITTA							
AEU4	23	24	25	30	29	28	27
AEU9	33	26	27	25	29	28	27
AEU12	27	27	28	26	27	27	24
AEU14	31	26	24	24	24	31	24
IDUKKI							
AEU12	27	24	23	31	24	30	25
AEU14	31	27	28	29	27	27	27
AEU16	23	26	25	24	25	24	28
AEU17	19	30	30	29	30	28	27
KOTTAYAM							
AEU4	23	24	26	26	24	25	25
AEU9	33	25	30	28	29	26	27
AEU12	27	27	28	27	28	28	29
ALAPPUZHA							
AEU1	29	25	24	27	24	27	23
AEU3	35	27	28	33	24	27	27
AEU4	23	23	27	26	25	27	26
AEU5	26	27	25	27	26	28	28
AEU9	33	26	28	25	28	26	27

The concept of the growing period is essential to AEU, and provides a way of including seasonality in land resource appraisal. The growing period defines the period of the year when both moisture and temperature conditions are suitable for crop production.

The growing period provides a framework for summarizing temporally variable elements of climate, which can then be compared with the requirements and estimated responses of the plant. Such parameters as temperature regime, total rainfall and evapotranspiration and the incidence of climatic hazards are more relevant when calculated for the growing period, when they may influence crop growth, rather than averaged over the whole year. The estimation of growing period is based on a water balance model which compares rainfall (P) with potential evapotranspiration (PET). If the growing period is not limited by temperature, the ratio of P/PET determines the start, end and type of growing period.

Thiruvananthapuram district have five agro ecological units comprises southern coastal plain (AEU1), southern laterites (AEU8), south central laterites (AEU9), southern and central foothills (AEU12) and southern high hills (AEU14). The length of growing period of these five AEUs under the present situation is having values 29,26,33,27 and 31 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 AEU1, AEU9, AEU12 and AEU14. In the case of AEU8, there is a week increase in length of growing period in 2080 RCP 4.5 and 2050 RCP 8.5 rest of the year's shows a decrease in both RCPs.

Kollam district is delineated into five agro ecological units including southern coastal plain (AEU1), onattukara sandy plain (AEU3), south central laterites (AEU9), southern and central foothills (AEU12) and southern high hills (AEU 14) the length of growing period these five AEUs under the present situation is 29,35,33,27 and 31 weeks respectively. Comparing the present condition with the projected climate of RCP 4.5 and RCP 8.5 AEU1 shows a decrease in length of growing period in all considered cases except in 2080 of RCP 4.5. In AEU3, AEU9, AEU12 and AEU14 there will be a decrease in length of growing period from the present value in both RCP 4.5 and RCP 8.5 of 2030, 2050 and 2080.

In Pathanamthitta district there is four agro ecological units comprises Kuttanad (AEU4), south central laterites (AEU9), southern and central foothills (AEU12) and southern high hills (AEU14). The length of growing period of these four AEUs under the present situation is 23, 33, 27 and 31 weeks respectively. While considering the projected climate of RCP 4.5 and RCP 8.5 by 2030, 2050 and 2080 there is an increasing trend in length of growing period in AEU4 while AEU9 and AEU14 will have the probability to show a decrease in the length growing period. AEU12 will show least variation.

Considering AEUs of Idukki district which include southern and central foot hills (AEU12), southern high hills (AEU14), kumily hills (AEU16) and marayur hills (AEU17) the length of growing period under the present condition is around 27, 31, 23 and 19 weeks respectively. Under the climatic projection of RCP 4.5 and RCP 8.5 for the periods 2030, 2050 and 2080 the AEU12 will have a decreasing trend in 2030 and 2050 of RCP 4.5 and 2030 and 2080 of RCP 8.5. In AEU14 there is a decrease in length of growing period by 2030, 2050 and 2080 in both RCPs. In AEU16 and AEU17 there is having a probability to increase in the length of growing period by 2030, 2050 and 2080 in RCP 4.5 and RCP 8.5.

The Kottayam district is having three agro ecological units including kuttanad (AEU4), south central laterites (AEU9) and southern and central foothills. The length of growing period of these three AEUs under the present situation is 23, 33 and 27 respectively. Under the projected climate of RCP 4.5 and RCP 8.5 by 2030, 2050 and 2080 there will be an increase in the length of growing period in AEU4 and AEU12 instead AEU9 will show a decrease in the length of growing period.

In Alappuzha district, considering southern coastal plain (AEU1), onattukara sandy plain (AEU3), kuttanad (AEU4), pokkali lands (AEU5) and south central laterites (AEU9) the length of growing period under the present condition is around 29,35,23,26 and 33 weeks respectively. According to the climatic projection for AEU1, AEU3 and AEU9 there will be a decrease in length of growing period by 2030, 2050 and 2080 under both RCP 4.5 and RCP 8.5 instead AEU4 and AEU5 will have the probability to increase the length of growing period by 2030, 2050 and 2080 in both RCPs.

4.3 Computation of Water Balance

4.3.1 Water balance of various AEUs of Thiruvananthapuram district

4.3.1.1 Monthly potential evapotranspiration, deficit and surplus of southern coastal plain (AEU1) in Thiruvananthapuram district

The monthly potential evapotranspiration of southern coastal plain (AEU1) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 108.

Table 108. Monthly potential evapotranspiration under projected climate of southern coastal plain (AEU1) in Thiruvananthapuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	118	138.4	142.4	121.2	145.2	161.2
February	166.4	144.4	147.6	152	144.4	148	155.6
March	222.3	159.5	161	165	159	164	171
April	174.4	165.6	168	171.2	165.6	171.2	180.4
May	194.7	182.5	184	186.5	182.5	185	188
June	140.4	168.4	172.8	175.6	169.2	175.6	187.2
July	180.9	152.5	157.5	161	165.1	163	172
August	150.9	162.8	164	167.2	163.2	166.8	171.6
September	180.4	144.5	152	156	158.8	158	174.5
October	131.6	158.8	159.2	162.4	158.8	161.6	167.6
November	134.4	142	149.2	152	145.2	152.8	163.2
December	134.4	122.4	120	136.8	119.2	119.2	140
Total	**1961.2**	**1821.4**	**1873.7**	**1928.1**	**1852.2**	**1910.4**	**2032.3**

At the present situation, the monthly potential evapotranspiration is maximum in July (222.3 mm.) and the minimum in October (131.6 mm.). In projected climate based on RCP 4.5 and RCP 8.5, the maximum values will occur during May and the minimum will be in January. There will be a decrease in the annual potential evapotranspiration of projected climate from the present values except in the case of 2080 of RCP 8.5.

The monthly deficit of southern coastal plain (AEU1) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 109.

Table 109. Monthly deficit under projected climate of southern coastal plain (AEU1) in Thiruvananthapuram district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.2	93.4	109.9	118.2	93.6	125	148.7
February	124.8	106.8	108.4	126.5	110.1	118	151
March	199	139.2	140	141.8	128.5	141.3	145.5
April	38.6	116.9	118.6	121	116.1	124.1	126.5
May	72.3	63.3	62.7	68.1	63.6	36.2	69.2
June	5.5	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	10.5	6.1	0	5.1	6.5	0	16.6
September	51.8	143.9	147.1	151.2	158.2	144.9	134.2
October	13.2	0.8	10.1	24.4	0.1	46.3	43
November	74.9	91.9	102	104.7	99.1	104.4	109.5
December	100.1	53.3	32.3	33.6	40.7	33.6	133.3
Total	**839.9**	**815.6**	**831.1**	**894.6**	**816.5**	**873.8**	**1077.5**

At present, the maximum deficit occurs during the month march and it is about 199 mm and zero deficit occurring during July. As per RCP 4.5 and RCP 8.5 in projected climate all the months except June and July will shows a huge deficit. Comparing the present and future climate during the month April, September and November there will be huge increase in deficit value but in the case of January, February, May, October and December the deficit value tends to decrease from the present value.

The monthly surplus of southern coastal plain (AEU1) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 110.

Table 110. Monthly surplus under projected climate of southern coastal plain (AEU1) in Thiruvananthapuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	6.5	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	26.8	1.1	2.4	3	8.6	7.2	0
May	178.1	165.1	81.2	85.7	166.1	24.5	75.5
June	160.4	296.9	360.9	370.5	286.3	349.6	346.7
July	401.1	397.6	331.8	355.7	388.6	341.9	299.5
August	301.7	153.8	194.3	153.2	163.6	178.7	231.6
September	101.3	0	0	0	0	0	46.5
October	75.9	225.3	147.6	136	134.1	142.7	147.1
November	50.1	0	81.8	50.3	82	140.4	0
December	0	5.9	16.3	15.6	24.6	4.8	0
Total	**1301.9**	**1245.7**	**1216.3**	**1170**	**1253.9**	**1189.8**	**1146.9**

Currently, there is surplus during most of the months April to November and January, March and December is having minimum surplus value. The maximum amount of surplus is occurring in July and August months. As per RCP 4.5 and 8.5, in projected climate there will be surplus during April to August and October months remaining months have surplus value zero. The maximum surplus will occur during the month June and July. The annual surplus values of projected climate will show a decreasing trend from the present value.

4.3.1.2 Monthly potential evapotranspiration, deficit and surplus of southern laterites (AEU8) in Thiruvananthapuram district

The monthly potential evapotranspiration of southern laterites (AEU8) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 111.

Table 111. Monthly potential evapotranspiration under projected climate of southern laterites (AEU8) in Thiruvananthapuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	147.2	112	146.8	150.8	143.6	150.8	158.8
February	163.2	155.6	121.6	141.2	114.4	137.2	153.2
March	213.6	163.5	160.5	165	157.5	164	173
April	166.9	174.4	171.6	174.4	169.2	174	182
May	187.3	173.5	177.5	180	175	176	182.5
June	138	162	180	182.8	178	184.8	190
July	181.7	160.5	166.5	170	164.5	168.5	179
August	151.6	164.4	160	163.6	157.2	164.8	171.6
September	178.9	159	164.5	167.5	162.5	167.5	177.5
October	127.2	152.4	156	159.6	154	156.8	162.8
November	131.2	92.8	155.2	158	153.6	133.6	166.4
December	131.2	99.2	96	101.2	92	110.8	144.4
Total	**1918**	**1769.3**	**1856.2**	**1914.1**	**1821.5**	**1888.8**	**2041.2**

At the present situation, the monthly potential evapotranspiration is maximum in March (213.6 mm.) and the minimum in November and December (131.2 mm). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and June, the minimum will be in December. The annual potential evapotranspiration of the projected climate shows a decreasing trend except in the case of 2080 of RCP 8.5.

The monthly deficit of Southern laterites (AEU8) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 112.

Table 112. Monthly deficit under projected climate of southern laterites (AEU8) in Thiruvananthapuram district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	115.1	98.4	98.8	102.7	94.8	98.2	140.3
February	163.2	151.1	99.4	133.4	100.3	129.7	131.6
March	196.6	136.1	133	122.9	129.3	124.8	163.3
April	10	136.2	130.8	95.7	119.7	106.2	147.1
May	72.5	104.4	99.6	95.2	95.9	74	74.4
June	39	2.3	10.5	8.5	0	14.4	35.6
July	57	10.2	26	14.7	39.4	0.1	9.3
August	0	9.1	20.7	21.2	22.7	5.1	16.2
September	77.8	60.1	33.8	44.4	38	28.9	7.3
October	26.4	76.2	78	28	77	52.6	40.3
November	42.8	51.5	103.7	45.9	104	33.1	59.8
December	56.7	72.8	65.3	59.7	61.7	74.3	141.6
Total	**857.1**	**908.4**	**899.6**	**772.3**	**882.8**	**741.4**	**966.8**

At present, the maximum deficit occurs during March (196.6 mm) and zero deficit during August. As per RCP 4.5 and 8.5 in projected climate, all the months shows a deficit. Comparing the present and future climate during the months of April, May, October, November and December, there will be huge increase in deficit value. The annual deficit values of projected climate tends to increase in most of the cases except in 2080 RCP 4.5 and 2050 RCP 8.5.

The monthly surplus of Southern laterites (AEU8) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 113.

Table 113. Monthly surplus under projected climate of southern laterites (AEU8) in Thiruvananthapuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	18.2	0	0	0	0	0	0
May	249.6	56.9	55.6	55.8	41.3	29.6	0
June	0	280.9	178.6	183.7	219.5	205	73.4
July	31.6	119.5	35.7	141.1	28.5	116.7	116.2
August	294	56.5	69.7	71.1	64.5	36.3	96.6
September	50.2	0	4	0.9	0	0	61.3
October	91.2	164.4	183	91.6	172.9	96.7	75
November	0	0	0	27.2	0	71.2	117.8
December	62.2	0	0	17	0	0	0
Total	**797**	**678.2**	**526.6**	**588.4**	**526.7**	**555.5**	**540.3**

Currently, there is surplus during the months April, May, July, August, September, October and December and in the remaining months, the surplus values are minimum. The maximum value for surplus is in May. As per projected climate, there will be surplus during May to august and October months. The maximum surplus will occur during the month June. The annual surplus values of projected climate will show a decreasing trend from the present value.

4.3.1.3 Monthly potential evapotranspiration, deficit and surplus of south central laterites (AEU9) in Thiruvananthapuram 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 presented in table 114.

Table 114. Monthly potential evapotranspiration under projected climate of south central laterites (AEU9) in Thiruvananthapuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	136.8	142.8	147.2	139.2	149.6	161.2
February	156.8	142	143.6	148.8	140.8	146	152.4
March	209.3	158	161	164.5	158	163	171.5
April	162.4	165.2	168.8	172.4	166	171.6	181.6
May	182.7	182	182	184.5	181.5	183.5	188.5
June	135.8	172.4	176	178.8	172.4	180.4	186.8
July	175.5	155.5	160.5	164	158.5	164	175
August	144.9	161.2	163.2	166.4	161.6	164.4	172.8
September	170.8	151.5	157.5	161.5	154	164.5	174.5
October	123.2	157.2	159.6	162.4	158.4	161.2	169.2
November	128.8	145.2	150	153.2	147.2	154	163.6
December	128.8	108.4	107.2	113.6	105.2	107.2	138.4
Total	**1861.8**	**1835.4**	**1872.2**	**1917.3**	**1842.8**	**1909.4**	**2035.5**

At the present situation, the monthly potential evapotranspiration is maximum in March (209.3 mm.) and minimum in October (123.2 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur in May and the minimum will be in December. The annual potential evapotranspiration of projected climate will shows an increasing trend from the present value in all considered cases except 2030s.

The monthly deficit of south central laterites (AEU9) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 115.

Table 115. Monthly deficit under projected climate of south central laterites (AEU9) in Thiruvananthapuram district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	126.5	128.5	132.2	124.1	134.7	148.3
February	154.8	129.8	131.9	138.7	129.1	135.9	147.5
March	208.3	122.4	135.2	126.9	132.2	141.5	107.2
April	59.5	120.8	105.9	98	109.6	87.2	85.4
May	64.7	68.1	86.1	88.6	47.5	97	105.5
June	0	1.5	2.9	2.4	0.7	16	0
July	0	0	0	0	0	3.3	0
August	7	2.5	11.3	12.8	3.7	17.2	3.2
September	26.3	99.2	78.9	81.4	91.3	76.7	53.8
October	0	30.7	77.3	78.1	48.8	62	84.6
November	74.6	91.9	88.7	90.5	93.4	91.4	99.4
December	70.6	52.5	53.5	55.5	51.8	54.5	134.1
Total	**808.6**	**845.9**	**900.2**	**905.1**	**832.2**	**917.4**	**969**

At present, the maximum deficit occurs during March (208.3 mm) and zero deficit during June, July and October. As per RCP 4.5 and 8.5 in projected climate, all the months except July shows deficit. Comparing the present and future climate during the month April, September and October there will be huge increase in deficit value. The annual deficit value of projected climate shows an increase from the present value.

The monthly surplus of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 116.

Table 116. Monthly surplus under projected climate of south central laterites (AEU9) in Thiruvananthapuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	74.1	9.8	42.5	39.3	23.8	31.9	59.9
June	383.2	286.3	297.5	334.1	242.9	343.8	354.6
July	791.3	312.1	340.9	359.7	382.6	288	349.7
August	482.1	90	73.2	81.4	74.2	148.7	107.3
September	261.5	4.5	6.8	7.4	5.5	10.7	16
October	162.8	72.1	100.8	107.1	76.7	95.6	167.2
November	7.8	28.3	49.4	52.4	49.4	51.8	0
December	85.8	0	0	0	0	0	0
Total	**2248.6**	**803.1**	**911.1**	**981.4**	**855.1**	**970.5**	**1054.7**

Currently, there is surplus during the months May to December and in remaining months the surplus values are minimum. The maximum amount of surplus occur in July. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to November months remaining months have minimum surplus value. The maximum surplus will occur during the months July. The annual surplus value of projected climate will show a decrease in projected climate from the present value.

4.3.1.4 Monthly potential evapotranspiration, deficit and surplus of southern and central foothills (AEU12) in Thiruvananthapuram district

The monthly potential evapotranspiration of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 117.

Table 117. Monthly potential evapotranspiration under projected climate of southern and central foothills (AEU12) in Thiruvananthapuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	142	148.4	151.6	144.8	149.2	158.8
February	147.2	124	117.6	139.6	114.4	137.2	148.4
March	168.5	156	160	162	157.5	161.5	171.5
April	132.1	164	168.4	171.6	165.2	173.2	181.2
May	166	176.5	179	181.5	176.5	179.5	184
June	149.2	175.6	176.8	179.2	175.2	180	189.6
July	202.1	154.5	160.5	164.5	157.5	166.5	175
August	175.6	158	160.8	163.6	157.2	163.2	172.4
September	214.4	160	163.5	167	163	166.5	174
October	157.1	152.4	156.4	159.2	153.6	158.4	164
November	139.2	145.6	150	152.8	147.2	156	164
December	142.4	90.4	92.8	98	89.2	100	140.8
Total	**1944.2**	**1799**	**1834.2**	**1890.6**	**1801.3**	**1891.2**	**2023.7**

At the present situation, the monthly potential evapotranspiration is maximum in September (214.4 mm.) and the base value in April (132.1 mm.). In projected climate based on RCP 4.5 and RCP 8.5 the potential evapotranspiration having maximum value in May and June months and minimum in December month. The annual potential evapotranspiration will show a decreasing trend from the present value except in the case of 2080 of RCP 8.5.

The monthly deficit of southern and central foothills (AEU12) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 118.

Table 118. Monthly deficit under projected climate of southern and central foothills (AEU12) in Thiruvananthapuram district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	102.8	127.1	134.5	133.4	130.5	123.7	150.9
February	134	113.5	107.1	102.8	104.4	102.5	117.7
March	164.7	136.4	140.8	142.3	137.9	123.7	128.3
April	54.2	86.8	88.3	141.2	87.2	132.4	132.8
May	0	87.3	105	76.9	91.9	125.5	105.4
June	33.4	13	0.2	0	3.9	0	33.3
July	76.1	0	0	14	0	2	0
August	0	35.5	10.5	12.5	11	23.9	0.3
September	0	74.9	73.1	76.5	75.8	89.2	28.5
October	25.2	38.2	48.4	46.4	47	79.2	112
November	58.9	83.6	77.7	79.5	59.1	113.3	90.6
December	7.5	53.4	54.9	42.2	41.2	88.9	127.4
Total	**656.8**	**849.7**	**840.5**	**867.7**	**789.9**	**1004.3**	**1027.2**

At present, the maximum deficit occurs during the month March and it is about 164.7 mm zero deficit occurring during May, August and September months. As per RCP 4.5 and RCP 8.5 in projected climate will show minimum deficit values. When comparing the present and future climate during the month January April, May and August to December having an increase in deficit value. The annual deficit values of projected climate tends to show an increase from the present value.

The monthly surplus of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 119.

Table 119. Monthly surplus under projected climate of southern and central foothills (AEU12) in Thiruvananthapuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	23.1	0	0	0	0	0	0
May	232.4	5	0	0	0	51	39.9
June	39.2	198	252.2	414.5	207.6	255.4	326.5
July	39.4	167.1	182.8	208.2	154.4	129.2	147.2
August	239.8	171.1	128.4	123.3	96.8	96.4	97.8
September	612.6	0.7	40.3	14.1	35.4	4	100.6
October	363.4	72.5	86	96.6	85.8	156	129.3
November	74.7	50.5	45.3	44.4	27.1	0	4.9
December	144.9	0	0	0	0	0	0
Total	**1769.5**	**664.9**	**735**	**901.1**	**607.1**	**692**	**846.2**

Currently, there is surplus during the months April to December and in remaining months the surplus values are minimum. The maximum amount of surplus is occurring in the months of September. As per RCP 4.5 and 8.5, in projected climate there will be surplus during June to November and remaining months have minimum surplus values. The maximum surplus will occur during the months June. The annual surplus values of projected climate will have a decreasing trend from the present value.

4.3.1.5 Monthly potential evapotranspiration, deficit and surplus of southern high hills (AEU14) in Thiruvananthapuram district

The monthly potential evapotranspiration of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 120.

Table 120. Monthly potential evapotranspiration under projected climate of southern high hills (AEU14) in Thiruvananthapuram district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	146.8	142.8	146.8	150.4	144	148.8	159.2
February	162.8	120	117.2	139.6	111.2	137.6	148.4
March	215	156.5	161	162.5	157	162.5	172
April	167.8	165.2	170	173.2	167.6	173.6	182
May	188.2	177	179	182	177.5	178.5	184
June	137.8	176	176.8	179.6	175.2	183.2	190.4
July	180.6	156.5	163.5	167.5	161.5	168.5	176
August	150.4	158	162	165.2	159.6	162.4	172.8
September	177.4	162.5	164	167	161.5	167	175
October	127.6	152.8	156.4	159.6	154.8	157.2	162.8
November	131.2	145.6	150	153.6	148	156.8	164.4
December	131.2	90	93.2	97.6	89.6	100.4	140.8
Total	**1916.8**	**1802.9**	**1839.9**	**1897.8**	**1807.5**	**1896.5**	**2027.8**

At the present situation, the monthly potential evapotranspiration is maximum in March (215 mm.) and the minimum in October (127 mm). In projected climate based on RCP 4.5 and 8.5 the maximum potential evapotranspiration values comes during the months of May and June and minimum in December. The annual potential evapotranspiration of projected climate will shows a decreasing trend from the present value except in the case of 2080 of RCP 8.5.

The monthly deficit of southern high hills (AEU14) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 121.

Table 121. Monthly deficit under projected climate of southern high hills (AEU14) in Thiruvananthapuram district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	145.8	127.5	131.9	132	128.8	131.4	140
February	140.8	109.3	106.1	101.7	100.7	122	102.3
March	156.4	128	131.5	117.6	127.3	118.9	147.3
April	103.4	86.9	90.7	141.7	90.5	117.2	161.1
May	56.7	83.8	110.5	98.9	110.1	93.6	121.6
June	0	11.2	0	0	0	0	34.2
July	0	0	0.7	23.9	0.8	21.1	4.7
August	3.1	25.8	12.7	16.8	15	27	1.2
September	30.4	71.5	58.7	63.6	63.6	40	49.8
October	5.9	38.8	78.2	79.8	77.4	78.6	111.9
November	16.6	79	74.8	122	73.5	87	79
December	81.4	51.8	52	40.1	48.7	67.9	124.4
Total	**740.5**	**813.6**	**847.8**	**938.1**	**836.4**	**904.7**	**1077.5**

At present, the maximum deficit occurs during the month March it is about 156.4 mm zero deficit occur during June and July months. As per RCP 4.5 and 8.5 in projected climate the maximum deficit will occur in January and March minimum of deficit values comes under June and July months. Comparing the present and future climate during the months May, July, September, October and November will have an increase in deficit value. The annual deficit values of projected climate will show an increasing trend from the present value.

The monthly surplus of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 122.

Table 122. Monthly surplus under projected climate of southern high hills (AEU14) in Thiruvananthapuram district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	151.8	0	4.1	8.5	2.2	2.1	3.5
June	166.7	200.3	192.1	404.9	189.4	239.4	140.8
July	271.4	181.9	130.6	85.4	144.2	28.6	135.3
August	300.7	113.1	83.8	88.4	75.6	108.4	75.7
September	91	33.8	0	0	0	22.1	29.2
October	255.7	79.5	132.8	141.2	129.9	99.6	139.7
November	9.6	53.2	43.5	0	41.8	5.5	7
December	0	0	0	0	0	0	0
Total	**1246.9**	**661.8**	**586.9**	**728.4**	**583.1**	**505.7**	**531.2**

Currently, there is surplus during the months May to November and in the case of remaining months the surplus values are minimum. The maximum amount of surplus is occurring in August month. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to November months remaining months have minimum surplus value. The maximum surplus will occur during the months June and July. The annual surplus values of projected climate will have a decreasing trend from the present value.

4.3.2 Water balance of various AEUs of Kollam district

4.3.2.1 Monthly potential evapotranspiration, deficit and surplus of southern coastal plain (AEU1) in Kollam district

The monthly potential evapotranspiration of southern coastal plain (AEU1) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 123.

Table 123. Monthly potential evapotranspiration under projected climate of southern coastal plain (AEU1) in Kollam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	1.2	122.8	137.2	141.6	124.4	141.2	156.8
February	52.2	146.4	149.6	154.4	146.8	153.2	159.6
March	19.2	159.5	163.5	165.5	159.5	165.5	172.5
April	166.7	167.2	169.6	173.2	168	172.4	180
May	296.4	183.5	185.5	187.5	184	187.5	192
June	295.3	169.2	172.8	176	170	175.2	185.2
July	586.1	151.5	158	162.5	154.5	161.5	173.5
August	442.1	166	166.8	170	165.6	170	176
September	225.8	144.5	148.5	152.5	145	153	168.5
October	194.3	160.4	162.4	165.2	160.8	164.4	170
November	109.6	136.8	143.6	146.8	139.6	148.8	162
December	34.3	139.2	140.4	144.4	138.8	142.8	147.2
Total	**2423.2**	**1847**	**1897.9**	**1939.6**	**1857**	**1935.5**	**2043.3**

At the current situation, the monthly potential evapotranspiration is maximum in July (586.1 mm) and the base value in January (1.2 mm). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during May and June and the minimum will be in January. Annually, there will be a decrease in potential evapotranspiration in projected climate from the present value.

The monthly deficit of southern coastal plain (AEU1) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 124.

Table 124. Monthly deficit under projected climate of southern coastal plain (AEU1) in Kollam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.2	81.7	125.9	130.1	95.3	123.2	145.1
February	124.8	145.3	119.1	149.5	141.7	136.9	155
March	194.6	116.9	132.5	115.3	132.3	134.6	139.7
April	38.6	88.2	102.4	87	90.3	101	127
May	67.9	7.9	51.6	58.5	18.1	61.3	44.8
June	3.5	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	6.7	16.4	4	2.2	0.2	2	0
September	47.4	109.7	132.5	94.3	128.7	94.3	63.4
October	9.1	31.5	0	0	30.6	0	36.9
November	70.2	88.4	87	89.7	100.8	92.9	112.5
December	100.1	79.1	123.9	127.5	60.5	66.5	130
Total	**812.1**	**765.1**	**878.9**	**854.1**	**798.5**	**812.7**	**954.4**

At present, the maximum deficit occurs during March (194.6 mm) and zero deficit during July. As per RCP 4.5 and 8.5 in projected climate all the months show a huge deficit except in June and July. Comparing the present and future climate during the month April, September and November will show an increase in deficit value whereas January, March, May and December will show a decrease. The annual deficit value have the tendency to increase in projected climate from the present value except in the case of 2030s.

The monthly surplus of southern coastal plain (AEU1) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 125.

Table 125. Monthly surplus under projected climate of southern coastal plain (AEU1) in Kollam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	2.1	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	22.4	18.7	0	5.1	0	0	0
May	178.1	279.4	179.2	215.2	202.7	187.2	68
June	156	586.5	389	416.6	599.5	417.6	447
July	399.1	649.5	732.7	557.6	763	560.5	500.6
August	297.9	159	211.9	173.7	145.1	191.1	273.5
September	101.3	0	0	7.4	0	7.8	67.7
October	71.5	218.4	237.4	240	250.4	246.3	165.4
November	45.7	0	0	0	0	0	0
December	0	0	0	0	0	0	0
Total	**1274.1**	**1911.5**	**1750.2**	**1615.6**	**1960.7**	**1610.5**	**1522.2**

Currently, there is surplus during most of the months except January, March and December were the surplus value is zero. The maximum amount of surplus is occurring in July and August months. As per RCP 4.5 and 8.5, in projected climate there will be surplus during April to august and October months remaining months have surplus value zero. The maximum surplus will occur during the month July. The annual surplus values of projected climate tends to show an increasing trend from the present value.

4.3.2.2 Monthly potential evapotranspiration, deficit and surplus of onattukara sandy plain (AEU3) in Kollam district

The monthly potential evapotranspiration of onattukara sandy plain (AEU3) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 126.

Table 126. Monthly potential evapotranspiration under projected climate of onattukara sandy plain (AEU3) in Kollam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	148.4	136	140	144.4	136.8	143.2	155.6
February	165.2	148.4	152	156.4	148.8	154	163.2
March	220.5	161.5	164.5	168	161.5	167.5	175
April	172.9	168.4	171.6	174.8	169.2	173.6	180.8
May	191.8	183.5	185.5	188	184	188	192.5
June	140	170.8	174	176.8	171.2	176.8	185.6
July	181.3	152.5	158.5	162.5	164.3	163.5	173
August	150.5	165.6	167.2	170	166	169.2	176
September	180.6	145.5	149	153	157.6	153	167.5
October	131.6	160.8	163.2	166	161.6	166	171.2
November	134.4	139.6	143.6	147.2	140	148.4	162
December	134.4	141.6	144	148	142.4	146.8	152
Total	**1951.6**	**1874.2**	**1913.1**	**1955.1**	**1903.4**	**1950**	**2054.4**

At the present situation, the monthly potential evapotranspiration is maximum in March (220.5 mm.) and the base value in October (131.6 mm.). In projected climate based on RCP 4.5 and 8.5 in RCP 4.5 and RCP 8.5 the maximum values will occur in May and the minimum will be in January and December. The annual potential evapotranspiration of projected climate shows a decreasing trend from the present value except in 2080s.

The monthly deficit of onattukara sandy plain (AEU3) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 127.

Table 127. Monthly deficit under projected climate of onattukara sandy plain (AEU3) and the projected climate in Kollam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	148.4	96.3	113.9	117.1	102	130.5	139.8
February	132.4	146.9	146.4	151.2	147.9	125.3	142.8
March	205.5	127.4	136.9	138.5	134.8	117.7	145.9
April	11.8	100.9	118	121.6	89.1	95.3	122.6
May	58.1	0.6	47.2	47.7	15.6	62.6	31.4
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0.	0
August	0.3	20.1	11.9	16.2	24.6	21.3	0
September	80.4	83.4	60.8	64.4	52.6	63.6	104.2
October	15.4	59.7	35.9	36.5	75.2	0	12.2
November	74.1	133.2	127.9	131.5	114.7	90.7	136.5
December	96.9	120.2	71.9	68.9	89.5	72.8	80.3
Total	**823.3**	**888.7**	**870.8**	**893.6**	**846**	**779.8**	**915.7**

At present, the maximum deficit occurs during the month March and it is about 205.5 mm and zero deficit occurring during June and July months. As per RCP 4.5 and 8.5 in projected climate all the months except May, June will shows a deficit. Comparing the present and future climate during the months April and November there will be an increase in deficit value. The annual deficit values of projected climate tends to show an increase in most of the considered cases except in 2050 of RCP 8.5.

The monthly surplus of Onattukara sandy plain (AEU3) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 128.

Table 128. Monthly surplus under projected climate of onattukara sandy plain (AEU3) and the projected climate in Kollam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	14.3	0	0	0	0	0	0
May	125.4	228	232.1	225.9	250.4	262.1	116.1
June	213.1	504.7	346.3	336.5	491.6	364.5	587.7
July	403.1	760.7	779.2	860.6	776.3	944.4	677.9
August	255.3	106.2	120.6	124.8	99	226	255.4
September	36	52.9	144.2	142.9	27.8	55.8	96.1
October	238.4	260.6	274.6	279	306.1	209.5	259.8
November	36.7	0	0	0	0	0	0
December	32.7	0	0	0	0	0	0
Total	**1355**	**1913.1**	**1897**	**1969.7**	**1951.2**	**2062.3**	**1993**

Currently, there is surplus during the months April to December and in the case of remaining months the surplus values are minimum. The maximum value for surplus is in July). As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October remaining months have minimum surplus value. The maximum surplus will occur during the month July. The annual surplus values of projected climate tends to show an increase from the present value.

4.3.2.3 Monthly potential evapotranspiration, deficit and surplus of south central laterites (AEU9) in Kollam 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 presented in table 129.

Table 129. Monthly potential evapotranspiration under projected climate of south central laterites (AEU9) in Kollam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	121.6	137.2	141.6	121.2	142.8	157.2
February	156.8	146.8	150	154	146.4	152.8	160.8
March	209.3	161	164.5	167.5	161	166	174
April	162.4	169.6	171.2	174	169.2	173.2	181.2
May	182.7	184	186	188.5	184.5	188	192.5
June	135.8	171.6	175.2	178	172.8	178	186.8
July	175.7	156	160.5	164.5	158	164	176
August	144.9	166	168.4	171.2	166.4	170.8	176.8
September	170.8	145	149	154.5	147	155.5	169
October	123.2	160.8	163.2	165.2	161.2	164.4	170.4
November	128.8	138.8	143.6	149.2	140.8	151.2	162
December	128.8	136.8	139.6	142	136.8	140	146
Total	**1862**	**1858**	**1908.4**	**1950.2**	**1865.3**	**1946.7**	**2052.7**

At the present situation, the monthly potential evapotranspiration is maximum in March (209.3 mm.) and the base value in October (123.2 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and June months and the minimum will be in January. The annual potential evapotranspiration of projected climate shows an increasing trend in all considered cases except 2030 of RCP 4.5.

The monthly deficit of south central laterites (AEU9) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 130.

Table 130. Monthly deficit under projected climate of south central laterites (AEU9) in Kollam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	95.9	120.7	129.1	104.8	130.8	141.5
February	154.8	140.9	135.2	125.3	131	123.5	140
March	208.3	131.5	129.6	103.2	129.9	131.7	138.3
April	59.8	88.6	99.8	83.4	90.1	97.7	124.5
May	63.7	18	48.1	59.7	48.7	60.6	45.1
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	6.7	0.1	3.7	1.9	2	1.7	0
September	25.4	124.3	130.7	89.3	84.5	89.5	60
October	0	27.1	0	0	0	26.3	32.4
November	72.6	97.1	83.7	88.9	81.3	127.1	113.1
December	69.6	65.3	66.1	59.7	59.5	119.2	80.4
Total	**803.7**	**788.8**	**817.6**	**740.5**	**731.8**	**908.1**	**875.3**

At present situation the maximum deficit occurs during the month march having value 208.3 and zero deficit occurring during June and July months. As per RCP 4.5 and 8.5 in projected climate all the months except June and July will shows deficit. Comparing the present and future climate during the month April and September there will be huge increase in deficit value and decrease in March and May months.

The monthly surplus of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 131.

Table 131. Monthly surplus under projected climate of south central laterites (AEU9) in Kollam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	4.4	2.3	0	0
May	73.2	180	161.8	183.2	202.8	135.9	58.5
June	382.2	539.8	353.7	379.9	544.1	350.7	410.7
July	791.3	769.5	736.8	558.1	743.9	574.7	496.5
August	481.8	153.4	215.3	195.3	186.3	209	276.7
September	260.6	0	0	4.7	5.3	5	68.1
October	162.8	237.4	234.3	237	237.9	162.8	165.3
November	6.8	0	0	0	0	0	0
December	84.8	0	0	0	0	0	0
Total	**2243.5**	**1880.1**	**1701.9**	**1562.6**	**1922.6**	**1438.1**	**1475.8**

Currently, there is surplus during the months May to December and in remaining months the surplus values are minimum. The maximum amount of surplus is occurring in July and August months. As per RCP 4.5 and 8.5, the maximum surplus will occur during the months June and July. The annual surplus values of projected climate will tend to show a decrease from the present value.

4.3.2.4 Monthly potential evapotranspiration, deficit and surplus of southern and central foothills (AEU12) in Kollam district

The monthly potential evapotranspiration of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 132.

Table 132. Monthly potential evapotranspiration under projected climate of southern and central foothills (AEU12) in Kollam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	121.6	140.8	145.2	136.4	148	160.8
February	147.2	146.8	150	154	146.8	150	159.6
March	168.5	162	164	167.5	162	166.5	174.5
April	132.1	168.8	171.2	174	169.6	174	182.8
May	166	185.5	187	189	186	188	191.5
June	149.2	174.8	178.8	182	175.6	182	190.8
July	202.1	159	163	167	160	168.5	177
August	175.6	167.2	168.8	171.6	168	170.8	176.8
September	214.4	152.5	158.5	161.5	154.5	164	175.5
October	157.1	161.2	162	164.4	161.6	164.4	170.4
November	139.2	143.6	150.8	154	146.4	154.8	164
December	142.4	135.6	135.6	139.6	134.8	135.6	144
Total	**1944.2**	**1878.6**	**1930.5**	**1969.8**	**1901.7**	**1966.6**	**2067.7**

At the present situation, the monthly potential evapotranspiration is maximum in September (214.4 mm.) and the base value in April (132.1 mm.). In projected climate based on RCP 4.5 and 8.5 the potential evapotranspiration having maximum value in May and minimum in January and December months.

The monthly deficit of southern and central foothills (AEU12) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 133.

Table 133. Monthly deficit under projected climate of southern and central foothills (AEU12) in Kollam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	103	106	135.6	139.6	131.1	139.6	150.6
February	134	131.6	134.9	140.9	105.7	136.9	136.1
March	164.7	135	136.8	132	111.4	131.1	121.7
April	54.4	122.2	123	111.8	146.8	111.4	128.8
May	0	63	53	46.6	62	42.3	97.5
June	33.6	0	0	0	0	0	0
July	76.3	0.1	0	0	0	0	0.1
August	0	9.1	8.9	9.2	9.8	0	6.7
September	0	141.6	147.5	150.5	144	143	121.1
October	25.4	17.8	11.4	10.3	6.4	41.6	63.2
November	59.1	120.9	95.4	97.5	92.3	98.1	87.6
December	7.7	68.8	62.9	59	61	66.4	71
Total	**658.2**	**916.1**	**909.4**	**897.4**	**870.5**	**910.4**	**984.4**

At present the maximum deficit occurs during the month march and it is about 164.7 mm. Zero deficit occurring during May and September months. As per RCP 4.5 and 8.5 in projected climate all the months except June and July will shows deficit. Comparing the present and future climate during the month April, May, September, November and December having a drastic increase in deficit value and decrease in March and July months. The annual deficit values tends to increase by 2030, 2050 and 2080 in RCP 4.5 and RCP 8.5.

The monthly surplus of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 134.

Table 134. Monthly surplus under projected climate of southern and central foothills (AEU12) in Kollam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	23.3	0	0	0	0	0	0
May	232.6	119.3	45.1	47.6	173.4	7.2	76.5
June	39.4	384.2	497.7	382	342.9	401.4	388.9
July	39.6	491.9	435.6	484.1	482.8	436.1	446.5
August	239.8	166.5	234.9	251.5	179.1	274.9	268.2
September	612.6	0	0	0	0	0	0
October	363.6	208.4	151.8	159.2	143.2	170.5	219.4
November	74.9	0	65.2	68.6	64.3	92.9	153.2
December	145	0	0	0	0	0	0
Total	**1770.8**	**1370.3**	**1430.3**	**1393**	**1385.7**	**1383**	**1552.7**

Currently, there is surplus during the months April to December and in remaining months the surplus values are minimum. The maximum amount of surplus is occurring in the months of September and October. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May, June, July August, October and November months. The maximum surplus will occur during the months June and July. The annual surplus values will tends to show a decrease in the projected climate from the present value.

4.3.2.5 Monthly potential evapotranspiration, deficit and surplus of southern high hills (AEU14) in Kollam district

The monthly potential evapotranspiration of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 135.

Table 135. Monthly potential evapotranspiration under projected climate of southern high hills (AEU14) in Kollam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	146.8	138.8	146.4	150.4	143.6	152	158.4
February	162.8	138	140.8	146.4	137.2	138.4	151.6
March	215	158	160.5	163	157	164	172.5
April	167.8	166.8	170.8	174	168.4	174	183.2
May	188.2	181	182	184.5	180	184.5	188
June	137.8	177.2	181.6	184.4	180	182.8	192
July	180.6	161.5	164	167.5	162	169.5	179.5
August	150.4	163.2	164.4	167.6	162.8	167.2	174.8
September	177.4	159.5	166	169	164	169.5	177
October	127.6	155.6	157.6	160	155.2	160.8	166
November	131.2	147.6	150.8	154	148.4	154.8	166
December	131.2	95.6	96	101.2	92	98.8	136.8
Total	**1916.8**	**1842.8**	**1880.9**	**1922**	**1850.6**	**1916.3**	**2045.8**

At the present situation, the monthly potential evapotranspiration is maximum in March (215 mm.) and the base value in October (127.6 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum potential evapotranspiration values comes during May and June and minimum in December. The annual potential evapotranspiration of projected climate will show a decreasing trend except in the case of 2080s.

The monthly deficit of southern high hills (AEU14) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 136.

Table 136. Monthly deficit under projected climate of southern high hills (AEU14) in Kollam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	145.8	131.8	135.7	139.8	132.4	145.3	142.4
February	140.8	95.5	96.9	103.6	96.2	103.2	113.6
March	156.4	115.5	118.9	108.4	113.7	111.9	113.6
April	103.4	92.6	93.1	95.1	93.4	97	135.3
May	59.3	85.4	91.5	93.1	90.6	102	90.1
June	0	0.1	0.7	0.3	0.7	1	0.8
July	0	0	0	0	0	0.4	15.7
August	3.6	19	5.5	18.2	26.8	13.3	11.4
September	33	93.3	90	98.3	94.3	77.9	34.9
October	6.7	62.7	62.7	63.9	61.4	41	83.5
November	19.5	131.2	133.9	136.3	131.8	122.4	58.5
December	84	69	73.3	76.3	69.1	43.3	109.1
Total	**752.5**	**896.1**	**902.2**	**933.3**	**910.4**	**858.7**	**908.9**

At present the maximum deficit occurs during the month March it is about 156.4 mm. Zero deficit occurring during June and July months. 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 May, August, September, October and November might have an increase in deficit value and decrease in January, February, March, April and December months. The annual deficit values of projected climate have the probability to increase from the present value.

The monthly surplus of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 137.

Table 137. Monthly surplus under projected climate of southern high hills (AEU14) in Kollam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	1.1	0	0	0
April	0	0	0	0	0	0	0
May	154.4	21.5	12.8	9.3	12.8	8.3	0
June	169.3	192.3	218.2	201.4	220.4	282.8	284.1
July	271.4	262.1	204.8	231.2	197.1	195.7	213.2
August	301.2	85.4	124.7	122.7	110.9	118.5	121.9
September	93.6	2.2	4.7	5.7	1.7	17.7	37.1
October	256.5	121.5	132.5	142.7	128.4	148.1	79.3
November	12.5	0	0	0	0	0	39.3
December	0	0	0	0	0	1.5	0
Total	**1258.9**	**685**	**697.7**	**714.1**	**671.3**	**772.6**	**774.9**

Currently, there is surplus during the months may to November and in the case of remaining months the surplus values are minimum. The maximum amount of surplus is occurring in July and August months. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October months remaining months have minimum surplus value. The maximum surplus will occur during the months June and July. The annual surplus values of projected climate will have a decreasing trend from the present value.

4.3.3 Water balance of various AEUs of Pathanamthitta district

4.3.3.1 Monthly potential evapotranspiration, deficit and surplus of kuttanad (AEU4) in Pathanamthitta district

The monthly potential evapotranspiration of kuttanad (AEU4) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 138.

Table 138. Monthly potential evapotranspiration under projected climate of Kuttanad (AEU4) in Pathanamthitta district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.6	139.2	143.2	147.2	140	146.8	158.8
February	166	150	153.6	158	150.8	156.4	164.8
March	221	163.5	166.5	169.5	163.5	169.5	176.5
April	173.9	171.2	174	176.4	171.6	176	183.2
May	193.9	184.5	186.5	189	185	189	193.5
June	140.2	172.4	175.2	178.4	173.2	178.4	187.2
July	181.2	156.5	160	164.5	157.5	164.5	174.5
August	151.3	166	168.8	170.8	166.8	170.8	177.6
September	180.1	145.5	149.5	154	147	155	168.5
October	130.8	161.6	164.4	166.8	162.4	166	172
November	134	142.8	146.4	151.2	143.6	152.4	164.4
December	134	142.4	145.6	148.4	143.2	146.8	154
Total	**1956**	**1895.6**	**1933.7**	**1974.2**	**1904.6**	**1971.6**	**2075**

At the present situation, the monthly potential evapotranspiration is maximum in March (221 mm.) and the base value in October (130.8 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur during May and June months and the minimum will be in January and December.

The monthly deficit of kuttanad (AEU4) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 139

Table 139. Monthly deficit under projected climate of kuttanad (AEU4) in Pathanamthitta district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	141.6	127.6	134.2	128.4	91.7	128.2	141
February	159.5	144.5	147.1	127.1	148.7	125.3	150.1
March	176.9	117.7	122.4	137.3	134.5	137.4	146.8
April	82.3	83.5	83.1	109.5	98.9	111	125.3
May	7.8	3.6	3.8	54.7	23.8	58.2	36.4
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0.5	0
August	0	0	0	7	0.1	5.5	0
September	149.4	117.5	118.7	44.9	80	45	47.7
October	0.6	63.7	4.5	0	58.3	0	13.4
November	104.9	118.7	121.9	87.5	93	89.7	105.3
December	117.4	129.4	129	67.9	72	71.5	78.5
Total	**940.4**	**906.2**	**864.7**	**764.3**	**801**	**772.3**	**844.5**

At present the maximum deficit occurs during the month march and it is about 176.9 mm and zero deficit occur during June, July and August months. As per RCP 4.5 and 8.5 in projected climate all the months except June, July and August will shows a deficit. Comparing the present and future climate during the months January, February, March and September there will be a decreasing trend in deficit value. The annual deficit values of projected climate will have the probability to decrease from the present value.

The monthly surplus of kuttanad (AEU4) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 140.

Table 140. Monthly surplus under projected climate of Kuttanad (AEU4) in Pathanamthitta district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0.3	0	1	0	0	0	0
May	297.1	287	300.5	250.7	223.1	207.8	85.5
June	673	570	638	544	519.3	565.2	472
July	771.8	745.2	793	769.3	726.1	766.2	579.9
August	195.1	196.4	177.6	247.2	164.4	276.7	197.1
September	0	0	0	132.3	26	132.5	141.8
October	237.7	275.7	212.5	253.1	248.7	258.3	165.5
November	0	0	0	0	0	0	56.4
December	0	0	0	0	0	0	0
Total	**2175**	**2074.3**	**2122.6**	**2196.6**	**1907.6**	**2206.7**	**1698.2**

Currently, there is surplus during the months April to August and in October the remaining months have minimum surplus values. The maximum amount of surplus is occurring in June and July months. As per RCP 4.5 and 8.5, in projected climate in most of considering years there will be surplus during May to October remaining months have surplus value zero. The maximum surplus will occur during the months June and July. The annual surplus value of projected climate will show a decreasing trend except in the case of 2080 of RCP 8.5.

4.3.3.2 Monthly potential evapotranspiration, deficit and surplus of south central laterites (AEU9) in Pathanamthitta 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 presented in table 141.

Table 141. Monthly potential evapotranspiration under projected climate of south central laterites (AEU9) in Pathanamthitta district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	136.8	140.8	145.6	137.6	146	159.6
February	156.8	149.2	152.8	157.2	150	156	163.2
March	209.3	164	166.5	170	164	168.5	176
April	162.4	171.2	173.2	176.8	171.6	176	183.6
May	182.7	185	187.5	189.5	185.5	189.5	193.5
June	135.8	174.4	177.2	179.6	174.4	180	188.4
July	175.7	159	162	166	160	166.5	177
August	144.9	166.8	168.8	172	167.6	172	178
September	170.8	150	153	157	150	158	171
October	123.2	161.6	164	166.4	162.4	166	172
November	128.8	144	149.2	152.4	144.8	154	164.4
December	128.8	140	141.6	145.6	140.8	143.6	149.2
Total	**1862**	**1902**	**1936.6**	**1978.1**	**1908.7**	**1976.1**	**2075.9**

At the present situation, the monthly potential evapotranspiration is maximum in March (209.3 mm.) and the base value in October (123.2 mm.). In projected climate based on RCP 4.5 and 8.5. The maximum values will occur in month of May and June and the minimum will be in December. The annual potential evapotranspiration of projected climate will show an increasing trend from the present value.

The monthly deficit of south central laterites (AEU9) for the current and projected climate (RCP 4.5 and 8.5) were computed and presented in table 142.

Table 142. Monthly deficit under projected climate of south central laterites (AEU9) in Pathanamthitta district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	120.2	131.9	129.2	117.8	134.7	143
February	154.8	126.4	146.6	134.9	129.9	150.6	141.8
March	208.3	130.9	116.1	134.5	129.1	112.6	149.3
April	59.6	125.9	81.4	132.3	125.7	86.4	121.5
May	63.7	28.9	28.4	57.5	14.5	60.1	30
June	0	0	0	0	0	0	0
July	0	0	0.8	0	0	0	0
August	6.7	0.4	5.5	0.8	1.5	5.5	0
September	25.4	119.1	42.7	86.9	80.3	45	57.9
October	0	48.7	0	28.4	47.2	0	32.7
November	72.6	103.5	90.6	127.7	103.9	97.8	115.8
December	69.6	79.6	126.9	74.5	79.6	103.3	79.3
Total	**803.5**	**883.6**	**770.9**	**906.7**	**829.5**	**796**	**871.3**

At present, the maximum deficit occurs during the month march and it is about 208.3 mm and zero deficit occurring during June, July and October months. As per RCP 4.5 and 8.5 in most cases the projected climate except June and July will shows a deficit. Comparing the present and future climate during the months April, September, November and December there will be an increase in deficit value and March and May have the probability to decrease. The annual deficit values of projected climate will tends to increase from the present value except 2050s.

The monthly surplus of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 143.

Table 143. Monthly surplus under projected climate of south central laterites (AEU9) in Pathanamthitta district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	4	0	0	0	0
May	73.2	257.1	242.3	221.3	268.3	231.7	84
June	382.2	338.6	573.7	294.1	361.6	402.4	465.4
July	791.3	741	718.6	585.7	724.6	550.6	632.5
August	481.8	207.5	221.3	225.1	230.1	221	320
September	260.6	0	21.6	6.7	99.4	20	73.7
October	162.8	281.9	240.2	171.6	266.2	141.8	169.1
November	6.8	0	0	0	0	83	0
December	84.8	0	0	0	0	0	0
Total	**2243.5**	**1826.1**	**2021.7**	**1504.5**	**1950.2**	**1650.5**	**1744.7**

Currently, there is surplus during the months may to December and in remaining months the surplus values are minimum. The maximum value for surplus is occurring in July month. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October remaining months have surplus value zero. The maximum surplus will occur during the month July. The annual surplus values of projected climate will show a decreasing trend from the present value.

4.3.3.3 Monthly potential evapotranspiration, deficit and surplus of southern and central foothills (AEU12) in Pathanamthitta district

The monthly potential evapotranspiration of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 144

Table 144. Monthly potential evapotranspiration under projected climate of southern and central foothills (AEU12) in Pathanamthitta district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	118	136.8	141.6	122.4	144.8	157.6
February	147.2	145.2	148.4	152.8	144.8	149.6	158
March	168.5	159.5	162.5	165.5	159.5	164.5	173.5
April	132.1	166.8	169.6	172.8	167.2	172	181.2
May	166	184.5	186.5	188.5	184.5	187.5	191.5
June	149.2	173.6	176.4	179.2	174.4	180.8	189.2
July	202.1	156.5	160.5	164	157.5	165	175.5
August	175.6	164	166.4	169.2	164.4	168	174.8
September	214.4	157.3	152.5	166.2	150	158.5	172
October	157.1	158.8	160.8	164	158.8	162.4	168.8
November	139.2	140.8	146.4	149.6	143.6	151.2	162
December	142.4	120.8	134.4	138.8	119.2	134.8	142.4
Total	**1944.2**	**1845.8**	**1901.2**	**1952.2**	**1846.3**	**1939.1**	**2046.5**

At the present situation, the monthly potential evapotranspiration is maximum in September (214.4 mm.) and the base value in October (142.4 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and June months and the minimum will be in December. The annual potential evapotranspiration of projected climate will show a decreasing trend from the present value.

The monthly deficit of southern and central foothills (AEU12) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 145.

Table 145. Monthly deficit under projected climate of southern and central foothills (AEU12) in Pathanamthitta district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	102.6	112.7	118.5	130	104.2	133.4	140.6
February	134	102	115.6	122	130.8	144	135.8
March	164.7	130.6	93.4	97.1	126	126.2	137.8
April	54	100.2	82.8	78.7	88.5	127.6	124.5
May	0	39.1	59.5	60.5	57.7	31.4	89.5
June	33.2	0	0	0	0	0	0
July	75.9	0	0	0	0	0	0
August	0	1.4	3.3	1.8	1.8	0	0
September	0	94.5	92.2	101.5	87.5	64.6	73.8
October	25	0	0	28.2	0	9.8	51.6
November	58.7	117.8	93.2	126.4	90.9	124.7	112.8
December	7.5	55.3	46.3	117.1	32.1	114.8	75.7
Total	**655.6**	**753.6**	**704.8**	**863.3**	**719.5**	**876.5**	**942.1**

At present, the maximum deficit occurs during the month March having value 164.7 mm. Zero deficit occurring during May, August and September months. As per RCP 4.5 and 8.5 in projected climate all the months except June, July will show a deficit. Comparing the present and future climate, during the month January, April, May, September, November and December will have an increase in deficit value and decrease in March. The annual deficit value of projected climate will have the tendency to increase from the present value.

The monthly surplus of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 146.

Table 146. Monthly surplus under projected climate of southern and central foothills (AEU12) in Pathanamthitta district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	22.9	0	0	0	0	0	0
May	232.2	87.8	175.9	170.9	160.5	20.5	91
June	39	463.5	302.9	320.9	466.7	365.9	374.1
July	39.2	776.2	802.8	622.6	853.4	542.8	528.9
August	239.8	225.5	273.5	222.1	238.5	299.6	297.5
September	612.6	7	9.9	6.6	7	62.5	107.2
October	363.2	212.5	137.9	163.6	137.2	157.4	184.3
November	74.5	0	76.5	0	81.9	0	0
December	144.9	0	11.2	0	12.7	0	0
Total	**1768.3**	**1772.5**	**1790.6**	**1506.7**	**1957.9**	**1448.7**	**1583**

Currently, there is surplus during the months April to December and in the case of remaining months the surplus values are minimum. The maximum amount of surplus is occur in September month. As per RCP 4.5 and 8.5, in projected climate the maximum surplus will occur during the months June and July.

4.3.3.4 Monthly potential evapotranspiration, deficit and surplus of southern high hills (AEU14) in Pathanamthitta district

The monthly potential evapotranspiration of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 147.

Table 147. Monthly potential evapotranspiration under projected climate of southern high hills (AEU14) in Pathanamthitta district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	146.8	143.2	144	148.4	141.2	150	162.4
February	162.8	158.4	147.6	152.8	144.4	150	159.2
March	215	165	164.5	167.5	161.5	167	174.5
April	167.8	182	172.4	176	170.4	176	184.4
May	188.2	177	187	189	185.5	187.5	192
June	137.8	164.4	181.2	183.6	178.8	184.8	192.8
July	180.6	168.5	168	171	165	170.5	179.5
August	150.4	159.2	169.2	172.4	167.6	171.2	177.2
September	177.4	163.5	161	164.5	158.5	166.5	179
October	127.6	150.4	161.6	164	159.2	163.2	169.2
November	131.2	110.4	152	154.8	149.6	156	164
December	131.2	142.4	112	118.8	108	112.8	140.8
Total	**1916.8**	**1884.4**	**1920.5**	**1962.8**	**1889.7**	**1955.5**	**2075**

At the present situation, the monthly potential evapotranspiration is maximum in March (215 mm.) and the base value in October (127.6 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during May and June. The annual potential evapotranspiration shows an increasing trend except in the case of 2030s.

The monthly deficit of southern high hills (AEU14) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 148.

Table 148. Monthly deficit under projected climate of southern high hills (AEU14) in Pathanamthitta district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	145.8	137.6	137.5	142.2	134.2	143.7	122.4
February	140.8	116	103.7	110.1	105.9	107.4	149.2
March	156.4	112.2	125.6	128	115.8	126.6	143.3
April	103.4	121.9	96.1	98.4	106.6	99	116.5
May	53.9	28	39.8	38.9	42.5	71.8	71
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	19.7
August	2.7	0	0	0.2	0.1	3.9	0
September	28	92.3	86.9	91.4	87.1	71.7	125.9
October	5.2	36	42.3	41.8	41.3	61.5	42.3
November	14.7	93	133.9	136.1	131.9	137	61.9
December	78.6	114.3	84.5	83.5	80.8	85.5	97.3
Total	**729.5**	**851.3**	**850.3**	**870.6**	**846.2**	**908.1**	**949.5**

At present, the maximum deficit occurs during the month march having value about 156.4 mm respectively and minimum deficit in the months June and July. As per RCP 4.5 and 8.5 in projected climate all the months except June and July will show deficit. Comparing the present and future climate there is having an increase in September, October

November and December. The annual deficit values of projected climate will have the tendency to increase from the present value.

The monthly surplus of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 149.

Table 149. Monthly surplus under projected climate of southern high hills (AEU14) in Pathanamthitta district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	149	34.6	0	10.5	34.6	26	41.2
June	163.9	388.7	316.6	298.5	375.9	263.8	361.5
July	271.4	480.9	561.2	570.1	524.7	572.1	307.2
August	300.3	173.1	145.3	144.3	119.2	179.4	282.6
September	88.6	5.9	20	19.1	14.1	6.6	35.5
October	255	113	120.6	127.8	118.2	150.7	170.6
November	7.7	0	0	0	0	0	112.3
December	0	0	0	0	0	0	0
Total	**1235.9**	**1196.2**	**1163.7**	**1170.3**	**1186.7**	**1198.6**	**1310.9**

Currently, there is surplus during the months May to November and in remaining months the surplus values are minimum. The maximum amount of surplus is occur in august month. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October months and the maximum surplus will occur during the month June and July. The annual surplus values of projected climate will have the tendency to decrease except in the case of 2080 of RCP 8.5.

4.3.4 Water balance of various AEUs of Idukki district

4.3.4.1 Monthly potential evapotranspiration, deficit and surplus of southern and central foothills (AEU12) in Idukki district

The monthly potential evapotranspiration of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 150.

Table 150. Monthly potential evapotranspiration under projected climate of southern and central foothills (AEU12) in Idukki district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	140	143.2	148	140.4	147.2	158.4
February	147.2	153.2	155.6	160.8	153.6	159.2	167.6
March	168.5	167	170	173	166.5	172.5	179.5
April	132.1	175.2	177.2	180.8	176	180.4	187.2
May	166	187	189	191.5	187.5	191	196
June	149.2	176.8	179.6	182.4	176.8	182	189.6
July	202.1	159	163	166.5	159.5	166	175.5
August	175.6	168	169.6	172.8	169.2	173.2	180.4
September	214.4	148	152.5	157.5	149.5	157.5	170
October	157.1	163.2	165.2	168	163.6	168.4	174.4
November	139.2	144	149.2	153.2	145.2	153.2	165.2
December	142.4	142	144.4	148.4	142.8	148	155.6
Total	**1944.2**	**1923.4**	**1958.5**	**2002.9**	**1930.6**	**1998.6**	**2099.4**

At the present situation, the monthly potential evapotranspiration is maximum in September (214.4 mm.) and the base value in April (132.1 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur during May and June and the minimum will be in January and December. The annual potential evaporation values of projected climate will have the probability to increase except in 2030s.

The monthly deficit of southern and central foothills (AEU12) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 151.

Table 151. Monthly deficit under projected climate of southern and central foothills (AEU12) in Idukki district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	101.3	127.6	131.8	136.4	127.6	135.8	155.1
February	134	147.9	149.8	138.3	148.4	136.6	157.9
March	164.7	110.6	113.5	135	109	134.7	132.8
April	52.7	105.3	101.9	138.9	105.9	139.6	138.6
May	0	3.6	19.3	3.5	4.2	3.5	40.9
June	31.9	0	0	0	0	0	0
July	74.6	0	0	0	0	0	0
August	0	0	0	0	0	0	0
September	0	113.1	111.4	64.5	114.6	64.9	70.4
October	23.7	63	52.6	0	62.9	0	0
November	57.4	119.8	125	99.1	120.6	99.5	106.3
December	7	129.1	130	69.8	129.4	73.3	70.2
Total	**647.3**	**920**	**935.3**	**785.5**	**922.6**	**787.9**	**872.2**

At present, the maximum deficit occurs during the month March and it is about 164.7 mm and zero deficit occur during May, August and September. As per RCP 4.5 and 8.5 in projected climate all the months except June, July and August will shows a deficit. When comparing the present and future climate during the months January, April, September, November and December. The annual deficit values of projected climate will show an increase from the present value.

The monthly surplus of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 152.

Table 152. Monthly surplus under projected climate of southern and central foothills (AEU12) in Idukki district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	21.6	3.5	0	0	4.3	0	0
May	230.9	386	383.4	326.1	393.4	331	315.2
June	37.7	701.6	584.2	437.4	730.5	441.8	685.7
July	37.9	1191.4	1247.9	1257.2	1198.5	1258.6	1064.6
August	239.8	518.2	407.4	343.5	527	345.9	362
September	612.6	0	0	53	0	52.5	51.2
October	361.9	269.1	311.6	354.3	279.3	357.6	268.2
November	73.2	0	0	0	0	0	70
December	144.9	0	0	0	0	0	0
Total	**1760.5**	**3069.8**	**2934.5**	**2771.5**	**3133**	**2787.4**	**2816.9**

Currently, there is surplus during the months April to December and in remaining months the surplus values are minimum. The maximum amount of surplus is occurring in September. As per RCP 4.5 and 8.5, in projected climate there will be maximum surplus during June and July months and the remaining months have minimum surplus value. The annual surplus values of projected climate will show an increase from the present value.

4.3.4.2 Monthly potential evapotranspiration, deficit and surplus of southern high hills (AEU14) in Idukki district

The monthly potential evapotranspiration of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 153.

Table 153. Monthly potential evapotranspiration under projected climate of southern high hills (AEU14) in Idukki district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	146.8	73.2	79.6	84	73.6	85.6	105.6
February	162.8	86.4	86.8	94	87.2	88	99.2
March	215	110	116.5	121	110	122.5	144
April	167.8	120.8	127.6	135.6	122	134.8	155.2
May	188.2	162	164.5	167.5	162.5	167	173
June	137.8	148.4	153.2	157.6	149.6	157.2	172.8
July	180.6	109.5	116.5	122	111.5	124.5	148
August	150.4	121.2	125.6	131.2	122.4	129.6	147.2
September	177.4	100	105.5	111	101	112.5	145.5
October	127.6	113.2	117.6	123.6	114.4	122.8	140
November	131.2	94	98	101.2	94.4	104	120.8
December	131.2	67.2	68	71.6	68.4	68.8	72
Total	**1916.8**	**1305.9**	**1359.4**	**1420.3**	**1317**	**1417.3**	**1623.3**

At the present situation, the monthly potential evapotranspiration is maximum in March (215 mm.) and the base value in October (127.6 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and the minimum will be in December. The annual potential evapotranspiration of projected climate will show a decreasing trend from the present value.

The monthly deficit of southern high hills (AEU14) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 154.

Table 154. Monthly deficit under projected climate of southern high hills (AEU14) in Idukki district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	145.8	58.8	67.1	71.8	61	73	97.8
February	140.8	60	69.5	77.3	70.7	71.3	77.3
March	156.4	82.3	83.5	86.8	76.5	93.7	105.8
April	103.4	72.2	91.4	100.1	87.1	94.8	109.8
May	56.4	27.9	27.9	28.6	27.5	41.2	85.1
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	3
August	3.1	0.3	0	0	0.5	0.4	0
September	30.1	55	58.8	56.1	55.7	61.1	27.7
October	5.8	10.2	13.8	12.8	10.3	13.5	21.3
November	16.2	73.3	76.3	80	73.3	82.3	57.2
December	81.1	26.8	27.1	21.9	26.4	34.4	22.7
Total	**739.1**	**466.8**	**515.4**	**535.4**	**489**	**565.7**	**607.7**

At present, the maximum deficit occurs during the month March and it is about 156.4 mm and zero deficit occurring during June and July months. As per RCP 4.5 and 8.5 in most cases the projected climate except June, July and August will shows a huge deficit. When comparing the present and future climate the September, October and November will have an increase in deficit value and January, February and December have the probability to decrease. The annual deficit values of projected climate will tends to decrease from the present value.

The monthly surplus of southern high hills (AEU14) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 155.

Table 155. Monthly surplus under projected climate of southern high hills (AEU14) in Idukki district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	151.5	34.1	39.4	41.9	26.7	25.4	45.1
June	166.4	312.5	284.5	261.5	286.6	285.8	260.2
July	271.4	545.3	490.1	530.4	544.4	503.1	381.4
August	300.7	207.3	260.6	222.3	198.6	227.4	253.1
September	90.7	12.8	14.5	14.2	12.1	22.8	104.6
October	255.6	141.6	163	135.3	153.1	139.6	101.6
November	9.2	0	0	0	0	0	119.3
December	0	0	0	0	1	0	0
Total	**1245.5**	**1253.6**	**1252.1**	**1205.6**	**1222.5**	**1204.1**	**1265.3**

Currently, there is surplus during the months may to November and the remaining months the surplus values are minimum. The maximum value for surplus is occurring in July and August months. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October remaining months have surplus value zero. The maximum surplus will occur during the month July.

4.3.4.3 Monthly potential evapotranspiration, deficit and surplus of kumily hills (AEU16) in Idukki district

The monthly potential evapotranspiration of kumily hills (AEU16) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 156.

Table 156. Monthly potential evapotranspiration under projected climate of kumily hills (AEU16) in Idukki district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	151.2	74.8	79.6	84	77.2	86.4	108.4
February	169.2	79.6	81.6	87.6	78	82.8	92
March	227.7	106.5	112	116	106.5	115	131.5
April	179.8	116.4	121.2	128.8	116.8	128.8	152.4
May	198.9	158	160.5	164.5	158	161.5	168.5
June	140.6	142.8	150.8	155.2	143.2	158	171.6
July	179.3	109	116	121	113	122	139.5
August	149.9	118	122.4	127.6	119.2	123.6	135.6
September	181.4	101	106	111	104	117.5	148.5
October	134	112	115.2	120	112.4	118	130.8
November	134	92.4	97.2	101.2	94.8	104	117.6
December	134	64	64	66.4	62	63.6	68
Total	**1980**	**1274.5**	**1326.5**	**1383.3**	**1285.1**	**1381.2**	**1564.4**

At the present situation, the monthly potential evapotranspiration is maximum in March (227.7 mm.) and the base value in October to December (134 mm. each). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and June months and the minimum will be in December. The annual potential evapotranspiration of projected climate will show a decreasing trend from the present value.

The monthly deficit of Kumily hills (AEU16) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 157.

Table 157. Monthly deficit under projected climate of kumily hills (AEU16) in Idukki district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	151.2	51.5	58	62.7	54.5	65.4	98.7
February	126.9	64	71.3	77.4	68.6	73.1	69.7
March	181.9	76	78.2	81	72.4	79.3	103.1
April	157.8	73.5	69.9	78.2	75.7	79.4	102.5
May	106.2	29.3	24.9	31.8	38.2	70.6	62.5
June	0.6	0	0	0	0	0	0.9
July	0	0	0	0	0	0	0
August	26.4	0	0	0	0	0	0
September	91.3	85.4	81	79.7	79.8	69.3	21.6
October	1.5	12.6	13.2	20.2	12.7	36.9	18.9
November	42.1	75.9	80	83.9	77.7	81.9	39.9
December	87.6	7.9	6.1	3.6	5.9	20	29.9
Total	**973.5**	**476.1**	**482.6**	**518.5**	**485.5**	**575.9**	**547.7**

At present, the maximum deficit occurs during the month march it is about 181.9 mm. and zero deficit occur during July. As per RCP 4.5 and 8.5 in projected climate June, July and August will have zero deficit value. Comparing the present and future climate, there will be an increase in deficit value during the month October and November and decrease in January to May and December. The annual deficit values of projected climate will show an increasing tend from the present value.

The monthly surplus of kumily hills (AEU16) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 158.

Table 158. Monthly surplus under projected climate of kumily hills (AEU16) in Idukki district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	28.1	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	1.9	0	0	0	0	0
May	5.5	53.5	16.3	5.7	42.5	38.6	23.3
June	95	363.5	304.3	280.8	380.1	296.6	242.7
July	279.2	482.7	508.7	536.8	488.9	497.2	440.7
August	0	279.1	263.9	225.4	202.2	234.7	234.4
September	0	0	0	0	0	1.3	114
October	56.5	166.1	185	160.1	179.5	177.2	106.2
November	224.7	0	0	0	0	0	100.4
December	0	24.5	27.2	34.1	28.3	33.5	6.4
Total	**689**	**1371.3**	**1305.4**	**1242.9**	**1321.5**	**1279.1**	**1268.1**

Currently, there is surplus during the months February, May, June, July, October and November and in remaining months the surplus values are minimum. The maximum amount of surplus is occur in July month. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to August and October and December months and January to April months also have minimum values. The maximum surplus will occur in the months July. The annual surplus values of projected climate will show an increasing trend from the present value.

4.3.4.4 Monthly potential evapotranspiration, deficit and surplus of marayur hills (AEU17) in Idukki district

The monthly potential evapotranspiration of marayur hills (AEU17) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 159.

Table 159. Monthly potential evapotranspiration under projected climate of marayur hills (AEU17) in Idukki district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.8	52.8	56.8	56.8	52.8	60	68.8
February	170.4	61.2	60.4	65.2	61.2	60.4	65.6
March	231.3	77	80	84	76.5	82.5	92.5
April	183.2	85.6	88.8	92.8	86	92.8	106
May	202.1	124.5	127	134.5	125.5	130	142
June	140.2	110	114	117.6	110.4	118.4	137.2
July	177.2	85	88	90	86	92.5	102.5
August	149.1	92.8	94.8	98	94	96.8	104.4
September	181.7	75.5	79.5	80	76.5	84.5	99
October	134.8	84.8	86.8	89.6	85.2	88.8	96.8
November	134.8	68	69.6	71.6	68	73.2	83.2
December	134.8	47.2	47.2	50.4	48	47.2	48.8
Total	**1990.4**	**963.8**	**992.7**	**1029.8**	**970.2**	**1026.8**	**1146.8**

At the present situation, the monthly potential evapotranspiration is maximum in March (231.3 mm.) and the base value in October, November and December (134.8 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum value will occur in May and annual potential evapotranspiration of projected climate will show a decreasing trend from the present value.

The monthly deficit of marayur hills (AEU17) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 160.

Table 160. Monthly deficit under projected climate of marayur hills (AEU17) in Idukki district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	96.8	35.6	39.4	37.9	35.2	40.8	48.4
February	110.4	46.6	45.4	50.4	46.9	45.6	51.4
March	88.6	50.8	53.5	65.1	49.6	61.3	67.8
April	142.7	37.2	40.1	45	37.5	53.3	61.7
May	165.1	30.9	21.2	19.7	31.3	22.9	63.7
June	80.1	0	0	0	0	0	0
July	31.8	0	0	0	0	0	0
August	12.2	0	0	0	0	0	0
September	15.5	22.7	33	28.5	23	20.1	63.3
October	113.3	0	0	0.4	0	9	29.5
November	116.8	15.3	10.5	43	15.3	39.2	37.7
December	123.8	0	0	2.3	0	3.8	10.7
Total	**1097.1**	**239.1**	**243.1**	**292.3**	**238.8**	**296**	**434.2**

At present, the maximum deficit occurs during the month May having value 165.1 mm. As per RCP 4.5 and 8.5 in projected climate all the months except June, July and August will shows a deficit. Comparing the present and future climate there is having a decrease in deficit value in all months except the month September. The annual deficit values of projected climate tends to decrease from the present value.

The monthly surplus of marayur hills (AEU17) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 161.

Table 161. Monthly surplus under projected climate of marayur hills (AEU17) in Idukki district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	17.8	0	0	0	0	0	0
April	0	0	0.8	0	0	0	0
May	0	46.1	28.1	29.5	44.6	30.8	73.7
June	19.9	337	359	416.5	347.3	466.8	366.7
July	212.1	661.4	611.4	733.4	641.8	707.2	630.8
August	560.1	280.2	335.4	264.7	269.3	352.6	358.2
September	142.8	17.7	17	78.6	18.9	67.4	13.1
October	0	220.3	187.7	135.7	223	157.5	190.7
November	0	109.8	158.3	0	109.9	1.4	0
December	0	44.8	48.6	19.9	46.7	20.4	28.5
Total	**952.7**	**1717.3**	**1746.3**	**1678.3**	**1701.5**	**1804.1**	**1661.7**

Currently, there is surplus during the months March, June, July, August and September and in the case of remaining months the surplus values are minimum. The maximum amount of surplus is occur in August months. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to December months remaining months have minimum surplus value. The maximum surplus of projected climate will occur during the month June and July. The annual surplus values of projected climate will tends to show an increase from the present value.

4.3.5 Water balance of various AEUs of Kottayam district

The computation the water balance for kuttanad (AEU4) in Kottayam district is of no use, since the region is a wetland and throughout the year the region is waterlogged. Hence there is no relevance in the calculation of water balance of AEU4 in Kottayam.

4.3.5.1 Monthly potential evapotranspiration, deficit and surplus of south central laterites (AEU9) in Kottayam 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 presented in table 162

Table 162. Monthly potential evapotranspiration under projected climate of south central laterites (AEU9) in Kottayam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	136.4	139.2	144	137.2	143.6	156.4
February	156.8	148.4	151.6	156.4	148.8	155.2	163.6
March	209.3	162	166	168.5	162	167.5	176
April	162.4	170	172.4	175.6	170.8	174.8	182.8
May	182.7	184	186	188.5	184.5	189	201.5
June	135.8	171.6	174.8	177.6	172.4	178	186.8
July	175.7	154.5	159	163	156	162.5	182.4
August	144.9	164	166.4	168.8	164.8	169.2	176
September	170.8	144.5	149	154	145.5	154	176.7
October	123.2	160.4	162.8	165.2	160.8	164.8	170.8
November	128.8	140	144.8	148.4	140.4	150.4	162.8
December	128.8	138.4	141.2	145.6	139.2	143.6	150.8
Total	**1862**	**1874.2**	**1913.2**	**1955.6**	**1882.4**	**1952.6**	**2086.6**

At the present situation, the monthly potential evapotranspiration is maximum in March (209.3 mm.) and the base value in October (123.2 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and June months and the minimum in January and December months. The annual potential evapotranspiration of projected climate shows an increasing trend from the present value.

The monthly deficit of south central laterites (AEU9) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 163.

Table 163. Monthly deficit under projected climate of south central laterites (AEU9) in Kottayam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	124.9	128.9	132.8	126.1	132.6	144.9
February	154.8	142.9	126.1	150.8	143	149.6	158.3
March	208.3	129.7	140.5	132.2	128.4	131.2	139.7
April	60	123.8	122.5	134.1	137.3	136.1	139.3
May	61.1	7.8	7	46.9	8.8	54.3	32.1
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	5.9	0	0	0.6	0	0	0
September	23.3	92.2	54.8	68.1	51.7	65.9	76.6
October	0	57.7	0	0	25.2	0	0.3
November	67.4	101	91	94.1	87.1	96.5	102.5
December	67	72.2	70.2	68.2	67.7	71.1	59.8
Total	**790.6**	**852.2**	**741**	**827.8**	**775.3**	**837.3**	**853.5**

At present, the maximum deficit occurs during the month March and it is about 208.3 mm and zero deficit occurring during June, July and October months. As per RCP

4.5 and 8.5 in most cases the projected climate in most cases except June, July and August will shows a huge deficit. Comparing the present and future climate during the month April, September and November there will be an increase in deficit value and March and may will have the probability to decrease.

The monthly surplus of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 164.

Table 164. Monthly surplus under projected climate of south central laterites (AEU9) in Kottayam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	71	329.5	278.9	274.8	352.5	240.1	132.5
June	379.6	461	676	331.4	482	463.8	564.4
July	791.3	1039.8	1070.4	1175.3	1043	1105.3	935.9
August	481	183.5	234.2	268.3	187.1	298.9	311.5
September	258.5	0.2	42	9.9	36.9	9.8	45.2
October	162.8	363.8	322.2	325.3	349.9	329.3	250.3
November	4.2	0	0	0	0	0	67.3
December	82.2	0	0	0	0	0	0
Total	**2230.6**	**2377.8**	**2623.7**	**2385**	**2451.4**	**2447.2**	**2307.1**

Currently, there is surplus during the months may to December and in the case of remaining months the surplus values are minimum. The maximum value for surplus is occurring in the month of July. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October remaining months have surplus value zero. The maximum surplus will occur during the month July. The annual surplus value of projected climate tends to show an increase from the present value.

4.3.5.2 Monthly potential evapotranspiration, deficit and surplus of southern and central foothills (AEU12) in Kottayam district

The monthly potential evapotranspiration of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 165.

Table 165. Monthly potential evapotranspiration under projected climate of southern and central foothills (AEU12) in Kottayam district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	124	140.4	145.2	136	146	159.2
February	147.2	149.6	152.8	157.2	150.4	156	163.6
March	168.5	164	166.5	169.5	163.5	168.5	176
April	132.1	170.8	173.2	176.8	171.6	175.6	184
May	166	186.5	188.5	190.5	187	190	194.5
June	149.2	175.2	178.8	181.2	176	182	189.6
July	202.1	158.5	162.5	166	160	166.5	177
August	175.6	166.8	135.2	172	167.6	171.2	178.4
September	214.4	150.5	155	159	151	161	172.5
October	157.1	161.2	217.6	166	162	164.8	172
November	139.2	144.8	200	153.6	145.2	155.2	164.4
December	142.4	136.8	184.8	143.2	138	140.8	149.2
Total	**1944.2**	**1888.7**	**2055.3**	**1980.2**	**1908.3**	**1977.6**	**2080.4**

At the present situation, the monthly potential evapotranspiration is maximum in March (214.4 mm.) and the base value in April (132.1 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur in May and June months and the minimum

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will be in January. The annual potential evapotranspiration of projected climate will show an increasing trend except in 2030s.

The monthly deficit of southern and central foothills (AEU12) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 166.

Table 166. Monthly deficit under projected climate of southern and central foothills (AEU12) in Kottayam district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	87.8	110.7	129.8	133.7	124.7	134.7	146.9
February	133.9	128.1	127.3	134	126.2	132.3	158.3
March	164.7	133.1	137.7	136.1	133.3	135.4	144.2
April	40.7	108.1	107.3	121.7	108.3	121.6	132.2
May	0	13.1	33.9	44.6	13.1	28.5	32.3
June	22.5	0	0	0	0	0	0
July	61.4	0	0	0	0	0	0
August	0	0	0	0.4	0	0	0
September	0	49.9	47.6	61.2	46	56.4	43.6
October	14.8	12.4	0	0	0	0	17.5
November	45	101	119.2	84.4	81.9	85.4	92.3
December	4.2	76.7	96.6	49.7	68	50.4	60.5
Total	**575**	**733.1**	**799.4**	**765.8**	**701.5**	**744.7**	**827.8**

At present, the maximum deficit occurs during the month march having value 164.7 mm. Zero deficit occur during May, August and September months. As per RCP 4.5 and 8.5 in projected climate all the months except June, July and August will shows deficit. Comparing the present and future climate January, April, May, September, November and December months will show an increase in deficit value. The annual deficit values of projected climate will tends to show an increase from the present value.

The monthly surplus of southern and central foothills (AEU12) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 167.

Table 167. Monthly surplus under projected climate of southern and central foothills (AEU12) in Kottayam district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	7.9	0	0	0	0	0	0
May	218.9	187.2	224.2	172.3	193.1	66.6	87.9
June	28.2	526	538.2	349.2	539.4	441.2	457.3
July	24.7	961.1	1055.8	1063.8	975.9	994.7	793.6
August	239.8	258.5	298.6	306.8	238.4	370	343.2
September	612.6	0	29.9	0	28.1	0	14.7
October	353	296.7	171.6	231.3	315.7	235.4	221.4
November	60.8	0	52.7	59.3	0	60.1	120.5
December	144.6	0	0	0	0	0	0
Total	**1690.5**	**2229.5**	**2371**	**2182.7**	**2290.6**	**2168**	**2038.6**

Currently, there is surplus during the months April to December and in the case of remaining months the surplus values are minimum. The maximum amount of surplus is seen in September month. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to November and January to April months will have minimum values. The maximum surplus will occur during the month July. The annual surplus values of projected climate will show an increase from the presented value.

4.3.6 Water balance of various of Alappuzha district

4.3.6.1 Monthly potential evapotranspiration, deficit and surplus of southern coastal plain (AEU1) in Alappuzha district

The monthly potential evapotranspiration of southern coastal plain (AEU1) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 168.

Table 168. Monthly potential evapotranspiration under projected climate of southern coastal plain (AEU1) in Alappuzha district

PET (mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	150.4	121.2	140	144	136.4	146	158.4
February	166.4	153.2	156	159.2	153.2	158	166.8
March	222.3	163	166	170	163	167.5	176
April	174.4	169.2	172	175.2	169.6	174.4	183.6
May	194.7	186	187	190	185.5	188.5	193
June	140.4	169.2	173.2	176	170	176	184.4
July	180.9	150	154	158	151.5	158	170.5
August	150.9	162	165.2	168	163.6	168.8	176.8
September	180.4	145	148	153	146.5	152	162
October	131.6	161.2	163.2	166	161.2	166	172.8
November	134.4	137.2	141.2	146	139.2	147.2	160.4
December	134.4	151.2	152	156	150	154	160.4
Total	**1961.2**	**1868.4**	**1917.8**	**1961.4**	**1889.7**	**1956.4**	**2065.1**

At the present situation, the monthly potential evapotranspiration is maximum in March (222.3 mm.) and the base value in October (134 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during April, May and June and the minimum will be in January. Annually, there will be a decrease in potential evapotranspiration during projected climate from the present condition except in the case of 2080 of RCP 8.5.

The monthly deficit of southern coastal plain (AEU1) for the current and projected climate (RCP 4.5 and 8.5) were considered and arranged in table 169.

Table 169. Monthly deficit under projected climate of southern coastal plain (AEU1) in Alappuzha district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.2	109.4	127	132.4	124.8	135.4	147.8
February	124.8	152.5	155.2	158.5	152.5	156.4	161.1
March	198.9	129.1	133.9	134	28.5	140.7	144.5
April	38.6	129.6	131.2	129.8	129.4	121.7	143.3
May	72.2	14.1	0	1	0	0	8.1
June	5.4	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	10.4	36.3	1.3	11.8	33.2	13.4	0
September	51.7	106.7	107.2	81.3	107.9	52.7	103.2
October	13.1	55.4	23.8	20.9	54.8	20.1	46.1
November	74.8	99.5	103.1	106.6	100.9	107.4	137.9
December	100.1	114.9	99.5	101.4	100.4	101.8	143
Total	**839.2**	**947.5**	**882.2**	**877.7**	**832.4**	**849.6**	**1035**

At present situation the maximum amount of deficit occurs during the month March and it is about 198.9 mm. and there is zero deficit during July. As per RCP 4.5 and 8.5 in projected climate all the months except in June and July will show a deficit. Comparing the present and future climate during the months April, August, September, October and November there will be a drastic increase in deficit where as in March and may will show a decreasing trend. The annual deficit values generally will show an increasing trend.

The monthly surplus of southern coastal plain (AEU1) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 170.

Table 170. Monthly surplus under projected climate of southern coastal plain (AEU1) in Alappuzha district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	6.4	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	26.7	0	0	0	0	0	0
May	178.1	508.2	402	295.9	395	300.9	352.4
June	160.3	619.9	741.3	508.5	675.7	493.3	382.6
July	401	925.3	933	1022.3	1002.5	956.7	905.8
August	301.6	256.3	136.6	160.5	169.3	213.1	204.7
September	101.3	144.8	10.8	60.5	16.2	24.6	115
October	75.8	147.2	207.3	202.4	287.3	212.8	195
November	50	16.2	21.8	18	4.3	15.8	0
December	0	0	0	0	0	0	0
Total	**1301.2**	**2617.9**	**2452.8**	**2268.1**	**2550.3**	**2217.2**	**2155.5**

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 months. As per RCP 4.5 and 8.5, in projected climate the maximum surplus will occur during the months June and July. The annual surplus values will show an increasing trend.

4.3.6.2 Monthly potential evapotranspiration, deficit and surplus of onattukara sandy plain (AEU3) in Alappuzha district

The monthly potential evapotranspiration of onattukara sandy plain (AEU3) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 171.

Table 171. Monthly potential evapotranspiration under projected climate of onattukara sandy plain (AEU3) in Alappuzha district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	148.4	144.4	149.2	141.2	148	158.4	158
February	165	155.2	159.6	152	158	166	164.4
March	220.5	165.5	169.5	162.5	168	176	175
April	172.9	173.2	176.4	171.2	176	183.2	181.6
May	191.8	186	188	184	187.5	193	193.5
June	140	172.4	176	170.8	175.6	184.4	186.4
July	181.3	156	159.5	152.5	161	171.5	173.5
August	150.5	167.6	170.4	169.2	169.6	176.8	176
September	180.6	147.5	151.5	145	151	165	167.5
October	131.6	193.1	165.6	161.6	165.6	172	171.2
November	134.4	144.4	148.8	142.4	150	163.6	163.3
December	134.4	147.2	151.2	144.8	150	155.6	153.2
Total	**1951.4**	**1883.4**	**1921.8**	**1965.2**	**1892.4**	**1959.5**	**2063.6**

At the present situation, the monthly potential evapotranspiration is maximum in March (220.5 mm.) and the base value in October (131.6 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur during April, May and June months and the minimum will be in January. Annually, there will be an increasing trend in potential evapotranspiration during projected climate from the present condition except in the case of 2030s of both RCP 4.5 and RCP 8.5.

The monthly deficit of onattukara sandy plain (AEU3) for the current and projected climate (RCP 4.5 and 8.5) were studied and represented in table 172.

Table 172. Monthly deficit under projected climate of onattukara sandy plain (AEU3) in Alappuzha district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	148.4	122.6	131.2	119.8	128.7	142.6	154.7
February	132.4	148.4	147.4	152.5	144.1	145.5	153
March	205.5	137.1	136.4	138.1	136.2	140.6	136.3
April	118	103.3	120.2	124	110.8	125.5	134.3
May	58.1	7.6	40.5	40.6	14.4	55.8	31.1
June	0	0	0.5	1.1	0	0	0
July	0	0	0	0	0	0	0
August	0.3	16.8	1.5	3.6	0	8.1	0
September	80.4	83.1	56.7	61.3	89.7	90.6	60.4
October	15.4	74.9	35.8	36.5	75.3	0	0.1
November	74.1	113.5	129.5	133	130.6	97.2	113.7
December	96.9	91.2	71.4	69	71.1	78.3	73
Total	**929.5**	**898.5**	**871.1**	**879.5**	**900.9**	**884.2**	**856.6**

At present situation the maximum amount of deficit occurs during the month March having value of about 205.5 mm and zero deficit occurring during June and July months. 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

February, October and November there will be a drastic increase in deficit where as in March and May will show a decreasing trend. The annual deficit values generally showed a decreasing trend.

The monthly surplus of onattukara sandy plain (AEU3) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 173.

Table 173. Monthly surplus under projected climate of onattukara sandy plain (AEU3) in Alappuzha district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	14.3	0	0	0	0	0	0
May	125.4	228	232.1	225.9	250.4	262.1	116.1
June	213.1	504.7	346.3	336.5	491.6	364.5	587.7
July	403.1	760.7	779.2	860.6	776.3	944.4	677.9
August	255.3	106.2	120.6	124.8	99	226	255.4
September	36	52.9	144.2	142.9	27.8	55.8	96.1
October	238.4	260.6	274.6	279	306.1	209.5	259.8
November	36.7	0	0	0	0	0	0
December	32.7	0	0	0	0	0	0
Total	**1355**	**1913.1**	**1897**	**1969.7**	**1951.2**	**2062.3**	**1993**

Currently, there is surplus during the months April to December and in the case of remaining months the surplus values are minimum. The maximum value for surplus is in July and august months. As per RCP 4.5 and 8.5, the maximum surplus will occur during the month July the annual surplus values will show an increasing trend in 2030, 2050 and 2080.

4.3.6.3 Monthly potential evapotranspiration, deficit and surplus of kuttanad (AEU4) in Alappuzha district

The monthly potential evapotranspiration of kuttanad (AEU4) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 174.

Table 174. Monthly potential evapotranspiration under projected climate of kuttanad (AEU4) in Alappuzha district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	149.8	133.9	139.9	149.2	141.2	148	158.4
February	166	152.8	155.2	159.6	152	158	166
March	221	162.5	165.5	169.5	162.5	168	176
April	173.9	169.6	173.2	176.4	171.2	176	183.2
May	193.9	184.5	186	188	184	187.5	193
June	140.2	169.6	172.4	176	170.8	175.6	184.4
July	181.2	150.5	156	159.5	152.5	161	171.5
August	151.3	164	167.6	170.4	169.2	169.6	176.8
September	180.1	145	1315.8	151.5	145	151	165
October	130.8	161.2	163.6	165.6	161.6	165.6	172
November	134	322.4	327.2	331.2	323.2	331.2	344
December	134	784	798.8	811.2	788.8	812.4	851.6
Total	**1956.2**	**2700**	**3921.2**	**2808.1**	**2722**	**2803.9**	**2941.9**

At the present situation, the monthly potential evapotranspiration is maximum in March (221 mm.) and the base value in October (130.8 mm.). In projected climate based on RCP 4.5 and 8.5, the maximum values will occur in November and December months and the minimum will be in January. Annually, there will be an increase in potential evapotranspiration during projected climate from the present condition in 2030s, 2050s and 2080s.

The monthly deficit of kuttanad (AEU4) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 175.

Table 175. Monthly deficit under projected climate of kuttanad (AEU4) in Alappuzha district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	140.6	88	108.8	114.4	90.3	113.2	152.5
February	166	151.5	154.5	158.9	150.8	157.3	154.6
March	306.6	136.1	136	136	135.4	134.8	147.2
April	66.6	119.9	138	133	121.1	137.7	149.8
May	133.2	239.8	276	266	242.2	275.4	299.6
June	78.3	16.5	0	8.2	11.4	28.2	54
July	42.4	0	0	0	0	0	0
August	0	0	0	0	0	0	0
September	0	38.5	17.1	21.4	24.4	0	2.2
October	758.3	113.6	100.2	837.9	115.3	134.5	70.7
November	74.8	92.7	58.8	37.1	76	45.6	15
December	0	98.1	132.4	132.7	101.5	125.9	113.7
Total	**1766.8**	**1094.7**	**1121.8**	**1845.6**	**1068.4**	**1152.6**	**1159.3**

At present situation the maximum amount of deficit occurs during the month October it is about 758.3 mm. There is zero deficit during August, September and December months. As per RCP 4.5 and 8.5 in projected climate all the months will shows an amount of deficit except July and August. Comparing the present and future climate during the months April, May, September, and December there will be a drastic increase in deficit where as in March and June will show a decreasing trend. The annual deficit values generally will show a decreasing trend except in the case of 2080 of RCP 8.5.

The monthly surplus of kuttanad (AEU4) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 176.

Table 176. Monthly surplus under projected climate of kuttanad (AEU4) in Alappuzha district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	46.9	0.4	0	0	0.6	0	0
May	62	261.9	432.6	353.1	266.3	388.4	201.6
June	30.2	631.4	728.7	525.7	652.1	485.9	460.9
July	972.5	815.8	729.8	793.5	701.4	819.6	803.2
August	473.9	277.1	217.1	239.4	267.6	218.3	156.8
September	239.3	10.3	10	0	3.7	0	152.6
October	36.8	177.2	263.1	167.9	240.6	195.8	165.7
November	148.4	0	0	0	0	0	65.7
December	84	0	0	0	0	0	0
Total	**2094**	**2174.1**	**2381.3**	**2079.6**	**2132.3**	**2108**	**2006.5**

Currently, there is surplus during the months April to December whereas in remaining months the surplus is minimum. The maximum amount of surplus is occurring in July and August months. As per RCP 4.5 and 8.5, in projected climate the maximum surplus will occur during the months June and July. The annual surplus values will show increase except in 2080s.

4.3.6.4 Monthly potential evapotranspiration, deficit and surplus of Pokkali Lands (AEU5) in Alappuzha district

The monthly potential evapotranspiration of pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 177.

Table 177. Monthly potential evapotranspiration under projected climate of pokkali lands (AEU5) in Alappuzha district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	151.2	115.6	138	142.8	118	144	158
February	169.2	154	157.2	160.4	154.4	159.6	166.8
March	227.7	164.5	167	171	165	169	177
April	179.8	169.6	172.8	176	170.4	175.6	184.4
May	198.9	186.5	188	190.5	187	189.5	193.5
June	140.6	169.6	172	175.6	169.6	175.6	184.4
July	179.3	151	154.5	158.5	152.5	158.5	169.5
August	149.9	162.8	166.4	168.8	164	169.2	178
September	181.4	145	149	153	146	153	162.5
October	134	162	164	167.2	162.8	166.8	173.6
November	134	137.6	142.4	146	138.4	147.2	160.4
December	134	152.8	154	157.2	153.6	156	161.2
Total	**1980**	**1871**	**1925.3**	**1967**	**1881.7**	**1964**	**2069.3**

At the present situation, the monthly potential evapotranspiration is maximum in March (227.7 mm) and the base value in October, November and December months (134 mm each). In projected climate based on RCP 4.5 and 8.5 the maximum values will occur during April, May and June. The annual potential evapotranspiration shows decreasing trend from the present value except 2080 in RCP 8.5.

The monthly deficit of pokkali lands (AEU5) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 178.

Table 178. Monthly deficit under projected climate of pokkali lands (AEU5) in Alappuzha district

Deficit(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	134.2	67.5	126.4	110	85	111.3	133.3
February	153.2	153.7	156.5	159.9	151.5	159.1	165.4
March	60.3	142	133.6	141.9	142.4	141.1	152.6
April	0	100.4	134	151.3	123.8	151.3	138.9
May	9.2	24.2	13.2	33.9	0	0	0
June	26.2	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	32.2	36.5	6	15.5	36.8	12	20.3
September	130.5	73.2	110.2	81	107.2	81	45.9
October	129.8	45.6	57.9	0	51	0	33.2
November	114	81.8	103.6	100.5	94.5	104.2	126.1
December	134	104.9	115.9	103.8	106.2	93.1	90.9
Total	**923.6**	**829.8**	**957.3**	**897.8**	**898.4**	**853.1**	**906.6**

At present the maximum deficit occurs during the month February it is about 153.2 mm respectively. Zero deficit occurring during April and July months. As per RCP 4.5 and 8.5 in projected climate all the months except June and July will shows deficit. Comparing the present and future climate there will be drastic increase in the deficit during March and April and decrease in January, September, October and December months. The annual deficit values tends to decrease except in 2050 of RCP 4.5.

The monthly surplus of pokkali lands (AEU5) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 179.

Table 179. Monthly surplus under projected climate of pokkali lands (AEU5) in Alappuzha district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	121.4	0	0	0	0	0	0
April	629.2	0	0	0	0	0	0
May	176.3	397.6	525.4	376.8	487.4	376.4	399.1
June	460.6	612.1	698.5	602.4	731.9	600.6	489.8
July	741.7	1036.2	1011.1	999.5	995.4	1004.4	959.3
August	10.5	233.9	148.1	164.3	230.7	163.2	174.1
September	18.9	174.1	171.6	172.9	157.5	64.3	113.5
October	0	95.5	163	191.5	139.2	301.3	361.8
November	0	0	20.3	10.5	0	0	0
December	0	0	0	0	0	0	0
Total	**2158.6**	**2549.4**	**2738**	**2517.9**	**2742.1**	**2510.2**	**2497.6**

Currently, there is surplus during the months march to September and in the case of remaining months the surplus values are minimum. The maximum amount of surplus is occurring in April and July. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October months. The maximum surplus will occur during the month June and July. The annual surplus values will tends to an increasing trend.

4.3.6.5 Monthly potential evapotranspiration, deficit and surplus of south central laterites (AEU9) in Alappuzha 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 presented in table 180.

Table 180. Monthly potential evapotranspiration under projected climate of south central laterites (AEU9) in Alappuzha district

PET(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	142.8	136.8	140	144.8	136.8	144.4	158
February	156.8	149.2	152	157.6	148.8	155.6	163.6
March	209.3	162	166	168.5	162.5	168	175
April	162.4	170.4	172.4	175.6	170	174.8	182
May	182.7	184.5	186.5	189	185	188.5	193.5
June	135.8	172.4	175.6	178.4	173.2	178	187.2
July	175.7	157	161.5	164.5	158.5	164.5	175
August	144.9	166	168	171.2	166	170.8	177.2
September	170.8	144.5	149.5	153.5	146	154.5	168.5
October	123.2	161.6	164	166	161.6	166	171.2
November	128.8	141.2	146	149.6	143.6	151.6	163.2
December	128.8	140.8	142.8	146.8	140.4	145.2	151.2
Total	**1862**	**1886.4**	**1924.3**	**1965.5**	**1892.4**	**1961.9**	**2065.6**

At the present situation, the monthly potential evapotranspiration is maximum in March (209.3 mm.) and the base value in October (123.2 mm.). In projected climate based on RCP 4.5 and 8.5 the maximum potential evapotranspiration values comes during the months May and June and minimum in January and December months. Annually, there will be an increase in the potential evapotranspiration during projected climate from the present condition.

The monthly deficit of south central laterites (AEU9) for the current and projected climate (RCP 4.5 and 8.5) were studied and presented in table 181.

Table 181. Monthly deficit under projected climate of south central laterites (AEU9) in Alappuzha district

Deficit(mm) / Month	Present	RCP 4.5			RCP 8.5		
		2030	2050	2080	2030	2050	2080
January	142.8	127.8	137.2	128.7	123.2	127.9	142
February	154.8	144.1	141.7	135.4	123.3	133.2	142.5
March	208.3	139.3	129.3	141.3	132.4	142.8	139.5
April	59.6	108	128.2	121.1	123	117.2	138.5
May	63.7	0	46.4	48.9	15.3	32.7	32.3
June	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0
August	6.7	1.6	3.6	2.5	0	0.3	0
September	25.4	95.6	74.2	88.4	109.5	81.4	64.4
October	0	18.8	0	30.3	3.9	27.3	10.4
November	72.6	90.9	95.1	125.2	116.4	127	135.3
December	69.6	78.3	80.2	73	69.5	77.3	78.3
Total	**803.5**	**804.4**	**835.9**	**894.8**	**816.5**	**867.1**	**883.2**

At present the maximum deficit occurs during the month February and March it is about 154.8 mm and 208.3 mm respectively. Zero deficit occurring during June, July and October months. As per RCP 4.5 and 8.5 in projected climate in most cases minimum of deficit values comes under June, July and August months. Comparing the present and future climate during the months April, September, November and December might have an increase in deficit value and decrease in January, February and March months. The annual deficit values will show an increasing trend from the present value.

The monthly surplus of south central laterites (AEU9) for the present and projected climate (RCP 4.5 and 8.5) were studied and presented in table 182.

Table 182. Monthly surplus under projected climate of south central laterites (AEU9) in Alappuzha district

Surplus(mm)	Present	RCP 4.5			RCP 8.5		
Month		2030	2050	2080	2030	2050	2080
January	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0
May	73.2	352.6	242.1	252.5	283.3	222.8	130.4
June	382.2	384.4	434.6	360.6	400.1	446.2	540.2
July	791.3	825.6	897.8	1023.3	750.8	719.2	640.3
August	481.8	130.3	217.6	261.5	196.5	239.2	338
September	260.6	0.4	11.1	11.7	0	101.2	76.3
October	162.8	339.3	317.6	186	213.1	174.8	169.9
November	6.8	0	0	0	0	0	0
December	84.8	0	0	0	0	0	0
Total	**2243.5**	**2032.6**	**2120.8**	**2095.6**	**1843.8**	**1903.4**	**1895.1**

Currently, there is surplus during the months may to December and in the case of remaining months the surplus values are minimum. The maximum amount of surplus is occurring in July and August months. As per RCP 4.5 and 8.5, in projected climate there will be surplus during May to October months remaining months have minimum surplus value. The maximum surplus will occur during the months July and the annual surplus values will have a decreasing trend from the present value.

4.4 Computation of Water requirement

4.4.1 Water requirement of major cropping systems of various AEUs in Thiruvananthapuram district and impact of projected climate change

The crop evapotranspiration (ET_c) values of various cropping systems for AEU1, AEU8, AEU9, AEU12 and AEU14 of Thiruvananthapuram district were studied and presented in table 183.

Rice-rice-fallow and coconut monocropping are the major cropping systems of AEU1. 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 ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value of projected climate will show an increasing trend in case of rice-rice-fallow. In coconut there is a decreasing trend in projected ET_c value except in the case of 2080 of RCP 8.5.

Rubber and coconut were found to be the major cropping systems in AEU8. Since rubber and coconut are perennial crops the ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value of projected climate will show a decreasing trend in the case of rubber and coconut except RCP 8.5 of 2080 in rubber and RCP 8.5 of 2050 and 2080 in coconut.

Rubber and coconut are major cropping systems in AEU9. Since rubber and coconut are perennial crops the ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value of projected climate will show a decreasing trend in the case of rubber and coconut except and RCP 8.5 of 2050 and 2080 in the case of coconut.

Rubber and coconut + pepper are major cropping systems in AEU12. Since rubber, coconut + pepper are perennial crops the ET_c values for a year is considered. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual ET_c

value of projected climate will show a decreasing trend from the present value except in the case of 2080 of RCP 8.5 in both rubber and coconut + pepper cropping systems.

Coconut and rubber were found to be the major cropping systems in AEU14. Since coconut and rubber are perennial crops the ET_c 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 2080s and 2050 of RCP 8.5 remaining cases will show a decreasing trend and in the case of rubber ETc values of projected climate will show a decreasing trend.

The water requirement for various cropping systems of AEU1, AEU8, AEU9, AEU12 and AEU14 of Thiruvananthapuram district were estimated and presented in table 184.

Presently, the annual water requirement of rice-rice-fallow and coconut is 262.9 and 187.3 mm respectively in AEU1. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual water requirement of both rice-rice-fallow and coconut will show an increasing trend from the present value except in the case of 2050s of rice-rice-fallow. Irrigation is not required during the months June and July in both present and future projections. In coconut, irrigation is not required for six months (June to November) and there is not much variation in the number of months requiring irrigation under projection.

Currently, the annual water requirement of rubber and coconut monocropping is 561 and 398.8 mm respectively in AEU8. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual water requirement of both rubber and coconut of projected climate will show a decreasing trend from the present value. In both cropping systems there is an increase in the number of months does not requires irrigation in projected climate.

Presently, the annual water requirement of rubber and coconut monocropping is 396.9 and 281.5 mm respectively in AEU9. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual water requirement of both rubber and coconut will show an increasing trend in the case of RCP 4.5 of 2030, 2050 and 2080 and a decreasing trend in RCP 8.5 of 2030, 2050 and 2080. In both cropping systems there will be a decreasing trend in the number of months does not require irrigation from six months (May to October) in projected climate.

Currently, the annual water requirement of rubber and coconut + pepper monocropping is 248.1 and 156.1 mm respectively in AEU12. Comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual water requirement of both rubber and coconut + pepper will show an increasing trend. In both cropping systems, the number of months which does not require irrigation of projected climate will show a decreasing trend from eight months (April to November) under present situation to four up to five months.

Presently, the annual water requirement of coconut and rubber monocropping is 260.9 and 382.5 mm respectively in AEU14. Comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual water requirement of coconut will show an increasing trend from the present value except in the cases of 2030s and 2050 of RCP 4.5. In the case of rubber except in the cases of 2050 of RCP 4.5 and 2030 of RCP 8.5 will show an increasing trend. In both cropping systems the number of months does not requires irrigation will show a decreasing trend from seven months (May to November).

Rubber of AEU8, AEU9, AEU12 and coconut of AEU9 is having high water requirement within the district.

Table 183. ET_c value of various cropping systems in different AEUs of Thiruvananthapuram district

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
				Crop evapotranspiration ET_c (mm)												
AEU1 Southern Coastal Plain	Rice-rice-fallow		Present	3.7	*	*	*	20.1	104	101.5	80.2	47.2	115.6	111.1	111.9	**695.3**
		4.5	2030	3.6	*	*	*	21	108.5	102.2	82.5	48.4	124.1	114.3	112.8	**717.4**
			2050	3.6	*	*	*	21.1	109.5	103.6	83.2	49	124.8	116.7	113.4	**724.9**
			2080	3.6	*	*	*	21.4	110.5	104.5	83.7	49.6	126.1	117.9	114.7	**732**
		8.5	2030	3.6	*	*	*	21	108.6	102.5	82.9	48.5	124.2	115.4	112.9	**719.6**
			2050	3.6	*	*	*	21.4	110.2	105	83.9	49.7	126.1	118	113.4	**731.3**
			2080	3.8	*	*	*	21.3	116.4	108.2	84.8	52	129.9	122.1	115.6	**754.1**
	Coconut		Present	82	80.8	97	92.8	81.9	71	69.5	77.3	80.4	78.7	73.9	74.6	**969.9**
		4.5	2030	77.9	72	84.3	80.9	78.6	73.9	71.2	80.3	81.4	84.7	79.3	78.9	**943.4**
			2050	78.7	72.5	84.3	81	79	74.8	72.1	80.7	82.8	85.1	80.7	79.1	**950.8**
			2080	79.7	73.5	85.7	82.1	79.9	75.4	72.7	81.5	83.6	86.1	81.6	80.1	**961.9**
		8.5	2030	78	71.9	84	80.8	78.5	74.1	71.3	80.4	81.8	84.8	80	78.8	**944.4**
			2050	75.6	70.8	85.4	82	81.9	75.2	73	81.6	84.1	86.1	80	75.1	**950.8**
			2080	83.6	74.5	86.1	83.7	77.5	79.4	75.2	82.7	87.9	88.7	84.5	80.9	**984.7**
AEU8 Southern Laterites	Rubber		Present	104.7	107	127.5	121.5	93.1	89.6	87.9	97.8	99.8	94.3	86.4	90.4	**1200**
		4.5	2030	93.5	90.8	112.4	109.6	87.4	96.1	91.9	101.2	103	96.7	85.2	82.1	**1149.9**
			2050	93.5	91.5	113	110.7	87.4	97.3	93.6	101.8	103.7	96.8	86	82.9	**1158.2**
			2080	94.8	93	115.1	112.3	88.5	98.2	94.5	102.9	104.6	97.8	86.9	83.9	**1172.5**
		8.5	2030	92.7	90.5	112.2	110	86.9	96.7	93.1	101.1	103.1	96.2	85.6	82.2	**1150.3**
			2050	95	92.2	114.4	111.8	87.2	98.4	4.3	103.1	4.7	97.1	86.5	84.5	**979.2**
			2080	97.8	95.5	118.1	115.1	88.9	100.2	97.2	105.4	108.3	99.2	88.7	87.6	**1202**
	Coconut		Present	84.1	81.1	95.3	91.8	81.4	70.7	69.5	77.2	80.4	78.9	75.1	77	**962.5**
		4.5	2030	80	70.8	83.7	81.6	76.1	75.9	72.6	79.9	84.5	85.3	81.2	76.8	**948.4**
			2050	80.4	71.6	84.2	82.6	75.8	76.9	73.9	80.3	85.2	85.5	82.3	77.8	**956.5**
			2080	81.5	72.9	85.9	83.9	76.7	77.5	74.6	81.2	85.9	86.5	83.2	78.6	**968.4**
		8.5	2030	79.8	71.1	83.7	82.1	75.4	76.3	73.6	79.9	84.6	85	81.9	77.2	**950.6**
			2050	81.9	72.4	85.6	83.7	75.4	77.6	74.6	81.4	86	85.9	82.7	79.4	**966.6**
			2080	84.3	75	88.4	86.1	76.8	79.2	76.7	83.3	89	87.8	85.2	82.7	**994.5**

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Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU9 South Central Laterites	Rubber		Present	104.3	106.8	127.4	121.7	93.2	89.8	88.2	98	99.8	94.2	86.1	90.1	**1199.6**
		4.5	2030	92.1	92.7	113.7	109.5	90.7	94.4	91.2	101.6	100.6	96.2	84.1	83.5	**1150.3**
			2050	93	93.2	114	110.3	88.9	95	92.2	102.3	102.1	97.2	85.2	83.6	**1157**
			2080	94.3	94.5	115.4	111.5	90	95.9	93.1	103.2	103.2	98.1	86	84.5	**1169.7**
		8.5	2030	92.2	92.4	113.5	109.5	90.6	94.2	91.6	101.9	101.2	96.5	84.6	83.2	**1151.4**
			2050	94.8	94.2	114.7	111	89.1	98.4	93.1	102.7	103.8	98	86.1	84	**1169.9**
			2080	98.1	95.9	117.1	114.7	91.3	98.2	95.8	105.4	107.2	100.8	88.7	86.4	**1199.6**
	coconut		Present	83.9	80.9	95.2	91.8	81.7	71	69.5	77.3	80.4	78.7	74.8	76.8	**962**
		4.5	2030	78.8	72.4	84.7	81.5	79.1	74.5	72	80.3	82.6	84.8	80	78	**948.7**
			2050	79.5	72.7	84.9	82	77.3	75.1	72.8	80.8	83.8	85.6	81.1	78.3	**953.9**
			2080	80.7	73.8	86	83.1	78.3	75.7	73.4	81.5	84.6	86.5	82	79.1	**964.7**
		8.5	2030	79	72.3	84.5	81.6	78.9	74.4	72.2	80.5	83	85.1	80.5	77.9	**949.9**
			2050	81	73.3	85.3	82.5	77.6	77.7	73.5	81.1	85.2	86.4	82.1	78.6	**964.3**
			2080	83.9	74.4	86.7	84.9	79.5	77.6	75.7	83.2	88	89	84.9	80.9	**988.7**
AEU12 Southern And Central Foothills	Rubber		Present	104.5	106.8	127.5	121.7	93.2	89.8	88.1	97.8	99.8	94.2	86.3	90.2	**1199.9**
		4.5	2030	92.6	91.7	112.4	108.7	87.1	96.7	91.2	100.6	102.5	95.8	84.2	81.6	**1145.1**
			2050	94.3	91.6	113.3	110.1	88.1	96.9	92.1	101.5	103.5	97.1	85.2	80.5	**1154.2**
			2080	95.3	93.1	114.2	111.1	88.9	97.8	93.1	102.5	104.5	98	86	81.4	**1165.9**
		8.5	2030	93.6	91.1	112.1	108.8	87	96.5	91.6	100.7	103.2	96.4	84.6	81.9	**1147.5**
			2050	94.6	92.3	113.7	111.5	88.5	97.6	93.6	102.6	104.4	97.7	86.6	83.6	**1166.7**
			2080	99.1	94.8	117.2	115.1	90	100.5	96.2	105.3	107.4	99.9	89.3	88.1	**1202.9**
	Coconut+ pepper		Present	83.9	81	95.2	91.8	81.7	70.8	69.5	77.3	80.4	78.7	74.9	76.8	**962**
		4.5	2030	79.2	71.6	83.7	81.1	75.9	76.3	71.9	79.4	84.2	84.6	80.2	76.3	**944.4**
			2050	80.6	71.4	84.3	82.1	76.7	76.6	72.7	80.2	85	85.5	81	5.2	**881.3**
			2080	81.3	72.4	84.7	82.5	77.4	77.2	73.5	80.9	85.8	86.4	81.9	76.1	**960.1**
		8.5	2030	79.7	70.8	83.6	81.2	75.6	76.2	72.3	79.5	84.7	85	80.4	76.3	**954.3**
			2050	80.8	71.9	84.5	82.8	77.1	77.1	73.9	81.1	85.8	86.1	82.4	78.1	**961.6**
			2080	84.2	73.6	87.5	86	78.1	79.4	76	83.2	88.1	87.8	84.6	81.8	**990.3**

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Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU14 Southern High Hills	Coconut		Present	83.9	80.9	95.3	91.8	81.7	71	69.5	77.3	80.4	78.7	74.8	76.8	**962.1**
		4.5	2030	77.8	69	80.4	79.6	76	78.3	72.9	79.6	84.6	84.7	80	75.7	**938.6**
			2050	80.7	72	85.3	83.3	77.8	74.8	73.3	80.7	85.2	85.5	81.1	77.1	**956.8**
			2080	81.4	72.9	85.7	83.9	78.6	75.4	74	81.4	86.1	86.6	82	77.8	**965.8**
		8.5	2030	80	71.4	84.4	82.6	77.5	74.4	72.8	80.2	84.6	85.2	80.7	76.6	**950.4**
			2050	81.5	73	86.1	84.6	77.7	77.6	74.5	81	85.9	85.8	82.6	78.5	**968.8**
			2080	84.4	74.9	88.8	86.9	79	79.7	76.3	83.4	88.4	87.6	84.4	81.8	**995.6**
	Rubber		Present	104.4	106.8	127.5	121.7	93.2	89.8	88.2	98	99.8	94.2	86.1	90.1	**1199.8**
		4.5	2030	93.6	92.1	111.4	109.7	86.4	99.2	92.4	100.8	103.3	96.7	84.8	82.3	**1152.7**
			2050	94.4	92.1	114.3	111.7	89.1	94.7	92.8	102.1	103.9	97.4	85.6	82.9	**1161**
			2080	95.4	93.6	115.2	112.7	89.9	95.6	93.8	103.1	104.9	98.3	86.6	83.7	**1172.8**
		8.5	2030	93.6	91.2	113.3	110.9	88.7	94.2	92.2	101.5	103.1	96.8	85.2	82.3	**1153**
			2050	94.8	92.7	115.5	113.1	89.1	98.3	94.5	102.6	104.6	97.4	86.9	84	**1173.5**
			2080	98.4	95.5	118.8	116.3	90.9	100.9	96.6	105.5	107.7	99.4	88.8	7.4	**1126.2**

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Table 184. Water requirement of various cropping systems in different AEUs of Thiruvananthapuram district

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU1 Southern Coastal Plain	Rice-rice-fallow		Present	3.7	*	*	*	90.7	0	0	0.8	92.4	0	1.3	74	**262.9**
		4.5	2030	3.6	*	*	*	90.7	0	0	0.8	140.1	2.3	0	26.4	**263.9**
			2050	3.6	*	*	*	90.7	0	0	0.9	133.1	1.8	0	24	**254.1**
			2080	3.6	*	*	*	90.8	0	0	0.9	133.5	0.4	21.4	16.1	**266.7**
		8.5	2030	3.6	*	*	*	90.7	0	0	0.9	140.3	2.4	0	24	**261.9**
			2050	3.6	*	*	*	90.7	0	0	0.9	122.6	0	0	35.7	**253.5**
			2080	3.8	*	*	*	90.7	0	0	0.9	108	0.4	68.5	109	**381.3**
	Coconut		Present	64	38.9	41.9	0.3	5.3	0	0	0	0	0	0	36.9	**187.3**
		4.5	2030	23.7	70.8	64.6	33.8	0	0	0	0	80.7	0	0	2.7	**276.3**
			2050	52.3	35.9	64	33.4	0	0	0	0	74.1	0	0	4.4	**264.1**
			2080	57.4	49.2	63.2	33.5	0	0	0	0	74.8	0	0	1.3	**279.4**
		8.5	2030	24.9	69.5	55.2	27.9	0	0	0	0	81.1	0	0	2.2	**260.8**
			2050	56.9	42.2	63.5	32.3	5.2	0	0	0	52.2	0	0	7	**259.3**
			2080	72.3	69.9	62.4	33.7	0	0	0	0	16.2	0	30.7	74.3	**359.5**
AEU8 Southern Laterites	Rubber		Present	104.6	85.9	98	22.2	0	1.3	67.1	16.9	82.2	0	0.4	82.4	**561**
		4.5	2030	81	86.3	86.2	73.7	11.3	0	0	0	7.5	0	2	56.7	**404.7**
			2050	50.2	69.8	86.9	71.3	11.9	0	7.3	0	3.3	0	9.3	53.3	**363.3**
			2080	48.9	87.7	76	34.7	12.6	0	0	0	5.9	0	0	29.4	**295.2**
		8.5	2030	48.7	76.9	85.3	59.8	20.7	0	16.9	0	5.4	0	10.7	52.6	**377**
			2050	47.7	84.6	77.7	38.1	6.6	0	0	0	11.2	0.8	0	46.7	**313.4**
			2080	80.9	74.6	108.6	82	38.2	0	0	0	0	0	0	79	**463.3**
	Coconut		Present	83.9	59.9	65.7	5	0	0	48.6	3.8	62.9	0	0	69	**398.8**
		4.5	2030	67.7	66.2	57.5	45.7	0.5	0	0	0	0.2	0	1.4	51.4	**290.6**
			2050	37	49.8	58.3	43.1	0.6	0	0	0	0	0	7.5	48.1	**244.4**
			2080	35.6	67.5	46.8	7.3	0	0	0	0	0	0	0	24.2	**181.4**
		8.5	2030	35.4	57.3	56.8	31.7	3.2	0	5.6	0	0	0	9	47.7	**246.7**
			2050	34.6	64.9	48.8	10.7	0	0	0	0	0.7	0	0	41.7	**201.4**
			2080	67.5	54.2	79	53	15.9	0	0	0	0	0	0	74.1	**343.7**

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU9 South Central Laterites	Rubber		Present	104.2	104.9	126.3	35.7	0	0	0	0	0	0	22.2	3.6	**396.9**
		4.5	2030	75.6	77.5	96.2	89.2	76.4	83.6	83.8	86.9	80	81.5	67.8	70.4	**968.9**
			2050	77.5	77.9	95.7	90.8	74.1	83.9	85.5	87.9	80.3	83.8	68.2	70.1	**975.7**
			2080	78	78.6	97.8	92.8	74.9	85	86.1	88.6	81.4	84.8	69.4	70.5	**987.9**
		8.5	2030	78.3	80.9	88.7	58.1	3	0	0	0	32.4	0	1.7	34.3	**377.4**
			2050	81.1	83.6	94.5	38	20.5	0	0	0	9.6	0	1.4	35.6	**364.3**
			2080	86.6	90.8	59.7	33.2	7.5	0	0	0	0	0	0.3	82	**360.1**
	coconut		Present	83.8	79.1	94.1	11.1	0	0	0	0	0	0	13.4	0	**281.5**
		4.5	2030	62.4	57.2	67.1	61.2	62.2	63.6	64.7	65.6	62	70.1	63.7	64.8	**764.6**
			2050	64	57.4	66.6	62.6	60	63.8	66.1	66.4	62	72.3	64.1	64.7	**770**
			2080	64.6	57.8	68.3	64.2	60.5	64.8	66.5	66.9	63	73.2	65.2	65	**780**
		8.5	2030	65.1	60.7	59.9	30.1	0	0	0	0	14.8	0	1	28.9	**260.5**
			2050	67.3	62.7	65.1	9.7	1.5	0	0	0	2.1	0	0.7	30.1	**239.2**
			2080	72.3	69.4	29.2	5.4	0	0	0	0	0	0	0	76.4	**252.7**
AEU12 Southern And Central Foothills	Rubber		Present	88	59.4	54.4	0	0	0	0	0	0	0	0	46.3	**248.1**
		4.5	2030	78.9	81.3	93.5	40.8	40.1	0	0	0	11.7	0	3.9	46.7	**396.9**
			2050	81.6	81.1	94.6	40.4	45.3	0	0	0	1.9	0	0	44.9	**389.8**
			2080	78.5	58.6	96	81.4	33.6	0	0	0	15.8	0	0	30.4	**394.3**
		8.5	2030	80.4	81.2	93.1	40.6	40.7	0	0	0	11.6	0	0	37.4	**385**
			2050	71.3	59.8	78.2	73.1	19.7	0	0	0	33.7	0	13.2	72.6	**421.6**
			2080	92.1	65.7	77.1	69.4	31.8	0	0	0	0	18.8	0	74.2	**429.1**
	Coconut+ pepper		Present	67.6	33.5	22.1	0	0	0	0	0	0	0	0	32.9	**156.1**
		4.5	2030	65.5	61.1	65	13.1	17.9	0	0	0	3.4	0	3.2	41.4	**270.6**
			2050	67.9	60.9	65.6	12.2	22.2	0	0	0	0	0	0	39.6	**268.4**
			2080	64.5	37.9	65.5	52.8	13.8	0	0	0	4.7	0	0	24.9	**264.1**
		8.5	2030	66.6	61	64.7	12.9	18.3	0	0	0	2.8	0	0	31.7	**258**
			2050	57.5	39.2	48.8	44.4	3.6	0	0	0	15.1	0	11.2	67.2	**287**
			2080	77.2	44.4	47.4	40.2	11	0	0	0	0	7.3	0	67.9	**295.4**

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU14 Southern High Hills	Coconut		Present	82.7	59.6	42.1	34.1	0	0	0	0	0	0	0	42.4	**260.9**
		4.5	2030	63.8	58.4	54.3	10.2	19.5	0	0	0	2.8	0	0	39.8	**248.8**
			2050	66.9	60.8	57.1	14	21.7	0	0	0	0	0	0	38.6	**259.1**
			2080	64.5	37.5	44.1	54	13.8	0	0	0	0	0	24.4	25.6	**263.9**
		8.5	2030	66	61.1	56.2	15.3	23.1	0	0	0	0	0	0	38.1	**259.8**
			2050	60.6	62.7	46.3	33.2	10.3	0	0	0	0	0	4.7	47.6	**265.4**
			2080	60.3	38.2	64.9	66.7	24.1	0	0	0	6.3	27.4	0	65.6	**353.5**
	Rubber		Present	103.3	85.4	74.4	63.7	0	0	0	0	0	0	0	55.7	**382.5**
		4.5	2030	79.6	81.4	85.3	40.4	41.4	0	0	0	11.7	0	0	46.3	**386.1**
			2050	80.7	81	86.1	42.4	45.1	0	0	0	0.6	0	0	44.3	**380.2**
			2080	78.3	58.1	73.6	82.8	33.9	0	0	0	2	0	29	31.3	**389**
		8.5	2030	79.6	80.8	84.9	43.4	46.7	0	0	0	2.4	0	0	43.9	**381.7**
			2050	73.8	82.4	75.2	61.7	30.7	0	1.4	0	0	0	6.1	53.2	**384.5**
			2080	74.3	58.8	94.9	96.1	48	0	0	0	18.5	39.1	0	71.3	**501**

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

The ET_c values of various cropping systems for AEU1, AEU3, AEU9, AEU12 and AEU14 of Kollam district were studied and presented in table 185.

Rice-rice-fallow and coconut + banana are the major cropping systems of AEU1. In rice-rice-vegetable cropping system the first season virippu is having a duration of four months (May to August) were the transplanting is done around first week of June and harvested during last week of August. The second crop mundakan is having a duration of six months (August to January) transplanted during last season of September and harvested in first week of January. Since, coconut is a perennial crop, the ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend in case of rice-rice-fallow in 2030s, 2050s and 2080s. The ET_c value of coconut + banana shows a decreasing trend from the present value except in 2030 of RCP 8.5.

Rice-rice-sesame and coconut monocropping are the major cropping systems in AEU3. In rice-rice-sesame the first cropping season virippu with a duration of four months (May to August) were the transplanting date is around first week of June and harvested in last week of August, the second crop mundakan is having a crop duration of six months (August to January) transplanted during last week of September and harvested during first week of January. The third crop sesame is planted during first week of February and harvested during first week of May. Since, coconut is a perennial crop, the ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show a decreasing trend in both cases of rice-rice-sesame and coconut.

Rice-rice-fallow and coconut were found to be the major cropping systems of AEU9. In rice-rice-fallow the first season virippu is having a duration of four months (May to August) the transplanting date is around first week of June and harvested during last week of August. The second crop mundakan is having a duration of six months (August to January) the transplanting during last week of September and harvested in first week of January. While comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend in rice-rice-sesame and a decreasing trend in coconut from the present value.

Rubber monocropping and coconut + pepper are the major cropping systems of AEU12. Since, rubber and pepper + coconut are perennial crop the ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show a decrease in both cases of rubber and coconut + pepper except in 2080 of RCP 8.5 of coconut+ pepper.

Rubber monocropping and rice-rice-fallow are the major cropping systems in AEU14. The rubber is a perennial crop the ET_c value for a year is considered. In rice-rice-fallow the first season virippu is having 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 a duration of six months (August to January) transplanted during last week of September and harvested during first week of January. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the rubber and rice-rice-fallow will show a decreasing trend from the present value.

The water requirement for various cropping systems of AEU1, AEU3, AEU9, AEU12 and AEU14 of Kollam district were studied and presented in table 186.

Presently, the annual water requirement of rice-rice-fallow and coconut + banana is 272.6 and 289.4 mm respectively in AEU1. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both rice-rice-fallow and coconut + banana will show an increasing trend except in case of rice-rice-fallow of RCP 8.5 in 2080s. Currently for rice-rice-fallow, the irrigation is not required for three months May, July and October and for coconut + banana irrigation is not required for six months (June to November). When comparing the present and future climate of rice-rice-fallow and coconut + banana of both RCP 4.5 and RCP 8.5 the irrigation is not required for two months in case of rice-rice-fallow and five months in case of coconut + banana.

Presently, the annual water requirement of rice-rice-sesame and coconut monocropping is 649.4 and 328.7 mm respectively in AEU3. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both rice-rice-sesame and coconut will show an increasing trend except in the case of 2050 of

RCP 8.5. In rice-rice-sesame except June all other months requires irrigation in present condition and in projection June and July months does not require irrigation. In coconut, annually six months (June to November) does not require irrigation under the present condition and in most cases of projection there will be a decrease to five months (May to August and October).

Presently, the annual water requirement of rice-rice-fallow and coconut is 291.3 and 388.2 mm respectively in AEU9. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 of rice-rice-fallow and coconut, the annual water requirement will show an increasing trend except in the case of 2080 of RCP 4.5 and 2030 of RCP 8.5 in rice-rice-fallow. In coconut there will be decreasing trend except in the case of 2050 of RCP 8.5. There is not much variation in the number of rainy days in rice-rice-fallow but in the case of coconut, irrigation is not required for five months in present situation and in most cases the projection will show an increase to six months.

Presently, the annual water requirement of rubber and coconut + pepper is 369.3 and 245.5 mm respectively in AEU12. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both rubber and coconut + pepper will show an increasing trend. Currently for rubber, the irrigation is not required six months (May to October) and in projected climate it will decrease to three up to four months. In case of coconut + pepper eight months (April to November) does not require irrigation in present situation and the climate projection shows a decrease to five months.

Presently, the annual water requirement of rubber and rice-rice-fallow is 560.6 and 388.2 mm respectively in AEU14. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both rubber and rice-rice-fallow will show an increasing trend. According to the present condition for rubber, the irrigation is not required for four months (June to August and October) and it will decrease to one month. In rice-rice-fallow throughout the cropping season irrigation will be required in present and projected climate of both RCP 4.5 and RCP 8.5.

The rice-rice-sesame of AEU3, rubber of AEU12, rubber and rice-rice-fallow of AEU14 is having high water requirement within the district.

Table 185. ET_c values of various cropping systems in different AEUs of Kollam district

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
				Crop evapotranspiration ET_c (mm)												
AEU1 Southern Coastal Plain	Rice-rice fallow		Present	4.6	*	*	*	8.5	111.2	132	126	52.7	133.6	131.8	144.2	**844.6**
		4.5	2030	4.2	*	*	*	22.5	136.4	131.9	99.4	53.3	139.6	126.1	137.3	**850.7**
			2050	4.3	*	*	*	22.7	137.7	133.3	100.3	53.7	140.6	130	138.2	**860.8**
			2080	4.3	*	*	*	23	139.3	134.9	101.3	54.3	142.1	128.7	139.7	**867.6**
		8.5	2030	4.2	*	*	*	22.5	136.4	131.9	99.4	53.3	139.6	126.1	137.3	**850.7**
			2050	4.3	*	*	*	23	138.9	134.2	101.3	54.3	142	131.5	139.2	**868.7**
			2080	4.5	*	*	*	23.5	143.9	139.7	103.9	56.7	145.8	137.7	142	**897.7**
	Coconut +banana		Present	105	105.8	122.9	112.9	96.6	88.3	86.6	88.1	89	90.9	85.7	97.5	**1169.3**
		4.5	2030	89.5	87.1	101.9	95.6	94.2	93.1	88.9	92.7	89.5	95	83	90.5	**1101**
			2050	90.1	87.6	103	96.2	92	93.8	89.8	93.2	90.1	95.7	85.7	91.1	**1108.3**
			2080	91.5	89.2	104.1	97.5	93.1	95	91	94.3	91.1	96.7	84.9	92.3	**1120.7**
		8.5	2030	89.7	87.1	101.9	95.7	91.2	93.1	88.9	92.7	89.5	95	83.1	90.5	**1098.4**
			2050	91.1	88.4	103.6	97	92.8	94.8	90.7	94.3	91.3	96.7	86.9	91.9	**1119.5**
			2080	97.8	91.4	104.6	98.7	95.4	98	94.3	96.8	95.6	99.3	92	96.7	**1160.6**
AEU3 Onattukara Sandy Plain	Rice-Rice-sesame		Present	4.8	57.5	174.9	134.9	25.6	165.6	185.8	138.1	67.4	168.3	163.2	156.4	**1442.5**
		4.5	2030	4.3	53.8	158	123.8	26.5	165.2	166.8	126	63.5	163.3	146.6	140.7	**1338.5**
			2050	4.4	54.4	160.3	125.4	26.7	167.2	170	127.2	64	164.7	146.8	141.1	**1352.2**
			2080	4.4	55.2	162.1	126.9	27.1	169.2	172.2	128.6	64.8	166.6	147.2	142.4	**1366.7**
		8.5	2030	4.4	53.8	158.1	124.1	26.5	165.6	167.6	126.4	63.6	163.7	146.8	141.1	**1341.7**
			2050	4.4	54.8	162.1	126.6	27	169.2	172.2	128.4	64.2	166.1	150.1	142.9	**1368**
			2080	4.6	56.7	166.8	130.2	27.8	175.2	177.8	132.1	67.5	171.2	157.3	146.9	**1414.1**
	Coconut		Present	109.6	107	127.9	119.7	109.9	112.7	119.3	121.2	115	114.3	104.1	104.8	**1365.5**
		4.5	2030	93.8	87.2	102.7	98.5	100.5	112.6	112.5	117	107.6	111.1	97.8	95.4	**1236.7**
			2050	95	88.3	104.3	99.8	101.1	75.5	114.7	117.9	108.5	112.2	98.3	96.1	**1211.7**
			2080	96.1	89.4	105.2	100.7	102.6	115.3	116	119.2	109.9	113.5	99	97.1	**1264**
		8.5	2030	94.1	87.2	102.6	98.6	100.4	112.9	113	117.3	107.9	111.4	97.9	95.7	**1239**
			2050	95.9	88.9	105.5	100.7	102.6	115.3	116.1	119.1	108.9	113.2	100.2	97.2	**1263.6**
			2080	99.3	91.3	107.8	103.1	105.9	119.5	120.1	122.5	114.7	116.6	105	99.7	**1305.5**

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Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU9 South Central Laterites	Rice-rice-fallow		Present	4.6	*	*	*	21.5	129.7	130.3	95.9	52.7	133.6	131.7	144.1	**844.1**
		4.5	2030	4.2	*	*	*	22.6	137.4	134.6	100.6	53.3	139.7	126.2	137	**855.6**
			2050	4.3	*	*	*	22.8	138.8	134.7	101.2	53.8	141	130.4	138	**865**
			2080	4.3	*	*	*	23.1	140.6	136.1	102.3	54.6	142.5	132.1	139.5	**875.1**
		8.5	2030	4.2	*	*	*	22.6	137.7	133.7	100.7	53.6	139.9	129.3	136.8	**858.5**
			2050	4.3	*	*	*	23.1	140.3	135.8	102.2	54.7	142.1	132.9	138.9	**874.3**
			2080	4.5	*	*	*	23.6	145	141.5	104.9	56.9	146.4	138	141.9	**902.7**
	Coconut		Present	105.2	105.7	122.9	112.9	96.8	88.3	86.6	88.1	89	90.8	85.7	97.5	**1169.5**
		4.5	2030	92.7	88.8	102.3	96.5	92.7	93.6	90.1	93.2	89.6	95.2	84.1	93.2	**1112**
			2050	93.6	89.4	103.6	97.2	93.5	94.5	90.7	94	90.5	96	87	94	**1124**
			2080	94.8	90.9	104.8	98.5	95	95.8	91.8	95	91.9	97	88.4	95.1	**1139**
		8.5	2030	92.7	88.5	102.4	96.4	93.2	93.9	90	93.4	90	95.3	86.2	93.3	**1115.3**
			2050	94.8	90.2	104.1	97.9	94.6	95.7	91.6	94.8	92	96.9	88.8	94.7	**1136.1**
			2080	98.7	92.6	106.4	100.3	96.4	98.8	95.3	97.4	95.9	99.6	92.2	96.7	**1170.3**
AEU12 Southern And Central Foothills	Rubber		Present	132.4	133.9	154.8	142.8	108	112.1	109.7	111.7	112.5	114	107.1	122.3	**1461.3**
		4.5	2030	113.9	115.3	136.1	128	105.2	119.9	114.3	118.8	113.2	114.3	99.6	108.6	**1387.2**
			2050	114.2	115.9	136.8	128.8	114.4	121.5	115.9	118.5	112	111.2	99	107.9	**1396.1**
			2080	116.8	117.8	138.8	130.4	107	123	117.4	120.8	116.3	116.1	102.4	110.1	**1416.9**
		8.5	2030	114	115	136	128.2	105.4	120.2	114.8	119.1	113.8	114.5	100.3	108.3	**1389.6**
			2050	117.5	116.9	137.9	130.1	106.2	122.6	117.7	120.9	117.1	116.2	102.7	108.9	**1414.7**
			2080	122.1	120.6	141.8	134.2	108.1	127.3	121.6	123.5	121.6	119.2	105.9	111.4	**1457.3**
	Coconut +pepper		Present	104.2	104.3	120.7	112.2	97.6	88.4	86.6	88.1	89	90.8	85.8	97.4	**1165.1**
		4.5	2030	92.9	89.6	103.8	97.7	94.8	94.6	90.3	93.7	91.3	95.8	86.9	93.4	**1124.8**
			2050	91.5	89	104.8	98.4	94.3	96	91.4	94.5	92.8	96.4	87.5	91	**1127.6**
			2080	95.6	91.5	105.8	99.4	96.8	97	92.6	95.4	93.8	97.5	89.5	94.9	**1149.8**
		8.5	2030	93.4	89.6	103.8	97.9	95.1	94.9	90.6	94.1	91.8	96	87.5	93.3	**1128**
			2050	95.8	90.4	104.6	98.9	95.9	96.7	93	95.4	94.4	97.5	89.7	93.6	**1145.9**
			2080	99.9	93.3	107.6	102	97.3	100.6	96	97.5	98.2	100.4	93	96.4	**1182.2**

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
				Crop evapotranspiration ET_c (mm)												
AEU14 Southern High Hills	Rubber		Present	138	134.9	160.7	151.1	121	142.7	150.7	153.5	145.1	143.1	130.1	131.4	**1702.3**
		4.5	2030	116.1	112.9	137.3	132.6	112.9	145.7	146.6	149	138.7	132	114.6	104.5	**1542.9**
			2050	117.8	114.1	138.6	134.4	123.8	148	148.1	148.1	137.7	129.5	113.1	104.2	**1557.4**
			2080	119.7	114.6	139.1	135.3	114.6	149.7	148.9	151.1	142.9	134.4	116.6	105.8	**1572.7**
		8.5	2030	117.6	113.2	136.9	132.9	112.5	146.9	147.1	148.8	140.4	132.3	114.8	103.9	**1547.3**
			2050	120.9	114.1	139.6	135.8	114.9	148.8	150.4	151.4	143.3	135.2	117.3	106.2	**1577.9**
			2080	123.3	117.4	143.7	140.6	116.9	155.1	156.8	155.8	147.2	137.5	121.2	109.8	**1625.3**
	Rice-rice-fallow		Present	4.8	*	*	*	24.3	165.6	185.2	138.1	67.3	167.9	163.2	156.4	**1072.8**
		4.5	2030	4.2	*	*	*	25.1	168.8	171.9	127.3	65.5	162.3	150.7	131.9	**1007.7**
			2050	4.3	*	*	*	25.3	171.4	173.6	127.5	66.7	164.2	152.1	132.3	**1017.4**
			2080	4.4	*	*	*	25.5	173.5	173.9	128.9	67.5	165.7	153.6	133.8	**1026.8**
		8.5	2030	4.3	*	*	*	25.1	170.1	172.7	127	66.3	162.7	150.8	130.8	**1009.8**
			2050	4.4	*	*	*	25.5	172.5	176.6	129	67.6	166.3	153.7	133.5	**1029.1**
			2080	4.5	*	*	*	26.1	179.7	184.6	132.9	69.4	169.8	159.8	138.8	**1065.6**

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Table 186. Water requirement of various cropping systems in different AEUs of Kollam district

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
AEU1 Southern Coastal Plain	Rice-rice fallow		Present	4.6	*	*	*	0	74.7	0	0.9	76.7	0	9.4	106.3	**272.6**
		4.5	2030	4.2	*	*	*	74.8	0	0	1	118	3.3	24.9	73.1	**299.3**
			2050	4.3	*	*	*	74.8	0	0	1	119.3	5.4	9.1	97.9	**311.8**
			2080	4.3	*	*	*	74.8	0	0	1	98.9	2.8	7.9	99.4	**289.1**
		8.5	2030	4.2	*	*	*	74.8	0	0	1	118.2	3.1	23.6	68.8	**293.7**
			2050	4.3	*	*	*	74.8	0	0	1	98.1	2.4	4.8	54.5	**239.9**
			2080	4.5	*	*	*	74.8	0	0	1	87.7	4.6	90.3	125.2	**388.1**
	Coconut +banana		Present	87	63.8	67.7	8.1	3.1	0	0	0	0	0	0	59.7	**289.4**
		4.5	2030	51.3	86.8	62	16.9	3	0	0	0	74.5	0	0	26.3	**320.8**
			2050	53.3	86.1	73.5	36.1	6	0	0	0	76.4	0	0	50.9	**382.3**
			2080	77.5	87.9	57.9	19.8	6	6	6	6	35.1	0	0	52	**354.2**
		8.5	2030	58.7	86.3	75.5	25.4	5.9	0	0	0	74.8	0	0	22.2	**348.8**
			2050	60.2	87.4	74.2	32.8	6	0	0	0	32.3	0	0	11.5	**304.4**
			2080	87.2	86.8	73.8	50	0	0	0	0	5.2	0	44.7	80	**427.7**
AEU3 Onatukara Sandy Plain	Rice-Rice-sesame		Present	4.8	26.7	133	41.8	127.3	0	12.2	9.4	135.8	10.2	36.2	112	**649.4**
		4.5	2030	4.3	53.3	125.9	67.4	127.4	0	0	1.2	154.6	15.6	133	117.6	**800.3**
			2050	4.4	53.3	133.9	72.4	127.4	0	0	1.2	149.1	13.3	54	77.5	**686.5**
			2080	4.4	54.2	133.9	73.6	127.5	0	0	1.2	150.5	14.2	54.8	73.5	**687.8**
		8.5	2030	4.4	53	132.5	60.2	127.4	0	0	1.2	149	12.8	134.4	80.9	**755.8**
			2050	4.4	53.7	116.4	61.5	127.5	0	0	1.2	150	15.1	15.9	56	**601.7**
			2080	4.6	36.9	138.8	77.4	127.6	0	1.2	1.3	144.2	19.3	109.2	83.5	**744**
	Coconut		Present	89.1	76.2	85.9	13.4	3.6	0	0	0	0	0	0	60.5	**328.7**
		4.5	2030	56.6	86.7	70.6	38.1	0	0	0	0	32.4	0	84.1	72.2	**440.7**
			2050	66.6	87.2	77.7	44.2	0	0	0	0	10.8	0	8.5	32.5	**327.5**
			2080	67.1	88.2	77.1	45.3	0	0	0	0	13.7	0	9	28.2	**328.6**
		8.5	2030	61.9	86.4	77	26.8	0	0	0	0	13.6	0	85.6	35.5	**386.8**
			2050	58.8	87.8	59.8	30.2	0	0	0	0	11.9	0	0	12.6	**261.1**
			2080	84.7	71.5	80	50.2	0	0	0	0	0	0	56.9	36.3	**379.6**

water requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU9 South Central Laterites	Rice-rice-fallow		Present	4.6	*	*	*	90.5	0	0	0.9	92.7	1.3	67.9	33.4	**291.3**
		4.5	2030	4.2	*	*	*	90.6	0	0	1	134	3.1	25.5	73.7	**332.1**
			2050	4.3	*	*	*	90.6	0	0	1	135.4	5.5	6	53.9	**296.7**
			2080	4.3	*	*	*	90.6	0	0	1	114.3	2.6	5.1	49.9	**267.8**
		8.5	2030	4.2	*	*	*	90.6	0	0	1	114.4	2.2	4.5	51	**267.9**
			2050	4.3	*	*	*	90.6	0	0	1	113.9	4.5	86.4	118.8	**419.5**
			2080	4.5	*	*	*	90.7	0	0	1	103.5	4.8	91.3	83.3	**379.1**
	Coconut		Present	105	103.9	121.7	26.9	3.1	0	0	0	0	0	21.7	5.9	**388.2**
		4.5	2030	64.6	87.6	74.2	23.8	0	0	0	0	74.3	0	0	29.7	**354.2**
			2050	65.8	87.9	70.7	33.8	0	0	0	0	76.6	0	0	13.2	**348**
			2080	58.2	89.7	47.3	16.7	0	0	0	0	32.4	0	0	9.9	**254.2**
		8.5	2030	64.5	87.1	72.8	25.6	0	0	0	0	34.4	0	0	11.6	**296**
			2050	59.5	87.5	71.6	31.4	0.7	0	0	0	32	0	42.3	74.5	**399.5**
			2080	84.2	72.4	72.8	48.5	0	0	0	0	4.7	0	45.4	38.1	**366.1**
AEU12 Southern And Central Foothills	Rubber		Present	116.1	86.5	81.8	6.6	0	0	0	0	0	0	0	78.3	**369.3**
		4.5	2030	86.6	113.8	110.4	84.5	2.9	0	0	0	112.9	0.1	0.6	45.5	**557.3**
			2050	110	101.1	110.5	84	1.6	0	0	0	102	0	1.4	43.8	**554.4**
			2080	112	104.9	105.2	74.4	15.1	0	0	0	106.2	0	0.9	39.8	**558.5**
		8.5	2030	76.9	109.2	89.6	106.2	10.2	0	0	0	113.4	0	1.7	43.2	**550.4**
			2050	110.1	103.9	104.5	73.6	19.4	0	0	0	75	0	1.4	47.4	**535.5**
			2080	112.9	97.8	96	82.5	8.1	0	0	0	52.2	0	0	46.8	**496.3**
	Coconut +pepper		Present	87.8	56.7	47.5	0	0	0	0	0	0	0	0	53.5	**245.5**
		4.5	2030	65.8	88.1	78.1	54.3	0	0	0	0	91	0	0	30.3	**407.6**
			2050	87.2	74.2	78.6	53.7	7.6	0	0	0	82.9	0	0	27	**411.2**
			2080	90.8	78.6	72.3	43.4	0.7	0	0	0	83.8	0	0	24.8	**394.4**
		8.5	2030	56.2	83.7	57.4	5.5	0.4	0	0	0	91.6	0	0	28.1	**322.9**
			2050	88.3	77.4	71.2	42.4	2	0	0	0	52.6	0	0	32.3	**366.2**
			2080	90.7	70.4	61.9	50.3	0	0	0	0	28.9	0	0	31.7	**333.9**

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU14 Southern High Hills	Rubber		Present	136.8	113.6	107.8	93.4	5.5	0	0	0	0.8	0	5.7	97	**560.6**
		4.5	2030	110	73.2	97.7	67.3	41.2	0.1	0	9.3	78	5.8	98.6	79.1	**660.3**
			2050	108.2	73.4	100.7	5.7	42.8	0.5	0	7	58.7	4.3	94.2	82.3	**577.8**
			2080	110.3	74.6	89.3	65.6	51.7	1.7	0	9.2	63.9	5.1	96.8	82	**650.2**
		8.5	2030	107.5	75	97.7	65.9	49.4	0.2	0.3	9.4	65.7	5.6	96	82	**654.7**
			2050	115.1	80.9	91.7	68.3	83.6	0.8	1.8	6.9	52.1	3	49.7	54.4	**608.3**
			2080	103.3	86.2	90.7	96.1	51.9	1	2.7	5.5	11.9	29.7	4.5	83.3	**566.8**
	Rice-rice-fallow		Present	4.8	*	*	*	89.7	9.7	25.3	1.2	100.3	9.6	25.5	122.1	**388.2**
		4.5	2030	4.2	*	*	*	89.8	7.8	10.7	1.2	124.3	25.9	134.6	106.4	**504.9**
			2050	4.3	*	*	*	89.8	8.3	14	1.2	120	24.4	133.2	110.5	**505.7**
			2080	4.4	*	*	*	89.8	9.6	11.8	1.6	120.4	23.7	134	110	**505.3**
		8.5	2030	4.3	*	*	*	89.8	7.9	14.1	2.1	120.7	24.5	132.1	109	**504.5**
			2050	4.4	*	*	*	89.8	8.6	20.3	1.9	117.4	23.2	86.2	81.8	**433.6**
			2080	4.5	*	*	*	89.9	9.9	24	7.1	109.2	61.9	36.1	112.3	**454.9**

4.4.3 Water requirement of major cropping systems of various AEUs in Pathanamthitta district and impact of projected climate change

The ET_c values of various cropping systems for AEU4, AEU9, AEU12 and AEU14 of Pathanamthitta district were studied and presented in table 187.

Rice-fallow and coconut monocropping are the major cropping systems in AEU4. In rice-fallow, the first cropping season virippu is having a duration of four months (May to August) transplanted during first week of June and harvested during last week of August. 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 the present value in case of rice and coconut except in the case of 2030s in coconut.

Coconut and rubber were found to be the major cropping systems in AEU9. Since coconut and rubber 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 except in the case of 2080s in both cropping systems of coconut and rubber.

Coconut and rubber are the major cropping systems of AEU12. Since coconut 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 will show a decreasing trend in 2030s and 2050 of RCP 4.5 remaining cases will show an increasing trend and in rubber the ETc values will show a decreasing trend except in the case of 2080 OF RCP 8.5.

Rubber and coconut + pepper + banana were found to be the major cropping systems of AEU14. When comparing the present and the projected climate of both rubber and coconut+pepper+banana of RCP 4.5 and RCP 8.5 will show a decreasing trend except in the case of 2080 OF RCP 8.5.

The water requirement for various cropping systems of AEU4, AEU9, AEU12 and AEU14 of Pathanamthitta district were studied and presented in table 188.

Presently, the annual water requirement of rice-fallow and coconut monocropping is 97.8 and 296.1 mm respectively in AEU4. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual water requirement of both rice-fallow and coconut of projected climate will show an increasing trend from the present value except 2080 of RCP 4.5 and 2050 of RCP 8.5 and irrigation is not required during the whole virippu season in case of rice-fallow and in coconut, annually six months (June to November) does not require irrigation under the present condition and the projection will show a decrease to five up to six months.

Presently, the annual water requirement of coconut and rubber monocropping is 356.6 and 499.4 mm respectively in AEU9. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 of coconut, the annual water requirement of projected climate will show an increasing trend except 2050s and 2030 of RCP 8.5. In case of rubber, the ETc value will show a decreasing trend in the case of 2050s and 2080 of RCP 8.5. Under the present situation coconut and rubber does not require irrigation for five months (June to October) and it will decrease to four up to five months under the projected climate.

Presently, the annual water requirement of coconut and rubber monocropping is 222.8 and 328.8 mm respectively in AEU12. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both coconut and rubber of projected climate will show an increasing trend from the present value. Under the present situation for coconut, the irrigation is not required for seven months (April and June to November) and in projected climate it decrease to four up to five months. In rubber six months (June to November) does not require irrigation under present situation and the climate projection will show a decrease to four up to five months.

Presently, the annual water requirement rubber monocropping and coconut + pepper + banana is of 467.4 and 335.6 mm respectively in AEU12.When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both rubber and coconut + pepper + banana of projected climate will show an increasing trend from the present value. Under the present situation for rubber and coconut + pepper + banana, the irrigation is not required for six months (June to November) and in projected climate it decrease to four to five months.

Rubber of AEU9, AEU12 and AEU14 is having high water requirement within the district.

Table 187. ETc value of various cropping systems in different AEUs of Pathanamthitta district

Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU4 Kuttanad	Rice-fallow		Present	*	*	*	*	22.1	143.2	143.8	105.2	*	*	*	*	**414.3**
		4.5	2030	*	*	*	*	23.5	150.2	144	106.2	*	*	*	*	**423.9**
			2050	*	*	*	*	23.7	151.7	145.6	107.3	*	*	*	*	**428.3**
			2080	*	*	*	*	24	153.6	147.3	108.4	*	*	*	*	**433.3**
		8.5	2030	*	*	*	*	23.5	150.5	144.4	106.4	*	*	*	*	**424.8**
			2050	*	*	*	*	24	153.6	147	108.4	*	*	*	*	**433**
			2080	*	*	*	*	24.7	159	152	111.2	*	*	*	*	**446.9**
	Coconut		Present	100.2	94.4	109	104.1	73	97.5	94.7	96.6	98.2	95.8	88.7	91.3	**1143.5**
		4.5	2030	91	84.1	99.2	96.1	98	102.4	96.8	99.5	93.5	97.4	88.3	90.3	**1136.6**
			2050	91.7	84.6	99.8	96.7	98.5	103.3	97.8	100.5	94.4	98.4	89.3	91.2	**1146.2**
			2080	92.8	85.8	101.1	97.8	100.1	104.6	99.2	101.5	95.7	99.5	90.5	92.1	**1160.7**
		8.5	2030	90.9	84.1	99.2	96.2	98.1	102.6	97.1	99.8	93.8	97.7	88.6	90.6	**1138.7**
			2050	92.4	85.1	100.8	97.4	100.1	104.6	99.1	101.5	95.8	99.3	90.8	91.8	**1158.7**
			2080	95.4	87.3	103.1	100	102.8	108.3	102.6	104.3	99.9	102.3	94.7	94.3	**1195**
AEU9 South Central Laterites	Coconut		Present	101.1	95.4	109.4	104.3	98.3	97.3	94.3	96.6	98.2	96	90.2	94.6	**1175.7**
		4.5	2030	90.6	84.6	100.1	96.8	98.8	102.9	97.1	100.1	94.5	97.9	88.9	90.1	**1142.4**
			2050	91.3	85.4	100.8	97.4	99.6	104.1	98	100.9	95.5	98.6	89.9	90.6	**1152.1**
			2080	92.8	86.8	102.2	98.9	101.1	105.2	99.1	102	96.6	99.8	91	91.8	**1167.3**
		8.5	2030	90.9	84.9	100.1	96.8	99	103	97.4	100.4	94.6	98.1	88.9	90.3	**1144.4**
			2050	92.6	86.2	101.4	98.1	100.6	105.3	99.2	102.1	96.8	99.7	91.5	91.3	**1164.8**
			2080	95.9	88.1	103.3	100.6	103.3	108.8	103	104.9	101	102.7	94.9	93.1	**1199.6**
	Rubber		Present	127.6	121.5	139.4	133.7	111.6	123.4	119.4	122	122.5	118.2	110.5	117.6	**1467.4**
		4.5	2030	114.1	110.2	130.3	126.5	116.7	130.4	123	125.5	114.2	113.7	101.8	107.9	**1414.3**
			2050	114.9	111.1	131.3	127.3	117.7	131.8	124.1	126.6	115.3	114.3	102.6	108.3	**1425.3**
			2080	116.7	112.9	133.2	129.3	119.4	133.3	125.5	127.9	116.7	115.7	103.8	109.7	**1444.1**
		8.5	2030	114.4	110.4	130.3	126.7	116.9	130.4	123.3	125.8	114.5	114	101.9	108.1	**1416.7**
			2050	116.6	112.3	132.2	128.4	119.1	133.3	125.7	128.1	117	115.5	104.4	109.2	**1441.8**
			2080	121.2	155.5	135.5	132	122	137.7	130.6	131.5	121.8	118.8	108.1	111.4	**1526.1**

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				Crop evapotranspiration ET_c (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU12 South And Central Foothills	Coconut		Present	101.1	95.4	109.4	104.3	73	97.4	94.7	96.6	98.2	96	90.2	94.6	**1150.9**
		4.5	2030	90	84.7	100.1	96.7	73.9	102.8	96.8	99.4	94	97.1	88	88.7	**1112.2**
			2050	90.9	85.4	100.8	97.3	99.5	103.7	98	100.4	63.3	97.8	89.4	89.4	**1115.9**
			2080	92.1	86.4	101.5	98.1	100.8	105	99.1	101.5	96.5	99	90.4	90.5	**1160.9**
		8.5	2030	90.2	84.3	99.4	96.3	98.8	103.1	97.1	99.7	94.6	97.2	88.6	88.6	**1137.9**
			2050	92.3	85.5	100.6	97.6	100.3	105.2	99.5	101.1	97	98.7	90.6	89.4	**1157.8**
			2080	95.8	87.7	103.4	100.7	102.2	109.1	103.2	104	101.3	101.8	94.1	91.5	**1194.8**
	Rubber		Present	127.6	121.5	139.4	133.7	111.6	123.4	119.8	122	122.5	118.2	110.5	117.6	**1467.8**
		4.5	2030	112.5	109.7	129.8	126.1	116.3	130.2	122.7	124.7	113.8	113	100.9	105.9	**1405.6**
			2050	113.7	110.6	130.7	126.8	117.3	131.5	124.2	125.9	115.1	113.7	102.3	106.7	**1418.5**
			2080	115.6	112.1	132	128.1	118.6	133	125.6	127.2	116.6	115.2	103.4	108.1	**1435.5**
		8.5	2030	112.8	109.3	129.2	125.5	116.3	130.6	123	125	114.4	113.1	101.4	105.9	**1406.5**
			2050	115.8	111.1	131	127.5	118	133.2	126	126.7	117.1	114.7	103.5	107	**1431.6**
			2080	120.5	114.3	134.9	131.8	120.7	138.1	130.6	130.3	122.4	118	107.5	109.3	**1478.4**
AEU14 Southern High Hills	Rubber		Present	122.2	120.7	139.2	133.5	111.7	123.4	119.9	122	122	117.5	109.5	115.5	**1457.1**
		4.5	2030	109.8	110.1	131.3	128.2	117.5	132.3	125.1	126.7	117	113.9	103	104.9	**1419.8**
			2050	111.5	111.3	132.5	129.3	118.3	133.5	127	128	118.6	115.1	104.4	105.5	**1435**
			2080	112.7	112.9	132.1	131.1	119.8	134.8	128.3	129.3	120	116.2	105.3	106.7	**1449.2**
		8.5	2030	110.4	110.2	131.2	128.6	117.5	132.2	125.8	127.1	117.9	115.3	103.8	104.7	**1424.7**
			2050	113.1	112.1	133.4	130.6	118.7	135.5	128.3	128.7	120.8	116	105.7	106	**1448.9**
			2080	117.7	115.5	136.7	135	121.9	140.6	133	131.7	125.8	119.2	108.4	108.5	**1494**
	Coconut +pepper +banana		Present	97.6	95	109.4	104.3	98.3	97.5	94.7	96.6	98.2	96	90.2	93.8	**1171.6**
		4.5	2030	88.1	85	101.2	98.4	100.6	104.4	98.8	101	96.6	97.7	89.6	87.8	**1149.2**
			2050	89.2	85.9	102.1	99.3	101.2	105.4	100.3	102	97.9	98.7	90.9	88.3	**1161.2**
			2080	90.4	87.2	103.1	100.7	102.5	106.5	101.3	103	99.1	99.8	91.9	89.4	**1174.9**
		8.5	2030	88.5	85	101	98.6	100.7	104.4	99.4	101.3	97.3	99	90.5	87.7	**1153.4**
			2050	90.5	86.5	102.7	100.2	101.4	107	101.3	102.6	99.7	99.6	92.1	88.8	**1172.4**
			2080	94.1	88.9	105	103.3	103.9	111	105	105	104.2	102.7	94.8	90.9	**1208.8**

Table 188. Water requirement of various cropping systems in different AEUs of Pathanamthitta district

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU4 Kuttanad	Rice-fallow		Present	*	*	*	*	97.8	0	0	0	*	*	*	*	**97.8**
		4.5	2030	*	*	*	*	98	0	0	0	*	*	*	*	**98**
			2050	*	*	*	*	98	0	0	0	*	*	*	*	**98**
			2080	*	*	*	*	98	0	0	0	*	*	*	*	**98**
		8.5	2030	*	*	*	*	98	0	0	0	*	*	*	*	**98**
			2050	*	*	*	*	98	0	0	0	*	*	*	*	**98**
			2080	*	*	*	*	98.1	0	0	0	*	*	*	*	**98.1**
	Coconut		Present	93	79.6	67.8	6.6	3.2	0	0	0	0	0	0	45.9	**296.1**
		4.5	2030	75.7	83.5	56.8	21.8	3.1	0	0	0	70.4	0	65.1	77.6	**454**
			2050	78	84.1	59	20.2	3.1	0	0	0	68.1	0	64.4	75	**451.9**
			2080	48.9	84.4	70.6	38	3.1	0	0	0	0	0	0	7.7	**252.7**
		8.5	2030	45.8	83.6	71.3	28.8	3.1	0	0	0	15.7	0	41.9	27.6	**317.8**
			2050	48.5	83.8	70.4	38.1	3.1	0	0	0	0	0	0	9.7	**253.6**
			2080	79	72.7	74.8	47.3	3.2	0	0	0	0	0	0	28	**305**
AEU9 South Central Laterites	Coconut		Present	101	93.5	108.4	19.5	3.2	0	0	0	0	0	26.4	4.6	**356.6**
		4.5	2030	55.5	83.7	68.8	54.8	3.1	0	0	0	74.3	0	66.1	22.5	**428.8**
			2050	79.1	83.6	54.6	16.9	3.1	0	0	0	3.2	0	0	53.6	**294.1**
			2080	58.1	85.9	68.9	55.7	3.2	0	0	0	33.1	0	46.8	23.7	**375.4**
		8.5	2030	55	84.1	67.2	54.4	3.1	0	0	0	0	0	63.6	23.8	**351.2**
			2050	82.2	80.8	50.6	21.3	3.2	0	0	0	3.4	0	0	5.5	**247**
			2080	80.6	67.5	77.9	44.7	3.2	0	0	0	4.5	0	48.3	31	**357.7**
	Rubber		Present	127.4	119.6	138.3	47.6	6.1	0	0	0	0	0	46.7	13.7	**499.4**
		4.5	2030	79	109.3	99	84.4	4.9	0	0	0	94.1	0	79	40.3	**590**
			2050	102.6	109.2	85.1	44.7	3.5	0	0	0	12.4	0	0	71.2	**428.7**
			2080	81.9	112.1	99.9	86.2	6	0	0	0	53.2	0	59.6	41.6	**540.5**
		8.5	2030	78.5	109.7	97.4	84.2	4.7	0	0	0	2.7	0	76.6	41.6	**495.4**
			2050	106.3	106.9	81.4	51.5	4.7	0	0	0	13.5	0	0	71.5	**435.8**
			2080	106	94.9	110	76.1	5.7	0	0	0	15.4	0	61.4	49.3	**518.8**

water requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU12 Southern And Central Foothills	Coconut		Present	84.8	47.8	36.4	0	3.2	0	0	0	0	0	0	50.6	**222.8**
		4.5	2030	47.5	83.1	72.4	36.7	3.1	0	0	0	34.7	0	0.3	26.6	**304.4**
			2050	46.8	83.1	39.4	22.3	3.1	0	0	0	29.5	0	0	9.4	**233.6**
			2080	55.4	84.2	40.7	18	3.2	0	0	0	35.6	0	45.3	69.3	**351.7**
		8.5	2030	66.3	77.9	67.5	27.5	3.1	0	0	0	35.3	0	0	9.4	**287**
			2050	81.8	79.9	71.2	50.1	3.2	0	0	0	1.5	0	45.1	70	**402.8**
			2080	80	66.2	69.7	49	3.2	0	0	0	52	0	48.7	31.6	**400.4**
	Rubber		Present	111.2	74	66.2	2.7	1.1	0	0	0	0	0	0	73.6	**328.8**
		4.5	2030	70	108	102.2	66.6	8.7	0	0	0	54.5	0	5.6	43.7	**459.3**
			2050	69.5	108.4	69.4	51.9	5.9	0	0	0	54.2	0	0	23	**382.3**
			2080	78.9	110	71	48.1	7.9	0	0	0	55.9	0	58.4	87	**517.2**
		8.5	2030	88.9	102.8	97.3	56.8	13.3	0	0	0	55.1	0	0	20.8	**435**
			2050	105.4	105.6	101.6	80.1	14.2	0	0	0	8.6	0	58.1	87.5	**561.1**
			2080	104.7	92.7	101.2	80.1	9.6	0	0	0	73.1	0	62	49.4	**572.8**
AEU14 Southern High Hills	Rubber		Present	121	99.3	86.1	75.7	4.2	0	0	0	0	0	0	81.1	**467.4**
		4.5	2030	105.1	70.6	95.2	62.3	8.8	0	0	0	40.1	0	85.6	78	**545.7**
			2050	105.9	70.8	96.1	62.1	24	0	0	0	39.1	0	86.4	79.4	**563.8**
			2080	107.4	73.3	97.1	62.7	19.1	0	0	0	40.4	0	86.7	73.4	**560.1**
		8.5	2030	104.4	74.2	88.9	70.9	12.8	0	0	0	44	0	86.3	78.9	**560.4**
			2050	107.6	72.3	95.6	63.1	27.5	0	0	0	40.4	0	87.2	80	**573.7**
			2080	81.1	105.6	109.7	71.9	33.9	0	0	0	61.7	0	0	67.8	**531.7**
	Coconut +pepper +banana		Present	96.5	73.6	56.4	46.5	3.2	0	0	0	0	0	0	59.4	**335.6**
		4.5	2030	83.4	45.5	65	32.7	3.2	0	0	0	19.7	0	72.3	61	**382.8**
			2050	83.6	45.1	65.7	32.1	4.2	0	0	0	18.7	0	73	62.2	**384.6**
			2080	85.1	47.5	66.2	32.4	3.2	0	0	0	19.5	0	73.3	56.2	**383.4**
		8.5	2030	82.4	49.1	58.7	41.2	3.2	0	0	0	23.4	0	72.8	61.9	**392.7**
			2050	85.1	46.7	64.9	32.7	5.3	0	0	0	19.4	0	73.7	62.9	**390.7**
			2080	57.7	79	78	40.2	8.3	0	0	0	40	0	0	50.4	**353.6**

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

The ET_c values of various cropping systems for AEU12, AEU14, AEU16 and AEU17 of Idukki district were studied and presented in table 189.

Rubber monocropping and coconut monocropping are the major cropping systems of AEU12. Since, rubber and coconut are perennial crop the ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show a decrease in both cases of rubber and coconut by 2030s and 2050 of RCP 4.5 remaining cases will show an increasing trend. Banana + vegetable and rubber monocropping were found to be the major cropping systems of AEU14. Banana is an annual crop and it is planted around second week of September and harvested in first week of September. The Vegetables is planted with banana in second week of September and harvested in second week of January. Since, rubber is a perennial crop the ET_c value for a year is considered. While comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend from the present value in banana + vegetable and rice except RCP 4.5 of 2030 of rice.

Coconut + pepper and coffee + tea were found to be the major cropping systems of AEU16. Since coconut + pepper, coffee + tea are perennial crop ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing tread from the present value in both case of coconut + pepper and coffee + tea. Banana monocropping and coffee monocropping are the major cropping systems of AEU17. Banana is an annual crop and it is planted around second week of September and harvested during first week of September. Since, coffee is a perennial crop ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend in banana and coffee except in 2030s.

The water requirement for various cropping systems of AEU12, AEU14, AEU16 and AEU17 of Idukki district were studied and presented in table 190.

Presently, the annual water requirement of rubber and coconut is 345.1 and 236.4 mm respectively in AEU12. When comparing the present and the projected climate of RCP

4.5 and RCP 8.5 the annual water requirement of both rubber and coconut will show an increasing trend. Currently for rubber, the irrigation is not required for eight months (April to November). The climate projection will show an increase in the number of irrigating months from four under present condition to seven months. Only five months does not require irrigation. In coconut when comparing the present and future climate of both RCP 4.5 and RCP 8.5 irrigation is not required for eight months (April to November) but in the projected climate except five months all other months requires irrigation. In case of rubber and coconut the annual water requirement of future climate will increase by 50% to 100%.

Currently, the annual water requirement of banana + vegetable and rubber is 400.8 and 378.3 mm respectively for AEU14. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both banana + vegetable and rubber will show an increasing trend. According to the present condition for banana + vegetable and rubber, the irrigation is not required seven months (May to November) and it will decrease to four months in both the projection RCP 4.5 and RCP 8.5.Currently, the annual water requirement of coconut + pepper and coffee + tea is 240.9 and 437.2 mm respectively in AEU16. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both coconut + pepper and coffee + tea will show an increasing trend. Currently, for coconut + pepper and coffee + tea, the irrigation is not required for six months (June to November). The climate projection shows a decrease in the number of months which does not requires irrigation from six to four months. Presently, the annual water requirement of banana and coffee is 188 and 213.9 mm respectively in AEU17. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both banana and coffee will show an increasing trend. Currently for banana and coffee, the irrigation is not required for five months (July to November). The climate projection does not have much variation in the number of months which does not requires irrigation but the annual amount of water requirement will show an increase more than 100%.

Rubber of AEU12, banana + vegetable and rubber of AEU14, coffee + tea of AEU16 is having high water requirement within the district.

Table 189. ET_c values of various cropping systems in different AEUs of Idukki district

AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
				Crop evapotranspiration ET_c (mm)												
AEU12 Southern and Central foothills	Rubber		Present	133	129.6	143.3	120	112.3	110.1	106.7	108.9	108.2	112.7	107.6	120.4	**1412.8**
		4.5	2030	128.1	122.3	134.7	117.7	128.8	104.9	97.7	99.8	89.5	119.7	111.8	122.1	**1377.1**
			2050	129.1	123.1	136	118.7	129.9	106.1	99.1	100.9	90.5	120.7	113.4	123.3	**1390.8**
			2080	124.6	123.9	139.6	122.3	119.9	119.4	113	116	108.9	113.7	104.6	114.6	**1420.5**
		8.5	2030	121.4	120.5	136.1	119.4	117.4	117.2	111	114.2	106.5	111.6	101.7	112.1	**1389.1**
			2050	123.9	122.6	138.9	121.7	119.6	119.2	112.9	116	108.8	113.7	104.3	114.1	**1415.7**
			2080	131.7	128.1	138.1	108.5	139.8	117.6	116.4	118.4	112.6	115	108.8	117	**1452**
	Coconut		Present	105.4	101.9	113	93.5	103	86.9	84.2	86.3	86.9	91.8	88.1	97	**1138**
		4.5	2030	105.5	104.4	116	95.7	97.9	76.2	71.9	74.6	82.1	94.5	88.2	97.2	**1104.2**
			2050	106.4	105	117.4	96.4	98.9	77.2	73	75.6	83.1	95.4	89.5	98.2	**1116.1**
			2080	99.5	96.1	108.3	94.3	102.7	94.3	89.2	92.2	89.4	96.5	89.7	95.1	**1147.3**
		8.5	2030	97.2	93.6	105.6	92.1	100.3	92.5	87.6	90.9	87.5	94.8	87.6	93.3	**1123**
			2050	98.9	95.1	107.7	93.7	102.2	94.1	89	92.2	89.4	96.6	89.8	94.8	**1143.5**
			2080	101.6	97	109.7	95.8	105	97	91.6	94.8	92.6	99.2	93.3	97.2	**1174.8**
AEU14 Southern High Hills	Banana+ vegetable		Present	94.5	124.3	154.4	134.7	123.7	93.9	84.7	89.6	54.8	52.7	43.7	53.4	**1104.4**
		4.5	2030	97.8	127	161.2	143.2	143.3	109.4	93.4	105.1	61.7	58.7	48.2	56	**1205**
			2050	99.3	127.6	162.9	137.4	143.8	118.4	94.9	106	62.4	59.2	48.7	54.8	**1215.4**
			2080	100.9	130.3	164.9	146.9	146.1	111.7	96	107.2	63.1	59.9	49.2	55.7	**1231.9**
		8.5	2030	97.8	127.3	161.3	143.4	143.6	109.6	93.9	105.4	62.7	59.1	48.3	56	**1208.4**
			2050	100.9	128.8	164.4	146.5	142.9	111.2	96.2	107.1	63.3	59.8	49.3	55.3	**1225.7**
			2080	105.1	133.1	169.3	151.3	145.7	115.5	99.2	106.5	65.8	61.5	50.9	56.5	**1260.5**

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Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU14 Southern High Hills	Rubber		Present	99.8	110.2	135.4	118.1	90.8	84.2	80.1	89.6	79.5	94.9	77.5	82.3	**1142.4**
		4.5	2030	108.9	110.3	135	119.7	119.8	91.7	80.2	92.7	73.6	111.4	91.4	92.4	**1127.1**
			2050	110.7	110.9	136.2	121	120.5	92.5	81.4	93.7	74.9	112.6	92.5	90.4	**1237.3**
			2080	106.2	111.9	139.6	124.4	108.6	102	91.4	106.1	90	106.3	85.3	84.5	**1256.3**
		8.5	2030	103.1	109.3	136.7	121.5	106.9	100.2	89.5	104.4	89.4	104.9	83.9	85.1	**1234.9**
			2050	106	110.6	139.1	124	106.3	101.7	91.6	106.1	90.2	106.1	85.5	83.9	**1251.1**
			2080	110.2	114	142.9	127.7	108.5	105.8	94.7	105.8	93.8	108.6	87.9	85.2	**1285.1**
AEU16 Kumily Hills	Coconut+ pepper		Present	73.5	75.3	93.4	92.3	93.5	77.6	67.2	76.1	74.9	77.5	67.8	66.3	**935.4**
		4.5	2030	80.2	81.8	100.3	93.2	91	75	63	72.6	77.4	84	73.9	72	**964.4**
			2050	81.2	82.5	101.5	94.1	91.9	75.9	64.2	73.4	78.3	84.6	74.7	72.3	**974.6**
			2080	82.5	84	102.6	95.4	93.2	76.8	64.8	74.2	79.1	85.5	75.6	73	**986.7**
		8.5	2030	75.5	75	93.6	91.8	94.8	90.3	77.3	85.6	81.6	84.1	73.6	69	**992.2**
			2050	82.7	83.3	102.1	95.2	92.3	77.2	65	73.6	79.8	85.5	75.9	70.8	**983.4**
			2080	86.7	86.2	105	99	94.9	80.5	67.6	74.6	82.8	87.9	77.9	72.5	**1015.6**
	Coffee+ tea		Present	103.1	108.7	135.1	134.2	111.3	108.6	94.1	106.2	102.9	105.2	91.7	91.7	**1292.8**
		4.5	2030	110.6	111.2	137.7	135.4	141.1	121.5	101.6	112.6	93.2	117.5	103.4	100.4	**1386.2**
			2050	111.9	112.1	138.8	136.4	141.9	122.5	103	113.8	94.3	118.5	104.7	100.8	**1398.7**
			2080	113.7	114.2	140.5	138.4	143.9	124	104.1	115	95.4	119.8	105.7	102	**1416.7**
		8.5	2030	108.1	110.5	138	136.1	121.6	126.4	108.3	119.4	112.1	114.2	99.6	96.2	**1390.5**
			2050	113.8	113.2	139.5	137.8	142.3	124.3	104.2	114.1	96.2	119.7	106.2	98.9	**1410.2**
			2080	119.2	117.2	143.2	142.8	145.7	128.9	107.6	116.3	100.5	123.2	109	101.1	**1454.7**

				Crop evapotranspiration ET_c (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU17 Marayur Hills	Banana		Present	93.9	125.5	151	134.4	123.6	93.6	85	93.3	54.7	52.2	43.3	52.8	**1103.3**
		4.5	2030	86.9	115.5	146	130	132.7	102.1	86.8	99.1	56.5	53.6	43.5	49.6	**1102.3**
			2050	88.5	116.3	147.4	131.5	133.8	103	87.9	100.1	57.4	54.1	43.9	48.6	**1112.5**
			2080	89.5	118.7	150.3	133.7	136.1	104.5	88.9	101.1	57.8	54.7	44.5	50.9	**1130.7**
		8.5	2030	87	115.7	143.4	130.1	133	102.2	87.1	99.5	56.9	53.7	44.1	49.9	**1102.6**
			2050	89.8	117.1	148.7	133.3	132.4	103.9	89.3	101	58.4	54.7	44.6	48.8	**1122**
			2080	93.5	121	153.4	137.9	135.3	107.5	92.1	103.2	60.8	56.6	46.4	50.4	**1158.1**
	Coffee		Present	113.9	124.3	147.4	131.1	100.5	92.7	88.7	103.6	89	106.9	87.9	93.5	**1279.5**
		4.5	2030	108.7	114.5	140.8	125.3	128	99	87.2	103.4	75.8	112.5	91.3	90.9	**1277.4**
			2050	110.8	115.1	142.1	126.8	128.9	99.9	88.1	104.4	77	113.7	92.2	89	**1288**
			2080	111.9	117.5	145	128.8	131.2	101.2	89.1	105.5	77.5	114.9	93.3	93.3	**1309.2**
		8.5	2030	106.7	114.2	139.4	126.3	110.1	102.8	91.5	109.5	91.4	109.9	89.5	88.5	**1279.8**
			2050	112.6	116.1	143.5	128.6	127.6	100.8	89.5	105.4	78.3	114.8	93.5	89.4	**1300.1**
			2080	117.2	120.1	148.2	133.1	130.4	104.3	92.5	107.8	81.8	118.7	97.4	92.3	**1343.8**

Table 190. Water requirement of various cropping systems in different AEUs of Idukki district

				water requirement (mm)												
AEU	cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU12 Southern and Central foothills	Rubber		Present	116.5	82	70.2	0	0	0	0	0	0	0	0	76.4	**345.1**
		4.5	2030	112.3	121.7	83.4	51.9	0	0	0	0	66.3	0	88.4	109.4	**633.4**
			2050	114.9	121.4	84.8	52.3	0	0	0	0	70.7	0	93	106.2	**643.3**
			2080	93.7	123.2	104.2	83	4.8	0	0	0	8.3	0	0	31.2	**448.4**
		8.5	2030	105.3	120	84	52.9	1.2	0	0	0	73.6	0	78	98.9	**613.9**
			2050	93	121.8	103.6	83.4	4.7	0	0	0	8.6	0	0	33.7	**448.8**
			2080	120.1	121.4	99	79.6	5.6	0	0	0	7.6	0	0	43.5	**476.8**

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				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU12 Southern and Central foothills	Coconut		Present	88.9	54.3	40.1	0	0	0	0	0	0	0	0	53.1	**236.4**
		4.5	2030	89.9	103.8	64.8	29.7	0	0	0	0	49.3	0	64.9	84.4	**486.8**
			2050	92.3	103.3	66	30.1	0	0	0	0	55.6	0	69.1	81	**497.4**
			2080	68.1	95.4	72.8	55	3.4	0	0	0	1.8	0	0	14.7	**311.2**
		8.5	2030	81.2	93	53.5	26.1	3.3	0	0	0	54.5	0	63.9	80	**455.5**
			2050	68.1	94.3	72.2	55.5	3.3	0	0	0	2	0	0	16.6	**312**
			2080	93.9	92.7	66.5	50.8	3.4	0	0	0	1	0	0	24.3	**332.6**
AEU14 Southern High Hills	Banana+ vegetable		Present	94.4	102.9	101.4	76.8	0	0	0	0	0	0	0	25.3	**400.8**
		4.5	2030	84.5	101.9	135	98.3	28.3	0	0	0	15.2	0	24.5	17.6	**505.3**
			2050	87.8	110.8	136.5	45.2	66.3	14.9	0	0	4.1	0	24.2	16.2	**506**
			2080	89.7	114	137.6	108.4	20.9	0	0	0	5	0	24	10.7	**510.3**
		8.5	2030	86.2	111	129.7	110.5	30.2	0	0	0	16.6	0	24.3	15.6	**524.1**
			2050	89.6	112.5	137.1	108.9	30.8	0	0	0	5.1	0	24.3	22.7	**531**
			2080	98.3	111.9	135.4	107.4	34.8	0	0	0	1	0	0	17.4	**506.2**
	Rubber		Present	98.7	88.9	82.5	60.3	0	0	0	0	0	0	0	47.9	**378.3**
		4.5	2030	95.7	85.2	108.7	74.8	9.8	0	0	0	35.1	0	67.4	54	**530.7**
			2050	99.2	94.1	109.9	81.9	7.1	0	0	0	21.9	0	67.1	51.8	**533**
			2080	95	95.6	112.3	85.8	7.9	0	0	0	23.6	0	59.8	38	**518**
		8.5	2030	91.5	93.3	105	88.5	9.5	0	0	0	39.4	0	59.1	44.8	**531.1**
			2050	94.8	94.2	111.9	86.5	9.8	0	0	0	23.5	0	59.6	51.3	**531.6**
			2080	103.3	92.8	109	83.3	12.6	0	0	0	14.8	0	0	39.1	**454.9**

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water requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU16 Kumily Hills	Coconut+ pepper		Present	57	63.3	61.8	23.4	18	0	0	0	0	0	0	17.4	**240.9**
		4.5	2030	58.5	66.4	71.8	51.2	0	0	0	0	44.5	0	56.2	2	**350.6**
			2050	61.2	72.3	69.7	47	0	0	0	0	43.4	0	56.1	1.5	**351.2**
			2080	62.6	73.7	69.7	48.8	2	0	0	0	45.5	0	56.6	0	**358.9**
		8.5	2030	54.4	65.8	61.6	53.3	3.1	0	0	0	49.6	0	55.6	0.1	**343.5**
			2050	63.2	73.1	68.9	49.7	2.4	0	0	0	45.8	0	57.1	2.8	**363**
			2080	78.3	64.9	78.5	52.4	7.4	0	0	0	10.4	0	0	29.4	**321.3**
	Coffee+ tea		Present	86.6	96.6	103.3	65.3	46.6	0	0	0	0	0	0	38.8	**437.2**
		4.5	2030	88.8	96	109.1	93.4	19.8	0	0	0	69.1	0	85.7	21.1	**583**
			2050	91.9	101.9	107.1	89.2	26.7	0	0	0	68.6	0	86	19.9	**591.3**
			2080	93.8	104.1	107.7	91.7	36.7	0	0	0	70.6	0	86.8	16.1	**607.5**
		8.5	2030	87.1	101.2	106.1	97.6	19.3	0	0	0	80.2	0	81.6	16.9	**590**
			2050	94.3	103	106.4	92.3	36.7	0	0	0	71.2	0	87.4	22.1	**613.4**
			2080	110.8	95.7	116.7	96.2	51.5	0	0	0	36.4	0	0	58.2	**565.5**
AEU17 Marayur Hills	Banana		Present	43.3	58.8	17.2	27.6	27.5	10.8	0	0	0	0	0	2.8	**188**
		4.5	2030	70.7	101.4	120.9	84.7	41	0	0	0	3.3	0	0	0	**422**
			2050	72.2	101.6	121.8	85.1	40.3	0	0	0	14.1	0	0	0	**435.4**
			2080	71.6	104.3	132	89.4	37	0	0	0	0	0	12.8	0.9	**448**
		8.5	2030	70.3	101.7	117.7	84.7	42.3	0	0	0	2.8	0	0	0	**419.5**
			2050	71.9	102.7	123.5	101.1	28.8	0	0	0	0	0	15	1.1	**444.1**
			2080	74.8	106.5	124.8	102	21.5	0	0	0	27.4	0	12	1.2	**470.2**
	Coffee		Present	63.4	57.6	14.2	24.3	20.9	9.7	0	0	0	0	0	23.8	**213.9**
		4.5	2030	92.5	100.3	115.6	79.9	36.3	0	0	0	27	0	0	12	**463.6**
			2050	94.5	100.5	116.7	80.5	35.5	0	0	0	39.5	0	0	11.3	**478.5**
			2080	94	103.2	126.6	84.6	32.1	0	0	0	1	0.1	58.4	22.6	**522.6**
		8.5	2030	90	100.3	113.5	80.9	31.2	0	0	0	28	0	0	10.7	**454.6**
			2050	94.4	101.7	118.2	96.2	24	0	0	0	15.3	0	60.3	22.1	**532.2**
			2080	98.5	105.6	119.5	97.1	17.9	0	0	0	57.5	0	58.5	22.6	**577.2**

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4.4.5 water requirement of major cropping systems of various AEUs in Kottayam district and impact of projected climate change

The ET_c values of various cropping systems for AEU4, AEU9 and AEU12 of Kottayam district were studied and presented in table 191.

Rice-rice-fallow and coconut monocropping were found to be the major cropping systems in AEU4. In rice-rice-fallow the first cropping season virippu with a duration of four months (May to August) transplanted around first week of June and harvested during last week of August. The second crop mundakan is having a crop duration of six months (August to January) transplanted in last week of September and harvested in first week of January. Since, coconut is a perennial crop the ET_c value for a year is considered. While comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value of projected climate will show an increasing trend in case of rice and decreasing trend from the present value in the case of coconut except in the case of 2080 of RCP 8.5 of coconut.

Coconut+pepper+banana and rubber were found to be the major cropping systems in AEU9. While comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value of projected climate will show an increasing trend from the present value in both coconut + pepper + banana and rubber cropping systems.

Coconut + pepper and rubber are the major cropping systems of AEU12. Since coconut, pepper and rubber are perennial crops the ET_c values for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value of projected climate will show a decreasing trend from the present value in both coconut + pepper and rubber cropping systems.

The water requirement for various cropping systems of AEU4, AEU9 and AEU12 of Kottayam district were studied and presented in table 192.

Presently, the annual water requirement of rice-rice-fallow and coconut monocropping is 335.7 and 314.1 mm respectively in AEU4. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5, the annual water requirement of both rice-rice-fallow and coconut of projected climate will show an increasing trend from the present value and irrigation is not required during the months of June, July and October in present condition and it will decrease to two months (June and July) in future projections. In coconut, annually seven months (May to November) does not require irrigation under the present condition and the projection will show a decrease to five months (May to August and October) and the remaining months need irrigation.

Presently, the annual water requirement of coconut + pepper + banana and rubber monocropping is 236.5 and 388.2 mm respectively in AEU9. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 of coconut + pepper + banana and rubber, the annual water requirement of projected climate will show an increasing trend. Under the present situation coconut + pepper + banana and rubber does not require irrigation for seven months (May to October and December) and it will decrease to five up to six months under the projected climate in both cases and the remaining months requires irrigation.

Currently, the annual water requirement of coconut + pepper and rubber monocropping is 206.6 and 311.3 mm respectively in AEU12. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both coconut + pepper and rubber the projected climate will show a decreasing trend from the present value except 2030 of RCP 4.5 and 2080 of RCP 8.5. Under the present situation for coconut + pepper, the irrigation is not required eight months (April to November) and in projected climate it decreases about five up to six months. In case of rubber seven months (May to November) does not require irrigation under present situation and the climate projection will show a decrease to five up to six months.

The rice-rice-fallow of AEU4 and rubber of AEU9 is having high water requirement within the district.

Table 191. ET_c value of various cropping systems in different AEUs of Kottayam district

AEU	Cropping systems	RCP	Year	Crop evapotranspiration ET_c (mm)												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
AEU4 Kuttanad	Rice-rice-fallow		Present	4.4	*	*	*	20	125.5	125.9	92	51.5	131.9	132	137.6	**820.8**
		4.5	2030	4.2	*	*	*	22.1	134.8	129	96.3	52.4	137.5	129.4	135.6	**841.3**
			2050	4.3	*	*	*	22.3	136.2	130.9	97.3	52.7	138.6	131.2	136.4	**849.9**
			2080	4.3	*	*	*	22.5	137.6	132.2	98.6	53.2	140.4	132.9	138.3	**860**
		8.5	2030	4.2	*	*	*	22	136.5	130	96.7	52.3	137.6	130.2	135.4	**844.9**
			2050	4.3	*	*	*	22.5	137.4	132.8	98.4	53.2	139.9	133.1	137.8	**859.4**
			2080	4.5	*	*	*	23.2	142.2	136.6	101.2	55.2	144.4	138.4	141.8	**887.5**
	Coconut		Present	98.8	95.8	127.4	102	93.3	85.5	83.9	84.9	86.7	89.6	85.5	92.8	**1126.2**
		4.5	2030	88.6	83.4	97.4	92	101.3	91.9	86.8	89.6	87.8	93.6	84.7	89	**1086.1**
			2050	89.8	84.1	98.3	93	102	92.8	88	90.6	88.3	94.3	85.8	89.6	**1096.6**
			2080	91.4	85.5	100	94.6	103.2	93.7	89	91.6	89.5	95.5	86.9	90.8	**1111.7**
		8.5	2030	89.2	83.4	97.4	92.3	101.3	93.1	87.5	90	87.7	93.7	85.1	88.8	**1089.5**
			2050	91	84.8	99	94	102.9	93.7	89.2	91.4	89.3	95.2	87.1	90.4	**1108**
			2080	93.5	87.1	102.2	96.8	106.3	96.9	92.1	94.3	92.7	98.2	90.8	93.1	**1144**
AEU9 South Central Laterites	Coconut+ pepper +Banana		Present	73.3	69	80.7	76.8	69.6	74.6	71	78.1	80.1	78.4	71.8	73.3	**896.7**
		4.5	2030	88.9	85	108.1	93.7	98.3	91.3	87.4	89.5	87.1	93.1	84.7	87.9	**1095**
			2050	89.4	85.4	109.2	94.2	99.2	92.4	88.5	90.4	88.1	93.4	85.9	88.6	**1104.7**
			2080	92.8	87.2	108.9	94.6	91	93.4	89.4	91.3	89.4	95	87.5	91.9	**1112.4**
		8.5	2030	88.9	84.9	107.8	93.6	98.4	91.6	87.7	89.8	87.5	3.2	84.9	87.9	**1006.2**
			2050	90.3	86.2	109.7	94.9	100.4	93.4	89.4	91.4	89.5	95	87.2	89.4	**1116.8**
			2080	96.1	89.2	111.6	97.2	93.5	96.7	92.5	93.7	93.1	97.7	92.2	94.5	**1148**
	Rubber		Present	88	90.2	108.8	103.5	93.7	94.4	90	97.3	94.2	86.5	75.7	80.8	**1103.1**
		4.5	2030	111.8	109.8	139.8	121.9	106.8	115.7	110.8	112.3	105.8	109.2	98.3	105.9	**1348.1**
			2050	112.5	110.4	141.3	122.8	107.8	117	112	113.4	106.9	110	99.3	106.7	**1360.1**
			2080	114	112.5	142.8	124.2	109.1	118.1	113.2	114.5	108.3	110.9	99.5	107.9	**1375**
		8.5	2030	111.8	109.8	139.6	122	107	115.9	111.1	112.6	106.2	109.3	98.3	105.9	**1349.5**
			2050	113.7	111.6	142.2	123.7	109.2	118.4	113.2	114.6	108.5	111.1	100.9	107.7	**1374.8**
			2080	118	115	146.4	127.3	112.2	122.4	117.2	117.5	112.7	113.9	104.9	110.5	**1418**

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Crop evapotranspiration ET_c (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU12 South And Central Foothills	Coconut+ pepper		Present	97.1	91.7	106	99.3	90.8	86.1	83.9	84.9	86.7	89.6	85.9	92.6	**1094.6**
		4.5	2030	65.3	62.9	76.8	73.3	88.6	79.9	72.8	82.9	82.2	82.4	71.9	68	**907**
			2050	65.8	63.2	77	73.4	89.2	80.7	73.6	83.6	82.7	82.9	72.8	68.3	**913.2**
			2080	71.4	66.1	77.1	73.9	72.7	81.4	74.3	84.3	83.2	83.6	75.7	73.7	**917.4**
		8.5	2030	65.4	62.9	76.6	73.2	88.8	80.1	73	83.2	82.5	82.6	71.9	68.1	**908.3**
			2050	66.6	63.7	77.3	73.9	90	81.5	76.1	84.1	84.2	83.7	73.7	68.8	**923.6**
			2080	73.9	67.4	78.4	75.4	73.5	83.7	78.5	86.2	87.2	86.3	78.4	75.3	**944.2**
	Rubber		Present	122	118	137.4	128.3	105	109.1	106.3	107	107.5	109.2	103.4	113.4	**1366.6**
		4.5	2030	81.4	84.7	103.6	99.5	98.8	101.3	92.1	102.8	94.7	87.3	73.8	76.4	**1096.4**
			2050	82.5	85.4	104.1	100	99.4	102.2	93.2	103.6	95.3	87.7	74.7	76.9	**1105**
			2080	83.6	86.6	105.3	101.2	100.5	103.1	94	104.5	95.7	88.6	75.5	77.8	**1116.4**
		8.5	2030	81.6	84.9	103.5	99.5	99	101.3	92.4	103	94.8	87.4	73.8	76.4	**1097.6**
			2050	83.4	86.2	104.8	100.6	100.3	103.1	96.5	104.2	97	88.6	75.6	77.4	**1117.7**
			2080	86.2	88.2	107.2	103.4	102.7	105.9	99.3	106.7	100.2	90.8	77.7	79	**1147.3**

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Table 192. Water requirement of various cropping systems in different AEUs of Kottayam district

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
AEU4 Kuttanad	Rice-rice-fallow		Present	4.4	*	*	*	114.7	0	0	0.9	116.6	0	6.9	92.2	**335.7**
		4.5	2030	4.2	*	*	*	114.8	0	0	0.9	155.6	0.9	106.5	120.6	**503.5**
			2050	4.3	*	*	*	114.8	0	0	0.9	116.7	4.4	106.8	123	**470.9**
			2080	4.3	*	*	*	114.8	0	0	1	118.1	6.8	107.5	120.3	**472.8**
		8.5	2030	4.2	*	*	*	114.8	0	0	0.9	152.2	0.9	106.9	120	**499.9**
			2050	4.3	*	*	*	114.8	0	0	0.9	118.4	6.6	107.3	120.7	**473**
			2080	4.5	*	*	*	114.8	0	0	1	116.8	8	91.9	75.8	**412.8**
	Coconut		Present	91.5	80.9	86.2	8.2	0	0	0	0	0	0	0	47.3	**314.1**
		4.5	2030	74.2	82.8	55.2	17.8	0	0	0	0	69.6	0	61.8	74	**435.4**
			2050	74.2	83.6	49.1	23.1	0	0	0	0	0	0	61.4	76	**367.4**
			2080	77	84.8	50.9	24.7	0	0	0	0	0	0	61.5	72.7	**371.6**
		8.5	2030	74.2	82.8	54	17.2	0	0	0	0	62.5	0	61.8	73.5	**426**
			2050	76.9	84.2	49.8	24.7	0	0	0	0	0	0	61.3	73.4	**370.3**
			2080	58.7	86.1	77.4	43.3	0	0	0	0	0	0	44.3	27.1	**336.9**
AEU9 South Central Laterites	Coconut+ pepper +Banana		Present	73.2	67.1	79.5	5.5	0	0	0	0	0	0	11.2	0	**236.5**
		4.5	2030	73.5	84.5	77.7	47.3	0	0	0	0	49.8	0	48.1	28.7	**409.6**
			2050	57	84.5	84.9	48.3	0	0	0	0	3.5	0	0	14	**292.3**
			2080	78.8	85.6	74.7	55.8	0	0	0	0	17.5	0	0	12.9	**325.3**
		8.5	2030	73.8	84.4	76	58.4	0	0	0	0	4.4	0	0	24.7	**321.7**
			2050	76.4	84.5	75.5	56.6	0	0	0	0	16.4	0	0	14.2	**323.6**
			2080	85.7	83.9	77.5	56.6	0	0	0	0	0	0	0	18.9	**322.6**
	Rubber		Present	87.8	88.2	107.6	18.9	0	0	0	0	0	0	13.8	0	**316.3**
		4.5	2030	96.6	109.2	109.3	75.7	0	0	0	0	68.5	0	61.6	46.8	**567.7**
			2050	80.2	109.6	117	76.8	0	0	0	0	10.7	0	0	29.5	**423.8**
			2080	100	110.8	108.8	85.4	0	0	0	0	35	0	0	25.2	**465.1**
		8.5	2030	96.6	109.2	107.8	86.7	0	0	0	0	11.2	0	3.8	42.7	**458**
			2050	99.8	110.1	108.1	85.4	0	0	0	0	33.5	0	0	28.9	**465.8**
			2080	107.6	109.6	112.3	86.8	0.2	0	0	0	0	0	0	32.9	**449.4**

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				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
AEU12 Southern And Central Foothills	Coconut+ pepper		Present	80.8	44.1	32.9	0	0	0	0	0	0	0	0	48.7	**206.5**
		4.5	2030	33.7	62.1	47.5	18.8	0	0	0	0	13.6	0	48.1	5.7	**229.5**
			2050	33.2	62.3	49.5	18.3	0	0	0	0	2.5	0	0	3.8	**169.6**
			2080	40	65.2	45.4	23.9	0	0	0	0	13.7	0	0	4.1	**192.3**
		8.5	2030	33.2	62.2	47.8	18.6	0	0	0	0	3.2	0	0	3.5	**168.5**
			2050	56.2	41.3	45.9	24.5	0	0	0	0	10.2	0	0	5.2	**183.3**
			2080	62.7	62	48.3	27.8	0	0	0	0	11.4	0	0	8.1	**220.3**
	Rubber		Present	105.7	70.4	64.4	1.3	0	0	0	0	0	0	0	69.5	**311.3**
		4.5	2030	49.9	83.9	74.2	41.5	0	0	0	0	22.8	0	50	11.4	**333.7**
			2050	49.8	84.4	76.6	40.9	0	0	0	0	6.7	0	0	7.6	**266**
			2080	52.3	85.7	73.7	50.8	0	0	0	0	23	0	0	6.5	**292**
		8.5	2030	49.4	84.1	74.7	41	0	0	0	0	7.3	0	0	7.3	**263.8**
			2050	73.1	63.8	73.3	51.2	0	0	0	0	15.9	0	0	9.1	**286.4**
			2080	75	83	77.3	55.6	0	0	0	0	18.8	0	0	10.3	**320**

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4.4.6 water requirement of major cropping systems of various AEUs in Alappuzha and impact of projected climate change

The crop evapotranspiration (ET_c) values of various cropping systems for AEU1, AEU3, AEU4, AEU5 and AEU9 of Alappuzha district were studied and presented in table 193.

Rice-vegetable and coconut monocropping are the major cropping systems of AEU1. In rice-vegetable cropping system the first season virippu is having a duration of four months (May to August) were the transplanting is done around first week of June and harvested during last week of August. In case of vegetables crop duration is about four months (September to January) and the date of planting is about last week of September and harvested during last week of January. Since, coconut is a perennial crop the ET_c value for a year is considered. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend in rice-vegetable. The ETc values of coconut will show an increasing trend from the present value except in 2030 of RCP 4.5.

Rice-fallow-fallow and coconut monocropping were found to be the major cropping systems of AEU3. In rice-fallow-fallow the first season virippu is having a duration of four months (May to August) were the transplanting date is around the first week of June and harvested during last week of August. Since, coconut is a perennial crop ET_c value for a year is considered. While comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend from the present value in case of rice and coconut except in 2030 of RCP 4.5 of coconut.

Rice-fallow-fallow and coconut monocropping are the major cropping systems of AEU4. In rice-fallow-fallow the only cropping season is virippu with a duration of four months (May to august) were the transplanting date is around first week of June and harvested around last week of august. Since, coconut is a perennial crop ET_c value for a year is considered. While comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend from the present value in case of rice and coconut except in 2030 of RCP 4.5 of coconut.

Rice-rice-vegetable and coconut monocropping are the major cropping systems of AEU5. In rice-rice-vegetable the first season virippu is having a duration of four months (May to august) and transplanted in first week of June and harvested in last week of August. The second season mundakan is having a duration of nearly six months (August to January) were the transplanting date about last week of September and harvested during first week of January. The third season vegetable is having a duration of five months (January to May) were the planting date around last week of January and harvested last week of May. Since, coconut is a perennial crop the ET_c value for a year is considered. Comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend in case of both rice and coconut except in 2030 of RCP 4.5 of coconut.

Coconut + pepper + banana and fallow-rice-fallow are the major cropping systems of AEU9. The second season mundakan of rice is having a duration of six months (August to January) the transplanting date is around last week of September and harvested during first week of January. When comparing the present and projected climate of RCP 4.5 and RCP 8.5 the annual ET_c value will show an increasing trend except in the case of 2030s of both cropping systems.

The water requirement for various cropping systems of AEU1, AEU3, AEU4, AEU5 and AEU9 of Alappuzha district were studied and presented in table 194.

Presently, the annual water requirement under the present situation is 267.4 and 232.6 mm in rice-fallow-fallow and coconut respectively in AEU1. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both rice-vegetable and coconut will show an increasing trend from the present value. Currently for rice, the irrigation is not required from the planting date to the harvest date. September and October months does not require irrigation for vegetables. In coconut the irrigation is not required almost seven months from May to November in present situation but in projected climate except five months (May to August and October) remaining months needs irrigation. In case of coconut the annual water requirement of future climate almost doubles comparing the present situation.

Currently, the annual water requirement under the present situation is 125.7 and 250.8 mm in rice-fallow-fallow and coconut respectively in AEU3. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of rice will not show much variation from the present value and there will be an increasing trend in the case of coconut. Irrigation is not required in case of rice from planting date to harvesting date. In coconut, annually seven months (May to November) does not require irrigation under the present condition and the projection will show a decrease to five months (May to August and October) remaining months need irrigation. In case of coconut the annual water requirement of projection shows an increase up to 50% to 100%.

Presently, the annual water requirement is 102.8 and 280.1 mm in rice-fallow-fallow and coconut respectively in AEU4. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of rice will not show much variation from the present value and there will be an increasing trend in the case of coconut. Irrigation is not required in case of rice from the planting date to harvesting date. In coconut, annually around seven months (May to November) does not require irrigation in present condition and the projection will show a decrease to five months (May to August and October). In coconut the annual water requirement of future climate almost doubles from the present value.

Currently, the annual water requirement is 420.3 and 215.3 mm in rice-rice-vegetable and coconut respectively in AEU5. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of rice-rice-vegetable and coconut will show an increasing trend from the present value. Irrigation is not required in case of rice from planting to harvesting date in first season virippu. In mundakan season except October remaining months need irrigation. In third season having vegetables also requires irrigation throughout the cropping period. In coconut, annually eight months (March to October) does not require irrigation under the present condition and the projection will show a decrease to five months (May to August and October). In rice-rice fallow cropping system the annual water requirement of future climate will show about 50% increase from the present value and in coconut it almost doubles from the present value.

Currently, the annual water requirement is 327.2 and 199 mm in coconut + pepper + banana and fallow-rice-fallow respectively in AEU9. When comparing the present and the projected climate of RCP 4.5 and RCP 8.5 the annual water requirement of both coconut

+ pepper + banana and fallow-rice-fallow will show an increasing trend except in the case of 2050 of RCP 4.5 in rice. Presently, irrigation is not required for six months (May to October) for coconut + pepper + banana and the projection will show a decrease to five months (May to August and October). In mundakan season every months from planting to harvest need irrigation.

Rice-rice-vegetable of AEU5 and coconut monocropping in all the five AEUs is having high water requirement within the district.

Table 193. ET_c values of various cropping systems in different AEUs of Alappuzha district

				Crop evapotranspiration ET_c (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU1 Southern Coastal Plain	Rice-vegetable		Present	110.5	*	*	*	22.8	136.6	131.2	97	16.6	74.9	97	133	**819.6**
		4.5	2030	107.6	*	*	*	22.8	137.1	131.6	97.7	16.8	77.4	94.2	135.5	**820.7**
			2050	109.3	*	*	*	23	138.3	132.7	98.2	16.9	78	95.2	136.1	**827.7**
			2080	110.9	*	*	*	23.3	139.9	134.4	99.5	17.2	78.8	96.6	138	**838.6**
		8.5	2030	108.4	*	*	*	22.8	137.1	131.6	97.7	16.9	77.4	94.6	135.1	**821.6**
			2050	111.1	*	*	*	23.1	139.9	134.1	99.4	17.1	78.8	96.8	136.9	**837.2**
			2080	115.7	*	*	*	23.8	144.2	139	102.4	17.6	81.1	101.1	141	**865.9**
	Coconut		Present	96.2	90.7	102.3	96.2	89.5	87.8	85.2	87.1	88.3	91.6	85.5	95	**1095.4**
		4.5	2030	101.8	103.7	120.8	107.5	96.8	75.8	70.6	73	63.1	94.7	83.7	100	**1091.5**
			2050	94.5	90.7	103.5	97	93.8	94.2	89.4	92.4	89.7	95.7	84.5	97.2	**1122.6**
			2080	95.9	91.8	105.2	98.3	95.4	95.3	90.3	93.5	91	96.7	85.7	98.6	**1137.7**
		8.5	2030	93.7	89.8	102.6	96.4	93.2	93.4	88.6	91.9	89.2	94.9	83.9	96.6	**1114.2**
			2050	95.9	91.3	103.8	97.6	94.4	95.3	90.3	93.5	90.7	96.7	86	97.9	**1133.4**
			2080	99.5	94.2	107.1	101	96.6	98.3	93.7	96.4	93.6	99.5	89.8	100.8	**1170.5**
AEU3 Onattukara Sandy Plain	Rice-fallow-Fallow		Present	*	*	*	*	21.1	128.5	127.9	93.4	*	*	*	*	**370.9**
		4.5	2030	*	*	*	*	22.6	137.1	132.2	85.5	*	*	*	*	**377.4**
			2050	*	*	*	*	22.9	138.6	132.4	98.7	*	*	*	*	**392.6**
			2080	*	*	*	*	23.1	140.3	136.2	100.5	*	*	*	*	**400.1**
		8.5	2030	*	*	*	*	22.6	137.3	133.2	98.6	*	*	*	*	**391.7**
			2050	*	*	*	*	23.1	140.2	135.9	100.4	*	*	*	*	**399.6**
			2080	*	*	*	*	23.8	145.1	140.1	102.7	*	*	*	*	**411.7**
	Coconut		Present	96.6	90.9	102.4	96.2	89.3	87.5	85.2	86.9	88.4	91.9	85.9	95.5	**1096.7**
		4.5	2030	102.3	103.2	120	107.4	96.5	76.3	71.6	74.3	54.3	94.9	84.4	97.8	**1083**
			2050	94.3	89.8	102.5	96.4	92.4	94.4	89.6	93.2	90	95.7	85.3	95.3	**1118.9**
			2080	95.7	91.1	103.7	97.6	94	95.6	91.6	94.5	91.1	96.8	86.5	96.6	**1134.6**
		8.5	2030	102.6	103.3	120.1	107.7	96.7	76.6	72	74.5	64.2	95.1	84.8	97.8	**1095.4**
			2050	95.2	90.2	103.4	97.2	93.7	95.6	91.6	94.2	91.2	96.7	88.3	96.2	**1133.5**
			2080	98.7	92.9	106.1	99.6	96.8	98.9	94.7	96.8	95.1	99.5	92.5	98.7	**1170.3**

AEU	Cropping systems	RCP	Year	Crop evapotranspiration ET_c (mm)												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
AEU4 Kuttanad	Rice-Fallow-Fallow		Present	*	*	*	*	21.1	128.7	128.1	93.4	*	*	*	*	**371.3**
		4.5	2030	*	*	*	*	22.6	136.6	130.8	97.6	*	*	*	*	**387.6**
			2050	*	*	*	*	22.9	137.7	132.7	98.7	*	*	*	*	**392**
			2080	*	*	*	*	23.1	139.6	134.4	99.8	*	*	*	*	**396.9**
		8.5	2030	*	*	*	*	22.6	136.9	131.7	98	*	*	*	*	**398.2**
			2050	*	*	*	*	23	139.2	134.6	99.7	*	*	*	*	**396.5**
			2080	*	*	*	*	23.8	143.9	138.4	102.6	*	*	*	*	**408.7**
	Coconut		Present	96.4	90.9	102.3	96.2	89.4	87.7	85.2	87.1	88.3	91.8	85.7	95.3	**1096.3**
		4.5	2030	102.5	104	120.6	107.5	96.3	75.6	70.5	73.4	63.4	94.8	84.1	98.7	**1091.4**
			2050	95	90.3	102.7	96.8	92.5	93.9	89.4	93.1	89.9	95.6	85.3	95.9	**1120.4**
			2080	96.6	91.9	104.6	98.3	93.9	95.1	90.6	94.1	90.8	96.6	86.3	97.3	**1136.1**
		8.5	2030	94.3	89.4	101.7	96.1	91.9	93.3	88.7	92.4	89.2	94.9	84.7	96.5	**1113.1**
			2050	96	91.2	103.9	97.9	93.4	94.9	90.8	94	90.8	96.4	85.6	96.7	**1131.6**
			2080	98.9	93.3	106.3	100.1	96.2	98.2	93.8	96.7	94.3	99.5	92.5	99.5	**1169.3**
AEU5 Pokkali lands	Rice-Rice-vegetable		Present	23.4	81.5	125.5	146	143.2	129	128.4	94.4	52.4	134.7	130.8	141.4	**1330.7**
		4.5	2030	22.9	83.8	131.7	151.9	154.1	136.9	131.8	98.3	53	139.7	126.4	147.3	**1377.8**
			2050	23.6	85.1	132.8	153.4	155.3	138.1	133	99.5	53.6	140.8	127.8	145.3	**1388.3**
			2080	24	86.1	135.1	155.9	157.6	139.9	134.6	100.7	54.2	142.5	129.5	147.4	**1407.5**
		8.5	2030	23	84	131.8	152.3	154.5	137	132.3	100.3	53.3	140.1	126.7	147.8	**1383.1**
			2050	24	85.9	133.8	154.7	156.5	139.9	134.4	100.6	54.1	142.2	129.7	146.5	**1402.3**
			2080	25.1	88.7	138.3	160.9	160.7	144.4	138.8	103.8	55.9	146.7	135.5	149.9	**409.9**
	Coconut		Present	96	90.6	102.2	96.2	89.5	87.8	85.5	87.1	88.2	91.5	85.4	94.8	**1094.8**
		4.5	2030	99.5	103.7	121.5	108	97.4	76.1	70.9	73.3	53.4	95.1	83.6	102.4	**1084.9**
			2050	94.6	91.6	104.9	98.5	95.1	94.2	89.4	92.6	89.8	95.8	84.8	97.9	**1129.2**
			2080	96.1	93	106.9	100.1	96.9	95.3	90.5	93.6	90.9	96.9	85.8	99.3	**1145.3**
		8.5	2030	91.7	90.7	104.3	97.8	94.8	93.3	88.8	92.9	89.4	95.3	83.9	99.5	**1122.4**
			2050	96.1	92.5	105.6	99.2	95.8	95.2	90.4	93.8	91	96.9	86	98.8	**1141.3**
			2080	100.2	95	108.5	102.6	97.9	98.5	93.5	96.8	93.7	99.9	89.9	101.2	**1177.7**

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				Crop evapotranspiration ET_c (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
AEU9 South Central Laterites	Coconut+ pepper + banana		Present	96.6	90.9	102.4	96.2	89.4	87.6	85.2	86.9	88.4	91.9	85.9	95.4	**1096.8**
		4.5	2030	101.4	102.6	120.2	108.2	97.2	77.4	72.8	75.3	54.8	94.7	83.9	96.7	**1085.2**
			2050	93.6	89.8	104.1	97.9	93.9	95.2	91.3	94	90.3	95.7	86.9	94.4	**1127.1**
			2080	95	91.5	105.2	99.1	95.5	96.2	92.2	95.1	91.4	96.6	86.1	95.7	**1139.6**
		8.5	2030	93	89	103	97.3	93.6	94.4	90.4	93.3	89.6	94.9	86.3	93.6	**1118.4**
			2050	94.9	91.1	105.2	99.1	95.3	96.1	92	95	91.6	96.7	88.3	95.5	**1140.8**
			2080	98.7	93.3	107.1	101.2	97.8	99.6	95.4	97.6	95.5	99.4	92	97.8	**1175.4**
	Fallow-rice-fallow		Present	4.4	*	*	*	*	*	*	0.9	52.4	135.2	131.4	142.3	**466.6**
		4.5	2030	4.3	*	*	*	*	*	*	1	53.1	139.3	126	138	**461.7**
			2050	4.3	*	*	*	*	*	*	1	53.7	140.6	130.3	138.8	**468.7**
			2080	4.4	*	*	*	*	*	*	1	54.3	142	129.2	140.9	**471.8**
		8.5	2030	4.3	*	*	*	*	*	*	1	53.2	139.4	129.5	137.8	**465.2**
			2050	4.4	*	*	*	*	*	*	1	54.5	142	132.2	140.6	**474.7**
			2080	4.5	*	*	*	*	*	*	1	56.7	145.9	138	144	**490.1**

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Table 194. Water requirement of various cropping systems in different AEUs of Alappuzha district

				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU1 Southern Coastal Plain	Rice-vegetable		Present	96.1	*	*	*	74.8	0	0	0	0	0	1.3	95.2	**267.4**
		4.5	2030	98.2	*	*	*	74.8	0	0	0	14.6	0	35.5	94.8	**317.9**
			2050	98.7	*	*	*	74.8	0	0	0	7.5	0	29.2	91.2	**301.4**
			2080	101.6	*	*	*	74.8	0	0	0	0	0	30.7	91.4	**298.5**
		8.5	2030	99.1	*	*	*	74.8	0	0	0	14.6	0	35.4	92.7	**316.6**
			2050	101.1	*	*	*	74.8	0	0	0	0	0	50.5	71.5	**297.9**
			2080	103	*	*	*	74.9	0	0	0	0	0	74.3	124	**376.2**
	Coconut		Present	78.2	48.8	47.1	1.3	0	0	0	0	0	0	0	57.2	**232.6**
		4.5	2030	91	93.2	97.7	54.4	0	0	0	0	46.6	0	24.5	59.2	**466.6**
			2050	82.6	81.2	90.2	50.3	0	0	0	0	50.4	0	18.1	52.3	**425.1**
			2080	85.4	79.9	88.8	49.5	0	0	0	0	4.8	0	19.4	52	**379.8**
		8.5	2030	83.2	79.4	88.3	50.1	0	0	0	0	79.9	0	24.4	54.1	**459.4**
			2050	85.3	90	78.7	49.2	0	0	0	0	4.9	0	39.7	32.3	**380.1**
			2080	85.2	93.6	77.2	59.7	0	0	0	0	0	0	63	83.8	**462.5**
AEU3 Onattukara Sandy Plain	Rice-fallow-Fallow		Present	*	*	*	*	125.7	0	0	0	*	*	*	*	**125.7**
		4.5	2030	*	*	*	*	125.9	0	0	0	*	*	*	*	**125.9**
			2050	*	*	*	*	125.9	0	0	0	*	*	*	*	**125.9**
			2080	*	*	*	*	125.9	0	0	0	*	*	*	*	**125.9**
		8.5	2030	*	*	*	*	125.9	0	0	0	*	*	*	*	**125.9**
			2050	*	*	*	*	125.9	0	0	0	*	*	*	*	**125.9**
			2080	*	*	*	*	126	0	0	0	*	*	*	*	**126**
	Coconut		Present	76.1	60.2	60.5	2.8	0	0	0	0	0	0	0	51.2	**250.8**
		4.5	2030	87.8	101.9	96.5	48.4	0	0	0	0	7.7	0	72.6	37.2	**452.1**
			2050	79.5	88.7	75.6	41.8	0	0	0	0	0	0	2.6	30.6	**318.8**
			2080	66.6	89.9	75.3	43.2	0	0	0	0	0	0	2.8	27	**304.8**
		8.5	2030	88.2	102.2	95.7	48.3	0	0	0	0	8.3	0	72.7	34.8	**450.2**
			2050	84.6	88.6	77.7	51.8	0	0	0	0	5.3	0	51.4	15.4	**374.8**
			2080	96.3	81.7	69.9	55.8	0	0	0	0	0.7	0	0	28.8	**333.2**

water requirement (mm)																
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU4 Kuttanad	Rice-Fallow-Fallow		Present	*	*	*	*	102.8	0	0	0	*	*	*	*	**102.8**
		4.5	2030	*	*	*	*	102.8	0	0	0	*	*	*	*	**102.8**
			2050	*	*	*	*	102.8	0	0	0	*	*	*	*	**102.8**
			2080	*	*	*	*	102.8	0	0	0	*	*	*	*	**102.8**
		8.5	2030	*	*	*	*	102.8	0	0	0	*	*	*	*	**102.8**
			2050	*	*	*	*	102.8	0	0	0	*	*	*	*	**102.8**
			2080	*	*	*	*	102.9	0	0	0	*	*	*	*	**102.9**
	Coconut		Present	89.2	76	61	4	0	0	0	0	0	0	0	49.9	**280.1**
		4.5	2030	56.3	99.9	98.5	61.3	0	0	0	0	52	0	58	37.4	**463.4**
			2050	62.3	89.6	74.6	63.6	0	0	0	0	65.3	0	59.7	38.2	**453.3**
			2080	64.2	88.7	75.4	57.9	0	0	0	0	71.4	0	58.3	32.8	**448.7**
		8.5	2030	47.8	88.9	75.8	49.4	0	0	0	0	88.3	0	57.9	33	**441.1**
			2050	63.8	90.7	72.5	58.1	0	0	0	0	71.1	0	57.1	35.8	**449.1**
			2080	88.8	87.1	78.9	68.4	0	0	0	0	0	0	0	30.2	**353.4**
AEU5 Pokkali lands	Rice-Rice-vegetable		Present	19.8	35.1	1.7	0	111.5	0	0	0	76.7	0.9	48.8	125.8	**420.3**
		4.5	2030	17.5	83.4	109.9	87.5	115.6	0	0	0.9	94.4	0.6	83.4	95.4	**688.6**
			2050	22.4	74.3	110.2	98.8	113.2	0	0	1	158.5	0	66.2	101.6	**746.2**
			2080	20.6	82.7	110	132.1	116.5	0	0	1	127.3	0	89.6	82.4	**762.2**
		8.5	2030	19.4	80.9	110	106.3	111.7	0	0	1	159	0	96.6	93.7	**778.6**
			2050	20.6	82.7	113	128	114.5	6	6	7	123.5	0	87.2	84	**772.5**
			2080	21.7	85.5	117.5	134.2	116.1	0	0	1	125	1.4	92.8	87.4	**782.6**
	Coconut		Present	81.6	44.2	0	0	0	0	0	0	0	0	10.3	79.2	**215.3**
		4.5	2030	56.1	103.4	99.7	43.5	0	0	0	0	11.5	0	40.7	50.4	**405.3**
			2050	84	80.9	82.4	44	0	0	0	0	78.6	0	24.2	54.3	**448.4**
			2080	65.9	89.7	81.9	76.5	0	0	0	0	10.1	0	43.1	34.3	**401.5**
		8.5	2030	61.6	87.6	82.5	52	0	0	0	0	79.8	0	53.8	45.5	**462.8**
			2050	65.9	89.3	84.8	72.5	0	0	0	0	4.5	0	43.4	36.3	**396.7**
			2080	70	91.7	87.7	75.9	0	0	0	0	5.4	0	47.3	38.7	**416.7**

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				water requirement (mm)												
AEU	Cropping systems	RCP	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
AEU9 South Central Laterites	Coconut +pepper +banana		Present	96.4	89	101.4	14	0	0	0	0	0	0	21.9	4.5	**327.2**
		4.5	2030	89	101.9	98.2	47	0	0	0	0	28.8	0	2.2	40.6	**407.7**
			2050	83.2	88.2	69.7	56.7	0	0	0	0	19.3	0	0	23.2	**340.3**
			2080	60.5	90.7	79.4	49.3	0	0	0	0	28.3	0	62.6	25.4	**396.2**
		8.5	2030	58	88.1	74.3	53.7	0	0	0	0	65.9	9	64.3	25.5	**438.8**
			2050	60	90.4	80.9	45.2	0	0	0	0	0	0	43.3	30.1	**349.9**
			2080	83.9	72.7	79.9	54.8	0	0	0	0	0	0	44.6	33.4	**369.3**
	Fallow-rice-fallow		Present	4.4	*	*	*	*	*	*	0.9	92.7	1.8	67.6	31.6	**199**
		4.5	2030	4.3	*	*	*	*	*	*	1	122.9	0	31	81.8	**241**
			2050	4.3	*	*	*	*	*	*	1	109.7	0	8	67.6	**190.6**
			2080	4.4	*	*	*	*	*	*	1	112.9	5.1	105.8	70.5	**299.7**
		8.5	2030	4.3	*	*	*	*	*	*	1	129.8	1.6	107.6	69.8	**314.1**
			2050	4.4	*	*	*	*	*	*	1	96	6.3	87.4	75.2	**270.3**
			2080	4.5	*	*	*	*	*	*	1	97.9	5.7	90.6	79.7	**279.4**

4.5 Crop weather calender of rice based cropping system

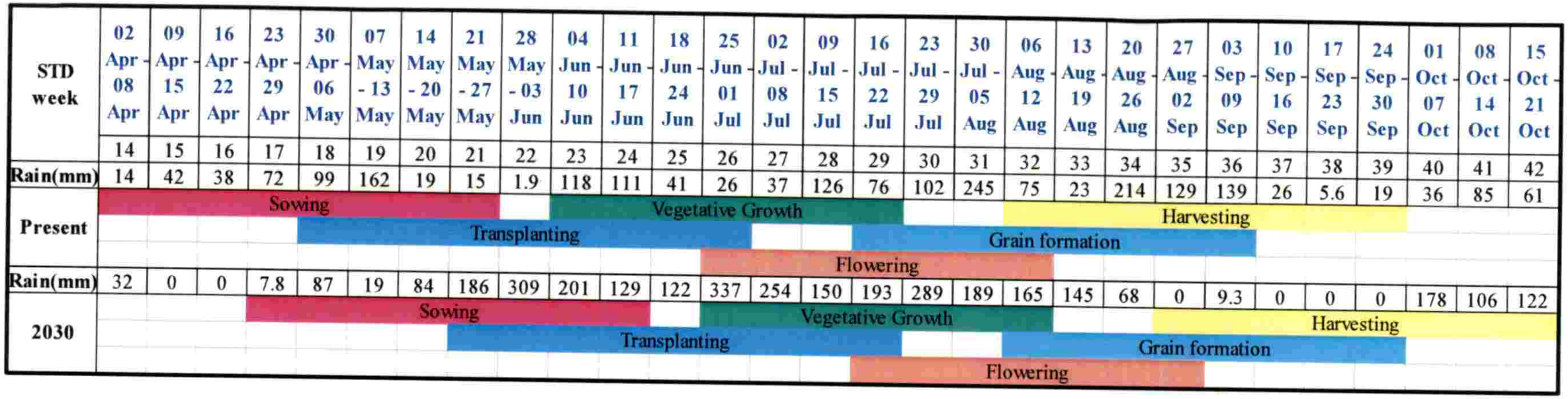

Fig.8. Crop weather calendar of southern coastal plain (AEU1) of Alappuzha district

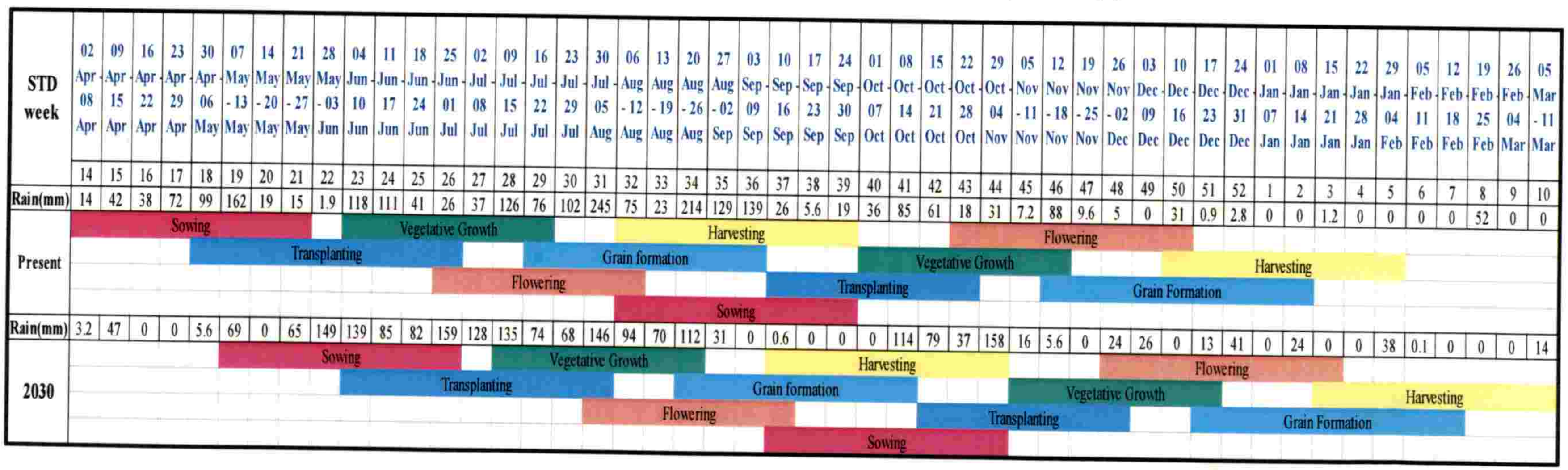

Fig.9. Crop weather calendar of southern coastal plain (AEU1) of Thiruvananthapuram district

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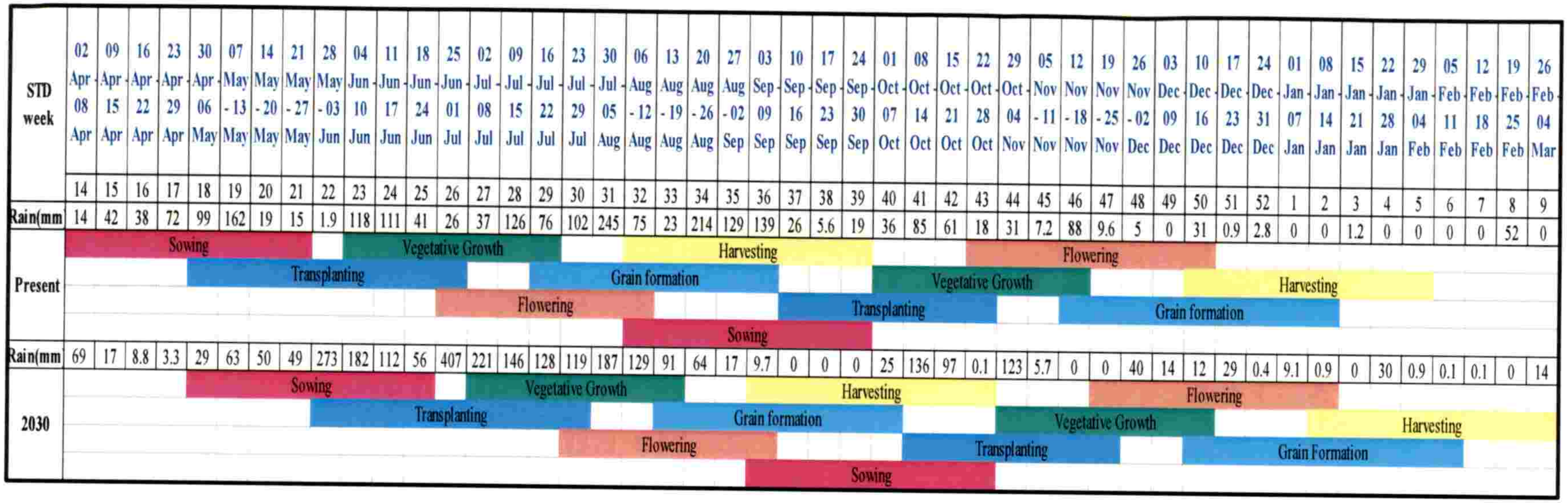

Fig.10. Crop weather calendar of southern coastal plain (AEU1) of Kollam district

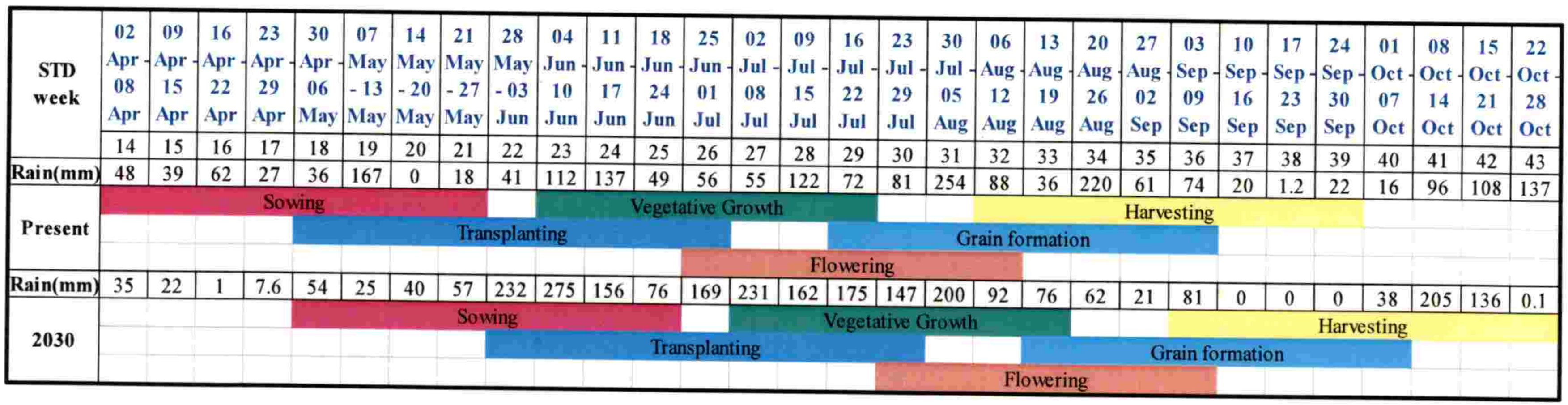

Fig. 11. Crop weather calendar of onattukara sandy plain (AEU3) of Alappuzha district

STD week	02 Apr - 08 Apr	09 Apr - 15 Apr	16 Apr - 22 Apr	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb	19 Feb - 25 Feb	26 Feb - 04 Mar
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9
Rain(mm)	48	39	62	27	36	167	0	18	41	112	137	49	56	55	122	72	81	254	88	36	220	61	74	20	1.2	22	16	96	108	137	14	8.2	74	12	2.2	0	70	0	0	0	0	0	0	0	0	0	33	0
Present	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth			Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting				Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering											
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation				Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth				Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting				
													Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation							
																			Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing																						
Rain(mm)	18	42	0.1	7.3	51	43	34	76	127	270	115	119	193	262	153	138	102	181	114	116	39	20	79	0	0	0	41	221	57	6.6	10	2.6	0	0	3.8	7.9	8.2	4.6	0.7	2.2	2.5	0	34	1	0.2	0.1	0	7.9
2030					Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth			Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting				Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering							
									Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation			
																	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering								Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth				Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
																							Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing																		

Fig. 12. Crop weather calendar of onattukara sandy plain (AEU3) of Kollam district

STD week	02 Apr - 08 Apr	09 Apr - 15 Apr	16 Apr - 22 Apr	23 Apr - 29 Apr	30 Apr - 06 May	07 May - 13 May	14 May - 20 May	21 May - 27 May	28 May - 03 Jun	04 Jun - 10 Jun	11 Jun - 17 Jun	18 Jun - 24 Jun	25 Jun - 01 Jul	02 Jul - 08 Jul	09 Jul - 15 Jul	16 Jul - 22 Jul	23 Jul - 29 Jul	30 Jul - 05 Aug	06 Aug - 12 Aug	13 Aug - 19 Aug	20 Aug - 26 Aug	27 Aug - 02 Sep	03 Sep - 09 Sep	10 Sep - 16 Sep	17 Sep - 23 Sep	24 Sep - 30 Sep	01 Oct - 07 Oct	08 Oct - 14 Oct	15 Oct - 21 Oct	22 Oct - 28 Oct	29 Oct - 04 Nov	05 Nov - 11 Nov	12 Nov - 18 Nov	19 Nov - 25 Nov	26 Nov - 02 Dec	03 Dec - 09 Dec	10 Dec - 16 Dec	17 Dec - 23 Dec	24 Dec - 31 Dec	01 Jan - 07 Jan	08 Jan - 14 Jan	15 Jan - 21 Jan	22 Jan - 28 Jan	29 Jan - 04 Feb	05 Feb - 11 Feb	12 Feb - 18 Feb	19 Feb - 25 Feb	26 Feb - 04 Mar
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9
Rain(mm)	5.4	41.8	38.2	111	97.9	6.8	8	4.5	32.8	40	58.8	89.4	37.4	70.8	110	11.6	30.4	23	121	202	58.6	116	114	49.4	2.1	0	0	10.6	36.3	106	51.5	31.7	24.5	2.4	0	0	0	2	27.9	5.2	0	0	0	0	0	0	0	0
Present	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth			Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting				Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering											
					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation				Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth				Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting				
													Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation							
																			Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing																						
Rain(mm)	66.1	22.8	0	3.2	57.6	68.4	63.5	79	285	223	141	246	277	174	238	98.2	144	219	170	103	90.6	24.2	5.7	0	0	0	41.7	248	76.5	2	17	2.4	0	0	5.3	9.9	2.7	1.5	0.1	8.9	0.4	0	4.4	1.2	0.3	0.1	0	16.9
2030					Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing		Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth			Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting				Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering							
									Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation	Grain formation				Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth	Vegetative Growth				Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting	Harvesting
																	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering					Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting	Transplanting			Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation	Grain Formation			
																							Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing	Sowing																		

Fig 13. Crop weather calendar of kuttanad (AEU4) in Kottayam district

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<table>
<tr><td rowspan="2">STD week</td><td>02 Apr - 08 Apr</td><td>09 Apr - 15 Apr</td><td>16 Apr - 22 Apr</td><td>23 Apr - 29 Apr</td><td>30 Apr - 06 May</td><td>07 May - 13 May</td><td>14 May - 20 May</td><td>21 May - 27 May</td><td>28 May - 03 Jun</td><td>04 Jun - 10 Jun</td><td>11 Jun - 17 Jun</td><td>18 Jun - 24 Jun</td><td>25 Jun - 01 Jul</td><td>02 Jul - 08 Jul</td><td>09 Jul - 15 Jul</td><td>16 Jul - 22 Jul</td><td>23 Jul - 29 Jul</td><td>30 Jul - 05 Aug</td><td>06 Aug - 12 Aug</td><td>13 Aug - 19 Aug</td><td>20 Aug - 26 Aug</td><td>27 Aug - 02 Sep</td><td>03 Sep - 09 Sep</td><td>10 Sep - 16 Sep</td><td>17 Sep - 23 Sep</td><td>24 Sep - 30 Sep</td><td>01 Oct - 07 Oct</td><td>08 Oct - 14 Oct</td><td>15 Oct - 21 Oct</td><td>22 Oct - 28 Oct</td></tr>
<tr><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td><td>41</td><td>42</td><td>43</td></tr>
<tr><td>Rain(mm)</td><td>5.4</td><td>41.8</td><td>38.2</td><td>111</td><td>97.9</td><td>6.8</td><td>8</td><td>4.5</td><td>32.8</td><td>40</td><td>58.8</td><td>89.4</td><td>37.4</td><td>70.8</td><td>110</td><td>11.6</td><td>30.4</td><td>2.3</td><td>121</td><td>202</td><td>58.6</td><td>116</td><td>114</td><td>49.4</td><td>2.1</td><td>0</td><td>0</td><td>10.6</td><td>36.3</td><td>106</td></tr>
<tr><td rowspan="3">Present</td><td colspan="8">Sowing</td><td></td><td colspan="7">Vegetative Growth</td><td colspan="2"></td><td colspan="8">Harvesting</td><td colspan="4"></td></tr>
<tr><td colspan="4"></td><td colspan="9">Transplanting</td><td colspan="2"></td><td colspan="8">Grain formation</td><td colspan="7"></td></tr>
<tr><td colspan="12"></td><td colspan="7">Flowering</td><td colspan="11"></td></tr>
<tr><td>Rain(mm)</td><td>52.8</td><td>23.6</td><td>9.1</td><td>2</td><td>33.3</td><td>96.6</td><td>47.4</td><td>59.8</td><td>242</td><td>199</td><td>109</td><td>89.2</td><td>346</td><td>226</td><td>174</td><td>161</td><td>103</td><td>238</td><td>135</td><td>121</td><td>56.8</td><td>50</td><td>14.5</td><td>2.1</td><td>0</td><td>0</td><td>0</td><td>278</td><td>90.2</td><td>3.5</td></tr>
<tr><td rowspan="3">2030</td><td colspan="4"></td><td colspan="8">Sowing</td><td></td><td colspan="7">Vegetative Growth</td><td colspan="2"></td><td colspan="8">Harvesting</td></tr>
<tr><td colspan="8"></td><td colspan="9">Transplanting</td><td colspan="2"></td><td colspan="8">Grain formation</td><td colspan="3"></td></tr>
<tr><td colspan="16"></td><td colspan="7">Flowering</td><td colspan="7"></td></tr>
</table>

Fig 14. Crop weather calendar of kuttanad (AEU4) in Pathanamthitta district

<table>
<tr><td rowspan="2">STD week</td><td>02 Apr - 08 Apr</td><td>09 Apr - 15 Apr</td><td>16 Apr - 22 Apr</td><td>23 Apr - 29 Apr</td><td>30 Apr - 06 May</td><td>07 May - 13 May</td><td>14 May - 20 May</td><td>21 May - 27 May</td><td>28 May - 03 Jun</td><td>04 Jun - 10 Jun</td><td>11 Jun - 17 Jun</td><td>18 Jun- 24 Jun</td><td>25 Jun - 01 Jul</td><td>02 Jul - 08 Jul</td><td>09 Jul - 15 Jul</td><td>16 Jul - 22 Jul</td><td>23 Jul - 29 Jul</td><td>30 Jul - 05 Aug</td><td>06 Aug - 12 Aug</td><td>13 Aug - 19 Aug</td><td>20 Aug - 26 Aug</td><td>27 Aug - 02 Sep</td><td>03 Sep - 09 Sep</td><td>10 Sep - 16 Sep</td><td>17 Sep - 23 Sep</td><td>24 Sep - 30 Sep</td><td>01 Oct - 07 Oct</td><td>08 Oct - 14 Oct</td><td>15 Oct - 21 Oct</td></tr>
<tr><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td><td>36</td><td>37</td><td>38</td><td>39</td><td>40</td><td>41</td><td>42</td></tr>
<tr><td>Rain(mm)</td><td>5.4</td><td>41.8</td><td>38.2</td><td>111</td><td>97.9</td><td>6.8</td><td>8</td><td>4.5</td><td>32.8</td><td>40</td><td>58.8</td><td>89.4</td><td>37.4</td><td>70.8</td><td>110</td><td>11.6</td><td>30.4</td><td>2.3</td><td>121</td><td>202</td><td>58.6</td><td>116</td><td>114</td><td>49.4</td><td>2.1</td><td>0</td><td>0</td><td>10.6</td><td>36.3</td></tr>
<tr><td rowspan="3">Present</td><td colspan="8">Sowing</td><td></td><td colspan="7">Vegetative Growth</td><td colspan="2"></td><td colspan="8">Harvesting</td><td colspan="3"></td></tr>
<tr><td colspan="4"></td><td colspan="9">Transplanting</td><td colspan="2"></td><td colspan="8">Grain formation</td><td colspan="6"></td></tr>
<tr><td colspan="12"></td><td colspan="7">Flowering</td><td colspan="10"></td></tr>
<tr><td>Rain(mm)</td><td>45.3</td><td>0</td><td>0</td><td>4.8</td><td>46.8</td><td>17.9</td><td>85.5</td><td>64.6</td><td>218</td><td>323</td><td>144</td><td>95.3</td><td>239</td><td>179</td><td>205</td><td>197</td><td>144</td><td>242</td><td>135</td><td>142</td><td>124</td><td>0</td><td>2.4</td><td>0</td><td>0</td><td>0</td><td>41.8</td><td>218</td><td>24.5</td></tr>
<tr><td rowspan="3">2030</td><td colspan="3"></td><td colspan="8">Sowing</td><td></td><td colspan="7">Vegetative Growth</td><td colspan="2"></td><td colspan="8">Harvesting</td></tr>
<tr><td colspan="7"></td><td colspan="9">Transplanting</td><td colspan="2"></td><td colspan="8">Grain formation</td><td colspan="3"></td></tr>
<tr><td colspan="15"></td><td colspan="7">Flowering</td><td colspan="7"></td></tr>
</table>

Fig 15. Crop weather calendar of kuttanad (AEU4) in Alappuzha district

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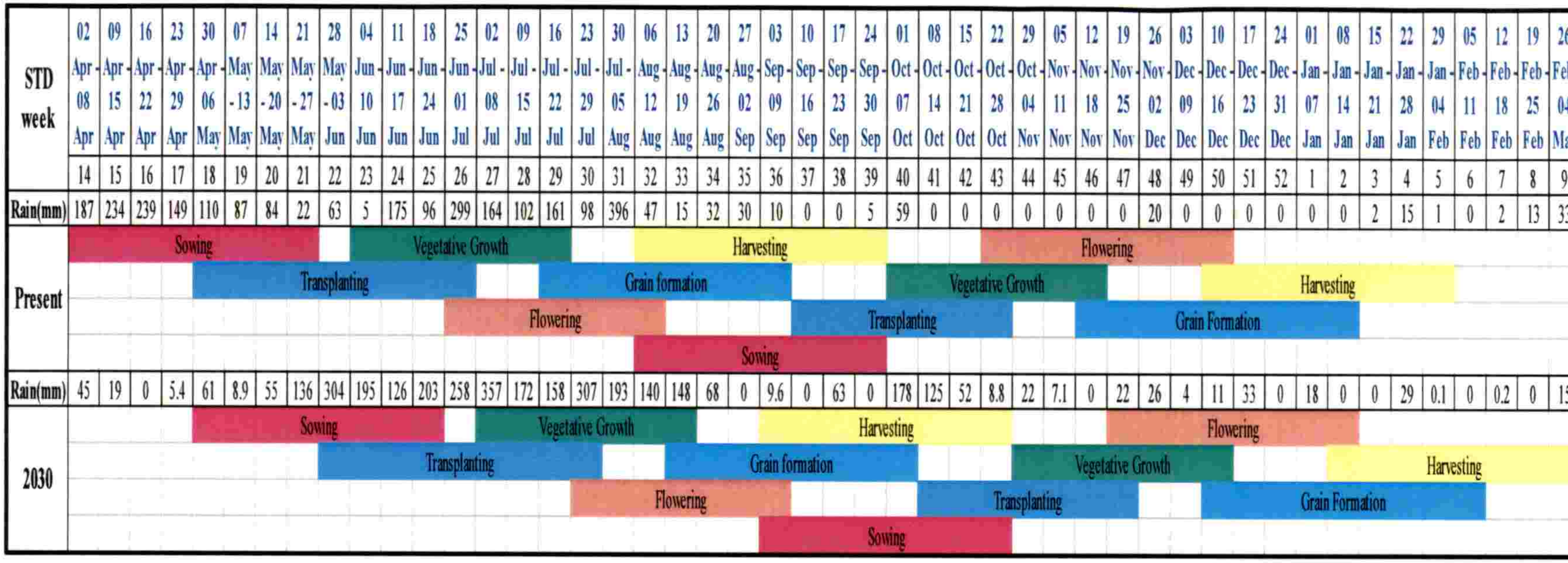

Fig 16. Crop weather calendar of pokkali lands (AEU5) in Alappuzha district

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The figures (fig.8 to 16) show the present and expected changes of rice crop in southern coastal plain (AEU1), Onattukara sandy plain (AEU3), Kuttanad (AEU4) and Pokkali lands (AEU5) of Thiruvananthapuram, Kollam, Pathanamthitta, Kottayam and Alappuzha calendar under projected climate. As a general trend, 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. It is also evident from the figures that the sowing date will be delayed by three weeks in AEU1 and AEU4 of Alappuzha district, four weeks in AEU1, AEU3 of Kollam district, AEU4 of Kottayam and Pathanamthitta district and AEU3 and AEU5 of Alappuzha district. Sowing date will be delayed by five weeks in AEU1 of Thiruvananthapuram 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 and will be under heavy rains at time of harvest in almost all the studied cases of different AEU. AEU5 of Alappuzha district was found to have an increase in the rainfall during grain formation stage with respect to other AEUs.

In general, there will be excess water available during rainy season (monsoon), even after fulfilling all the needs of user sectors and then will be shorter during non-monsoon seasons which may be reduced only through long-term storage structures. As more and larger scale storage structures have limitations due to the recent enforcement of environmental clearances, a realistic approach to 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 leads to high soil erosion and nutrient loss and worsen the crop productivity.

In projected climate of both RCP 4.5 and 8.5 there will be the probability to decrease in the number of months having the surplus. The annual surplus values will have an increasing trend in Idukki, Kottayam and Alappuzha districts and a decreasing trend in Thiruvananthapuram, Kollam and Pathanamthitta 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.

Given climate change, farmers develop coping mechanisms such as adjusting some of their farming practices. They have to design their own agricultural calendar by relying on personal experience. Due to climate change, the 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.

CHAPTER 5. SUMMARY

Climate change poses an emerging threat to sustainability of socio-economic development, livelihoods, and environmental management across the globe. Rising temperatures associated with climate change will likely have a detrimental impact on crop production, livestock, fishery and allied sectors. Agriculture faces hastily growing challenges because it must supply food to an increasing population under shifting climatic conditions. Kerala state is considered to be highly susceptible to climate change due to its high dependency of climate sensitive sectors like agriculture, fisheries, forest, water resource and health. The purpose of this study is to delineate the effects of climate change on regional water availability, changes in the cropping pattern and water requirement at agro ecological unit level in southern districts of Kerala.

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

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 Agro ecological Units of southern Kerala.

5.1 Methodology

The software used for the study include WEATHER COCK v 1.5 to compute PET and Thornthwaite water balances and CROPWAT for reference evapotranspiration, crop water requirements and irrigation requirements for the development of irrigation schedules under various management conditions and scheme water supply.

5.2 Major findings of the study

- The estimated annual rainfall in most of the AEUs of Thiruvananthapuram, Kollam and Pathanamthitta districts show a decreasing trend in the projected climate and an increasing trend in Idukki, Kottayam and Alappuzha.

- In most of the cases, increase in rainfall availability during the months of June and July and decrease in January February and September months are predicted.
- The number of annual rainy days generally shows a decreasing trend. The number of rainy days during the months of September, October and November will have a decreasing trend and May, June and July months have an increasing 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 most of the cases.
- Compared to the present situation, the chances of occurrence of high rainfall events (>50 mm) will be more in projected climate than low rainfall events (10 mm to <50 mm).
- In most of the agro ecological units in southern Kerala, a decreasing pattern in the length of growing period in projected climate as per RCP 4.5 and 8.5 is expected.
- In projected climate, the annual potential evapotranspiration will have the higher probability to decrease from the present value. The maximum value for potential evapotranspiration could be observed during May and June months.
- The projected climate will have an increasing trend in annual deficit values and also an increase in the number of months showing the deficit.
- In projected climate of both RCP 4.5 and 8.5, there will be high probability of having reduction in the number of months having the surplus.
- The annual surplus values will have an increasing trend in Idukki, Kottayam and Alappuzha districts and a decreasing trend in Thiruvananthapuram, Kollam and Pathanamthitta district.
- The crop evapotranspiration values of rice based cropping system in most cases will show a tendency to increase in projected climate.
- 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 ET_c 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 in 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 by three to five weeks.
- It can also be observed that the crops 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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Impact of projected climate change on cropping pattern of different agro ecological units of southern Kerala

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ABSTRACT OF THE THESIS

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ABSTRACT

Climate change poses an emerging threat to sustainability of social and economic development, livelihoods, and environmental management across the globe. Characterization of the ecosystems using the AEZ concept is a good decision making approach for variety of farming activities performed by the farmers and is a useful tool for the studying the impact of climate change. The objectives of this study are (1) to study rainfall variability and to determine water availability periods of Agro ecological units of 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 southern 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 Thiruvananthapuram, Kollam and Pathanamthitta districts show a decreasing trend in the projected climate and an increasing trend in Idukki, Kottayam and Alappuzha. The number of annual rainy days generally shows a decreasing 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 there will be high probability of having reduction in the number of months having the surplus and an increase in the number of deficit. The crop evapotranspiration values of rice based cropping system will show a tendency to increase. 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.