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Effect of climate changes on the Coorg Mandarin-An overview

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Abstract:
Climate change is the drastic and hazardous problem in the world now a days and these effecting to agriculture directly or indirectly. Climate change impact on different environmental components-land, soil, water, atmosphere, biosphere is creating very serious and effective situation. These are changing the public scenarios. Agriculture is arguably the most important sector of the economy that is highly dependent on climate. Climate change is just one of vital factors that may affect global orange production. It is nonetheless likely to be one of the most important ones. It is true that a great degree of uncertainty still exists with regard to how individual producing regions will be affected, and how climate change will affect overall orange production. However, experts expect some changes to occur, and these could be significant in some regions. This paper throws light on impact of climatic conditions on Coorg orange production.

Keywords: *Climate change, orange, environmental components.*

Introduction:

Coorg Mandarin, Citrus reticulata Blanco is an important fruit crop of Kodagu, Hassan and Chikkamagaluru districts of Karnataka state. In Mandarins are raises as rainfed, under multi-storied coffee based cropping system. The area under mandarin cultivation in the country is 480(000ha) with annual production of 6368(000MT)[1]. (Anonyms, 2019-20) The climatic conditions of Coorg mandarin growing areas are characterized by mild temperature and high humidity, which favours the pests and disease incidence. In the past few decades, the growers are facing, the Coorg mandarin decline as the health of the plants deteriorated. The problem is broadly referred to as 'decline' or 'die back' and a number of factors are attributed to this problem[2]. Citrus growth and production affected by different climate elements like low temperature and freezing, heat stress change, CO2 assimilation, rainfall, heat waves, drought or intensive rainfall and relative humidity, therefore, any change in climate elements affect directly and indirectly on citrus production[3](Lengnick et al., 2013). In a world where more than one billion people currently do not have enough to eat (Anon 2009), more work is needed to understand the impact of climate change adaptation procedures available to decrease predicted disease-induced losses in crop yields.

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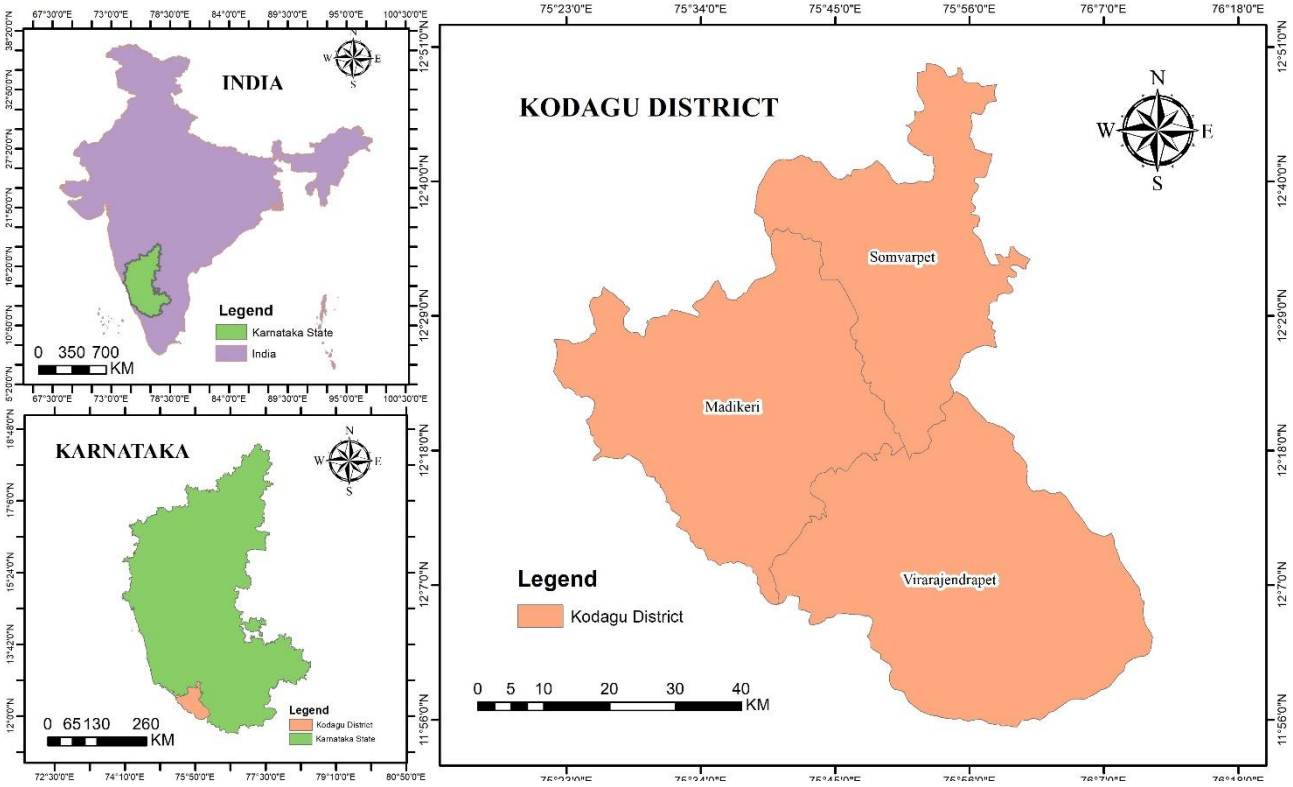
Study Area:

The Kodagu district of Karnataka State is situated on the summits of the eastern and western slopes of the Western Ghats, on the south-western border of Karnataka and Kerala States. It extends from 11º 56' to 12º 52' North latitude and 75º22' to 76º 12' East longitude. When one hears the word 'Kodagu' what at once crosses one's mind is the majesty of its mountain ranges, its sprawling Coffee plantations, evergreen forests with valuable timber like teak, rosewood, sandalwood, and other forest wealth, Orange gardens, monsoon rains, river the Cauvery, Kodavas its inhabitants a handsome and robust set of people conspicuously different from the rest of the people around them in south India, their customs, culture and a host of many more things which are very fascinating and lovely.

Kodagu district is the smallest district in the state with an area of 4102 Square kilometers. It is bounded by Hassan district on the North, by Mysore district on the East, by Dakshin Kannada district on the West and by Cannanore district of Kerala State on the South. The shape of the district on the map has been compared to that of an 'infant's knitted sock.' A narrow arm about 20 kilometers long and about 10 kilometers wide projects northwards into Hassan district on the East. It is a land-locked district.

The steamy summers of Coorg last from March to the end of May, with temperatures exceeding into the thirties. The summers are followed by the rich and calming monsoons-Coorg district receives one of the highest rainfalls in India, most vigorous during the months of July and August with constant showers all the way till November.

Fig 1. Location map of Kodagu district.



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The district is a captivating site in the monsoons as mist envelopes the higher reaches of the forests. Winters in Coorg are very mild by most standards, with temperatures sometimes dipping into single digits but usually hovering around the early to mid-teens. It usually will not get hotter than 20 degrees in the winter months of Coorg-December to February. Coorg also receives some blossom showers in the month of March.

Objectives:

1. To discuss the impact of climatic conditions on production of Mandarin in Coorg.
2. To know the diseases and pest related to climate.
3. Suggestion to use Genetic seeds of adverse climatic condition.

Methodology: The study was undertaken collecting information from primary sources from DC Office, Madikeri, Agriculture office, Madikeri, Horticulture Office, Madikeri, Orange grower's society, Gonikoppal, Central Horticultural Extension Station, Chettalli and secondary sources. Many journals, newspapers and research articles have been consulted to prepare the paper.

Results and Discussion:

The productivity of oranges depends on many factors such as climate, site, varieties and rootstocks, fertilization, irrigation, soil management practices, pest and disease control etc. Among the above factors, adequate supply of plant nutrients seems to be a very important factor in regulating cropping and influencing the quality of fruits. However, our knowledge regarding fertilizer requirement, time of fertilization, forms of fertilizers, method of application, etc., is still incomplete and more work is needed on these aspects. This work gives an overview of effect of climate change on citrus growth and productivity, of course, there is need for more research in the future to understanding the impact of different climatic factors on citrus productivity.

The fruit crops are selected for cultivation based on climatic conditions for their proper growth and development and higher economic yield. The following different climatic conditions are mentioned under which certain fruits are grown.

Climate:

The earth's climate is a dynamic process and it has always responded to changes in the cryosphere, hydrosphere, biosphere, and other interacting atmospheric galaxies. Although the effects of climate change on plant diseases was assessed in early nineties for New Zealand[4](Prestige and Pottinger., 1990) and United Kingdom[5](Atkinson., 1993). However, how the changing climate may influence the plant pathogens and the diseases they cause gained international importance only after Manning et.al.,(1995)[6] first reviewed the impact of changing atmospheric CO_2, O_3 and UV-B on plant diseases. It is well established that temperature, moisture and greenhouse gases are the major elements of climate change. Current estimates of changes in climate indicate an increase in global mean annual temperatures of 1°C by 2025 and3°C by the 2100.

The climate is the most important parameter for selecting the location of an orange field. The climate of Kodagu is generally humid (85% to 100%), with heavy rainfall on the hills, and thus cool, equable and

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pleasant practically all the year. The climate mostly determines the success of the orange farm and the quality of citrus fruits, while soil and water determine in general terms the productivity of orange trees. Cold is the most important enemy of an orange tree. Oranges grow well in both tropical and sub-tropical climate. Kodagu situated in the sub-tropical climatic region which is highly suitable for orange cultivation. But high humidity and frost conditions are a perfect environment for the spread of diseases. "Karnataka, Tamil Nadu and Kerala are humid regions (Coorg, Wynad, Nilgiri and Shevroy hills) and cannot be grown as a pure crop, however, being grown as intercropped with coffee. These areas are not suitable for mandarin orange. Mandarins are grown in north-eastern India. The climatic conditions of these regions favour the production of excellent colour and quality"[7]. (Prasad/Kumar., 2016)

Temperature:

Agriculture is one sector, which is immediately affected by climate change. The major cause to climate change is increased levels of greenhouse gases like carbon dioxide (Co_2), methane (CH_4), nitrous oxide(N_2O), chlorofluorocarbons (CFCs) beyond their natural levels due to uncontrolled activities such as burning of fossil fuels, increased use of refrigerants and enhanced agricultural related practices. These activities accelerated the processes of climate change and increased mean global temperatures by 0.6 to 0.8^oC during past 100 years called a phenomenon of 'Global Warming'[8](IPCC, 2006). It is thought that mean global temperature may increase by 1.4 to 5.8^oC by the end of twenty first century.

The temperature in Kodagu ranges from 11^o to 28^o Celsius, summer months of April and May being the warmest. During March-April, the mean daily maximum temperature is 28.6^oC and the mean daily minimum temperature is 17.8^oC[9].(District disaster management authority., 2019) From December to February, the first is 23.8^oC and the second, 14.3^oC. Sometime the minimum temperature goes down to about 9^oC. Temperatures below 0^o are dangerous for the orange tree, especially when maintained for long periods. High temperatures may also prove critical for the productivity of trees. Cool temperature is best suited for orange cultivation. The range of temperature of Kodagu is 10-30^oC. In the summer months of March to May the mean everyday temperature remains at 28.6^oC. Thus, Coorg mandarins are predominantly grown here. The traditional Coorg mandarin areas of Kodagu and other regions in Tamil Nadu and Kerala are characterized by mild temperature and high humidity.

Table-1.1 Variation of temperature over the world (Degree Celsius)

	2015	2016	2017	2018	2019
World	1.42	1.67	1.44	1.30	1.47
India	0.58	0.98	0.87	0.77	0.69

(Source[10]: F.A.O. Production year book, Table 57, 2020, p.347)

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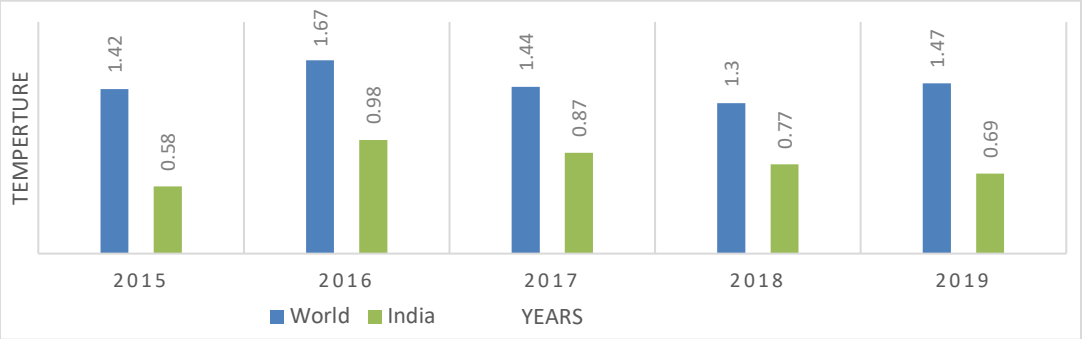
Graph 1.1: Variation of temperature over the world (Degree Celsius)



Humidity:

Atmospheric humidity has a greater role in the performance of citrus. In general, low humidity gives good colour and external appearance, whereas high humidity favours thin skinned, juicy fruits, which are smaller in size, but high in quality. Fruits grown near coastal areas tend to more spherical than those grown in the interior. Low humidity promotes transpiration and loss of water, resulting in fruit abscission. Disease infection is favoured by high humidity. "Mandarins grow well under humid climate. They prefer slightly higher elevations and tracts with relatively higher humidity"[11](CBS Rajput & R Sri Harbabu,1985). The range of humidity of Kodagu is 85% to 100% which ideal climatic condition for growing of orange. Coorg Santras (Mandarins) tolerate more humidity in summer and winter season than sweet oranges.

Hot winds:

High-speed and cold winds can also cause damage to trees, vegetation reduction, loss of fruits and deterioration of their quality. As well as cold winds even, hot winds cause the plant to lose its flowers and young fruits during the summer months. The climate of Coorg has changed due to human economic activities. Mohanta and Konwar[12](2014) reported that maximum growers faced climatic problems such as wind and storms, drought etc. In addition, this, global warming is also affected the climate change on the earth's surface. So that, during the winter and summer seasons a hot wind blows along the Coorg and it affecting the mandarin trees. "Hot winds and excessive heat during flowering and fruit set are detrimental for growth and fruit bearing. Low humidity favours colours development, whereas plants not having adequate sunlight produce low yields of poor-quality fruits"[13]. (Prasad/Kumar., 2016)

Rainfall:

Proper distribution of rainfall is more important than the total rainfall. An annual rainfall of 500 mm is considered inadequate, while 700 mm rainfall is said to adequate provided it is favourably distributed. An annual rainfall of 1250 to 1850 mm is generally regarded as sufficient. Considering the rainfall pattern of Kodagu, this tract receives most of its rains in the south-west monsoon. In Kodagu orange is being grown in regions where rainfall ranges from 75 cm to 250cm. The rainfall in Mandarin areas is around 30 inches in the plain and up to 100 inches on hill-slopes.

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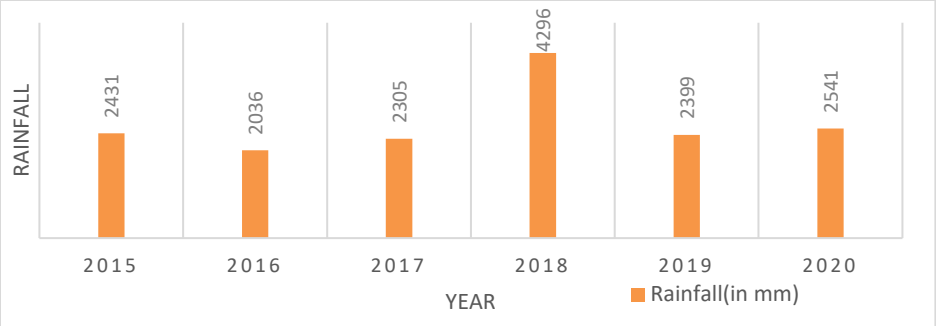
Table 1.2: Actual Annual Rainfall of Kodagu district

Sl. No	Year	Rainfall (In mm)
1	2015	2431
2	2016	2036
3	2017	2305
4	2018	4296
5	2019	2399
6	2020	2541

Source[14]: Kodagu District Statistical at a glance, 2018-19, p.37.

Graph 1.2: Actual Annual Rainfall of Kodagu district



In the past few decades Kodagu receiving excess of rainfall due to climatic disturbances. Thus, lot of coffee estates and orange orchards destroyed due to landslides. In 2018, Aug 3rd Kodagu received heavy downpours, leading to landslides. By August 6th, rainfall recorded at the three taluks like Madikeri (95.10mm), Virajpet (77.92mm) and Somwarpet (57.89mm) respectively. Next August 7th Kodagu had received 145.58mm of rainfall. There was water logging in most parts of the district. In just 9 days of August, Kodagu received 935mm of rain, way more than the average rainfall of 600mm for the entire month. In the following week till August 14th, although the rain fury abated somewhat, it was still 696.9mm, more than 3.5 times the long-term average.

The heavy downpours were debilitating for the people who depend mostly on farming. A preliminary survey by authorities revealed that Rs.2.7 billion worth of crops were lost. Over 102,034 hectares of coffee plantation and 6350 hectares of pepper plantations were damaged and 3623 hectares of the standing paddy crop was levelled[15]. (Kodagu district administration, 2018) Oranges are grown across the district and mainly in South Kodagu. Due to untimely heavy rainfall, orange plantations have experienced excessive fruit drop and the yield has come down to less than 50 per cent[16]. (The New Indian Express daily, 2019) Experts say the change in rainfall patterns leading to extreme weather events are becoming more common.

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Irrigation:

Orange trees need large amount of water. Orange crops can either be irrigated in an orchard or rain fed in case of reliable rains. But stagnant of water is harmful to this crop. No irrigation is required during the rainy months. As such, Kodagu situated on the hilly tracts of steep and gradient slopes which is ideal place for orange cultivation without irrigation. Although, in Coorg where irrigation facilities do not exist, the severe shortage of water on the hill slopes in the pre-monsoon period seems to be a strong contribution to the citrus decline[17]. (Ranjith Singh.,1995) Even the hilly areas of Assam, Darjeeling, Wynad and lower Nilgiris are also cultivating the Mandarin orange without irrigation. But in the plains and pleatue regions like Nagpur and Central India's orange is cultivating with the help of irrigation.

Irrigation is one of the most important components of the orchards and it should be need based. Differential water management strategies are required during growth and reproductive phase. In order to avoid moisture stress during growth phase, irrigation at 10 days interval from March to end of April is beneficial in sustaining the vigour of plants. However, in the reproductive phase, irrigation should be given as blossom shower either through sprinkler or drip irrigations (18-20 litres) of water per day per plant for one week-one acre inch during March-April and there after supportive irrigations to ensure sufficient soil moisture for retention and good growth of fruits. Mulching the basins with dry leaves during summer conserves soil moisture. To minimize the damages arising from the development of soil-borne diseases, effective drainage is necessary[18](Tripathi P.C.) In Kodagu planters applying the water through sprinkler method due to lack of moisture between November to February.

Shade:

Citrus is usually considered as a light loving plant and trees are sensitive to shading. Trees exposed to high light intensity usually exhibit paler foliage colour, while those under shade develop deep green foliage. Trees under shade are usually poor fruit yielder but partial shading often results in higher fruit quality. Tripathi P.C. found that the excess shade and sub optimal management practices affect the growth and fruiting of the trees. The proper regulation of shade is essential for the optimum growth of mandarin, coffee and pepper[19](Tripathi P.C.).

Soil:

In Coorg and Wynad tracts of South India, Santras flourish well in deep but well drained black and red loadmy soils[20](Sing S & Singh D. 1957) In Kodagu district red loamy and laterite soils are common. In the deeper layers of loamy, clay loamy and gravel mixed sandy loamy soils are found. These soils are well drained with moderate permeability. They support coconut, coffee, cardamom, orange and cashew in transitional and hilly tracts[21](Gazeteer of India.,1993). The soils of Kodagu are acidic with the pH varying from 3.5 to 6.5. Soils are rich in nitrogen, deficient in phosphorous and with medium amounts of potash[22](Gazeteer of India.,1993). The soils of Kodagu highly eroded with heavy rainfall and it leads to declining of nutrients. De[23](De., 2017) reported that planting of trees in steep slopes and heavy rainfall and lack of supplementary application of nutrients cause gradual decrease in soil fertility.

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Altitude:

Altitude, in general is of importance only as it influences temperature. Mandarin Orange is sub-tropical fruit and grows in varied types of climate and soil, and has wide adaptability for different topographical situations. Mandarin oranges prefer slightly higher elevations and tracts with relatively higher humidity. It grows in valleys, 200-500ft. Height above sea level, Sub mountains tract(500-2000ft) and mountains (2000ft above). The climate and height do have an effect on physical-chemical characteristics of the fruit. Moreover, the low hills and valleys are more suitable for its cultivation.

There are hilly and plain areas in South India between the two coasts. Hilly areas include Coorg (Karnataka), Wynad (Kerala), Nilgiris, Palnis, Shevroy and Yercaud hills (Tamil Nadu) where the elevations range from 650-1500m and are quite suitable mainly for the cultivation of mandarin oranges[24](Rajput CBS & Sri Harbabu R., 1985). Kodagu situated about an altitude range from 600 to 1200meters which is ideal for orange cultivation. In Kodagu, most of the areas red, clay loamy soils could be seen. This tract supports paddy, cardamom, coffee, tea and Orange. Coorg mandarins are grown in hilly areas and elevation of up to 1700 m in Kodagu region. In Coorg and adjoining areas like Kerala and Tamil Nadu regions of mandarins grows at an altitude ranging from 2000 to 3000 feet.

Deforestation:

Forests also play a big role in mitigating the damage from extreme rainfall events in Kodagu district. Its extreme climatic events are set to be more frequent in the future. In Kodagu, as in many other parts of the country, large and conversions in the name of development are common. Kodagu witnessed protests in 2014 when over 50,000 trees were proposed to be cut in both forests and private lands to facilitate a 400KV high tension power line from Mysuru to Kozhikode in Kerala. Early this year, 800 trees were felled in an 80 acre by a businessman for commercial purposes despite a ban on land conversion that came into effect after the 2018 floods. In July last year, just before monsoon played truant, 100 trees were axed to facilitate the chief minister's visit to the district. The common property resources like streams and sacred groves that provide important ecological services have been occupied by private parties and have led to large scale deforestation in Kodagu. Also in Kodagu, the forest decides people's economy. If these forest systems are messed with, people pay the price. People lose water and food security[25](T.V.Ramachandra) Linear corridors like rain routes, power lines and highways are another major threat to Kodagu's contiguous forest cover[26](Col.Muthanna).

Natural hazards:

Karnataka's Kodagu district, witnessed one of the worst flood situations in its history. It received more than double of its average August rainfall in just nine days. According to different sources, between 1 and August 10, the district received 36.8 inches(920mm) of rainfall. The average rainfall for Kodagu in August is around 15inches. Traditionally north kodagu was known for receiving heavy rain. The havoc of 2018 was also in this region. However, South Kodagu, for the first time received more rainfall than the North[27]. (District Disaster Management Authority., 2019) The heavy rains and landslides are common in Kodagu will deprive the delicious oranges. This season as the calamity has destroyed the cultivation. The recent floods have damaged many estates, severely affecting the orange yield[28](Ashwini M Sripad,

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2018).Forest fragmentation also results in reduction soil capability, making these regions vulnerable during high-intensity rainfall with instances of landslides and mudslides occurring.

Fig.2 Images taken during flood in Kodagu district.

A Coffee estate (102,034ha) submerged in the floodwaters of Cauvery River

Army soldiers look through debris at the site of landslide in Thora Village, Kodagu

Virendra Kumar[29](Virendra Kumar) explained that change in the weather, apart from the diseases, has reduced the yield of orange in Kodagu.

Rama Rao[30], a local planter, who owns 20 acres at Gaalibeedu near Madikeri, said they used to grow around 50 tonnes of oranges every year. “This is the season when flowers turn into fruits. But, due to heavy rains, the crop has been severely damaged. I have spent more than Rs 50,000 on fertilisers and others,” he said.

Another planter, Subbiah[31] from Ibnivalavadi village, who owns 14 acres, said the trees in his land were uprooted following heavy rains. “It is difficult to grow oranges again here. I will not get any yield this year. My hard work and money are gone,” he said. These growers have not insured their crops.

Macchamada Kanda Bheemaiah[32], a local resident of Virajpet stated that “with more diseases, the production cost has gone up, eating into profits, While Coorg oranges are greatly valued in markets, the growers earn very little”.

Local residents said at least 10 acres of farmland was washed away in landslip.

Table 1.3: Talukwise cumulative rainfall pattern of Kodagu district.

Taluk Names	**Cumulative Rainfall Pattern**		
	Normal (mm)	Actual (mm)	% of departure from Normal
Madikeri	3265	3488	7
Somavarpet	2098	1784	-15
Virajpet	2468	2177	-12
Total	**2729**	**2541**	**-7**

Souce: District disaster management authority, Kodagu, 2020.

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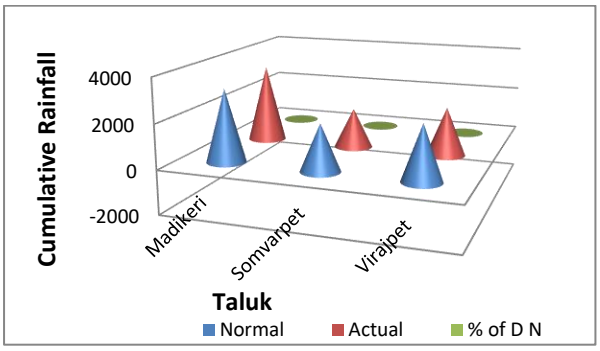

From the above planters' statements, it is understood that the Coorg mandarin is badly affected by the natural hazards every year.

Weather experts are reluctant to immediately attribute this year's extreme rain directly to climate change. Studies shows that the all-India rainfall for the monsoon has remained at 89 cm. This is a 50-year value. Some intra-annual variability does happen, which is natural[33]. (Gita Agnihotri) Meteorological department suggested that Kodagu and the Western Ghats region are used to heavy rainfall, but why this is leading to landslides, floods and other natural calamities now is something that needs to be studied properly.

Slope Modification:

In the recent years, slope cutting is most common in Kodagu district. The fast development of urbanization, tourism activities are directly responsible for this. Thus, people of Kodagu cutting the slope for extending of their plantation field, construction of buildings, home-stays, Villas, resorts, roads etc. So, the cracks are gradually formed along the slopes of the hill. A Geological Survey of India (GSI) report conducted after the 2018 floods found that slope modification was the main reason for landslides that caused the maximum damage. It also cautioned about the absence of guidelines, regulations and monitoring related to land use changes in the area. The GSI Survey found cracks in various hillocks, such as the Ayyappa Betta hillock and Nehru Nagar hillock in Virajpet taluk and also in the Brahmagiri hill range in Talakavery. The cracks are mostly seen in places that have undergone slope modifications. These cracks show the possibility of landslides in the future if preventive measures are not taken[34]. (GSI., 2018) The GSI has made an inventory of over 150 landslip-prone spots in Kodagu alone. They make up nearly 20% of the 704 spots in Karnataka's Western Ghats region[35]. (Disaster Management Report, 2018) The study goes on to say that the likelihood of landslide and surface erosion is higher in the areas disturbed by linear infrastructure (power line, road & railway lines etc.) through alteration of hill slopes.

An estimate of 1,18,978 hectare of crop was lost due to the heavy rains in the district which estimated to about Rs. 266.52 crore. The unscientific land-use modifications that have been happening in the district for years. The development of Kodagu and the district's status as a tourist hotspot have seen many resorts and villas coming up in the area in modified coffee plantations. Recently, studies indicated that the epidemic of Phytophthora blight of pigeonpea (P.drechslerif.sp.cajani) in India over the last decade can be attributed to high intermittent rainfall(>300 mm), within a week during the crop season[36](Pande et al.2010; Sharma et

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al.2006).

In addition to the above reasons, other factors also directly and indirectly responsible for low production of mandarin cultivation in Kodagu. The factors like improper cultivation practices, lack of interest on orange cultivation by the planters, hiking of coffee price, introduction of Nagpur mandarin and other varieties to the market, lack of research and other technological support from the concerned authorities, lack of storage and marketing facilities etc. are associated with cultivation of mandarin in Kodagu.

Coorg orange lost its vigour and the production declined drastically in the wake of a virus attack, rampant use of pesticides and fertilizers by coffee growers, and destruction of several natural species that were supplementing its growth. Even the neglect of government towards orange disease-hit orchards responsible for its decline. Although, the planters of Kodagu do not take intensive care of orange orchards also greatly responsible to declining of orange.

Diseases associated with environment:

Citrus is a delicate plant which has not been able to survive in the wild jungles anywhere in competition with other plants. It cannot withstand water stagnation, which prevents the functioning of its roots. It also requires heavy fertilization. The major causes of citrus decline are improper management and poor soil drainage[37]. (Ranjith Singh., 1995) Singh et.al.[38](2016) reported that the major cause, however, is the prevalence of insect/pest, some fungal, bacterial and viral diseases which have a significant impact and often become a major constraint in mandarin production.

Phytophthora is the most serious soil borne disease of mandarin accounting for more than 20-30% losses. It may occur in seedbeds as damping off, in young tree as foot rot and gummosis and in adult tree as bark gummosis and feeder root rot characterized by leaf discoloration starting from main vein. Use of tolerant rootstocks, budding well above the soil lien, avoidance of water logging and painting the plant with copper fungicide is recommended as preventive measures.

Tristeza is caused by clostero virus which is transmitted by citrus aphids *Toxoptera citricidus* and *T. aurantii*. Coorg mandarin is tolerant and symptomless to tristeza except if attacked by very severe strain. Severe strain of tristeza causing stem pitting in Coorg mandarin has been observed. Co-infection of greening and tristeza result in much rapid and severe decline of the plants. This disease is primarily spread through the use of bud-wood.

Greening disease has assumed an alarming situation and has threatened the mandarin growing in Kodagu. The leaves of the infested plant show vein chlorosis and chlorotic mottle on all or part of leaf blade. Leaves are luster less and show downward curling. Green patches in yellow background, manganese and zinc pattern deficiency and corking vein are also induced by greening. The disease affects all the scion cultivar irrespective of the scion-rootstock combination.

Citrus Canker (Xanthomonas axonopodis pv.citri) is most serious bacterial disease of citrus crops during rainy season and it can cause severe losses. The disease appears on leaves, twigs, petioles, branches, fruits, fruit-stalks and thorns.

Powdery mildew is another serious disease-causing considerable loss to mandarin orchards. The disease is

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characterized by appearance of powdery substance on tender shoots. Incidence of this disease is high in mandarin grown in intercrop where high humidity is prevalent.

Gummosis is favoured by rains. Timmer and fucik (1975) observed that percentage of fruit loss due to Phytopthora nicotiana var. parasitica in an orange orchard was directly related to amount of rainfall in August and September/October.

Citrus scab (Eisinoe fawcetti) is one of the major diseases in the hilly tracts where low temperature and high humidity prevail. Humidity and rainfall play a very important role in the development of scab. It attacks on leaves, twigs and fruits.

Citrus leaf miner (*Phyllocnistiscitrella*) showed four population peaks in a year on Coorg mandarin and nine peaks on Rangapur lime. Availability of tender flush seemed to be major governing factor with weather parameters showing no correlation.

Fruit drop is a common phenomenon that otherwise occurs in small quantity, has grown manifold due to extreme day and night temperatures, which make crop more susceptible to fungal and other infections.

Citrus Psylla (*Diaphorinacitri*): Citrus psylla is a kind of plant lice that sucks sap from young leaves, tender shoots and flower buds. It excretes a honey dew on which develops the sooty mould fungus. The general vitality of the tree is deteriorated, young fruits are shed.

Brown/ black citrus aphid *(Toxopteracitrida T.aurantii)*: Highest number of aphids caught on the yellow sticky traps included *Toxoptoracitricida* followed by*, T. aurantii*, *Apisgossypii* and *A. spiraecola*. Cubical & cylindrical yellow sticky traps were highly efficient in trapping aphids Management practices have to be initiated during January, April, June and October for suppressing aphids.

Soft green scale*-Coccus viridis* (Green) suck the plant sap and secrete a large quantity of honeydew which attracts the sooty mould. The adult female is pale green, ovate, slightly convex and measures about 3 mm in length. Female produces 300 to 500 young ones, and these young one's crawl and settle on tender leaves.

Shoot borer *(Oberea lateapicalis* Pic.) and the ***stem borer*** *(Chelidonium argentatum* Dalm) are serious problems in mandarin especially when planted as intercrop. The shoot borer attacks the young shoot while stem borer attacks the trunk which results in death of plant.

***Fruit flies* (*Bactroceracaryeae/Bactroceradorsalis*):** Mainly mature fruits are subjected to the attack of fruit flies. The adult fruit fly makes small punctures on fruits and lay eggs in the fruits. The growing larvae eat the fruits and fruit become yellow and fall down.

Mealy bugs are closely related to scales and have been reported from various parts of the country. The body of the insect is segmented and is covered with white mealy wax. They suck the sap and secrete honey dew on which Sooty mould develops. Development of sooty mould interferes with the photosynthetic activity of the leaves.

***Fruit sucking moths* (*Otheraea*spp):** These moths having grey and orange-coloured wings. Generally,

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the appear during heavy rains in western, northern and south India. These moths visit fruits during night. These moths puncture the skin of the ripening fruits especially in orange orchards.

Mites are highly destructive pests of citrus. Injury to leaves, tender fruits and green bark is caused due to oviposition and feeding by the adults and the nymphs. Nymphs are particularly more harmful on account of their fast rate of feeding. Partial or even complete defoliation, particularly in young nursery plants was reported due to mite infestation, along with reduction in the size of fruit.

Thrips (Textranychidate)is a pest on all citrus fruits. Thrips are too minute to be seen with nacked eyes. They occur in warm dry areas.

New Genetic seeds: A large collection of citruses was made at Central Horticultural Extension Station, Chettalli, Kodagu district from various sources. A consolidated Citrus germplasm block was planted during 1987 with 138 varieties/accessions/species having 4 plants per accession. There were 12 mandarin, 5 Unshiu, 2 hybrid mandarins, 12 small fruited mandarins, 3 tangeloes, 16 Rangapur limes, 11 pumeloes: Grape fruit and citrons, 5 lemons, 5 limes, 10 rough lemons, 3 citrus karmas, 11 trifoliates, 5 hybrids of trifoliates, 6 hybrids (inter-specific), 6 sour orange, 12 sweet oranges, 10 citrus species, 4 related genera in this block. This block was planted by expressly avoiding synonyms and duplications made earlier.

Table 1.4: Citrus germplasm at CHES, Chettalli, Kodagu district, Karnataka

Sl.No	Mandarin Group
1	Mandarin (Citrus reticulate Blanco)
2	Mandarin Hybrids
3	Tangeloes (Citrus reticulate) X citrus paradise)
4	Small fruited mandarin (*Citrus reshini* Tan.)
5	Satsuma/Seedless mandarin (Citrus unshiu Marc.)

Source: CHES, Chettalli, Kodagu district.

Suggestions and Remedies:

- Farmers/planters should follow scientific cultivation method from nursery to harvesting.
- Orange growers have to take the steps to adapt of expected climate changes in the future.
- Growers must be insured their crops.
- Soil quality must be regulated periodically to control the soil borne diseases.
- State government has agreed to provide compensation and conducting a survey to assess crop damages.
- People must stop constructional activities in the slopes of the hills.

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- Universities and research institutes in this region have to be initiated.
- Community awareness program have to be conducted by the concerned authorities.
- Local authorities must be monitoring the illegal development and infrastructural activities.
- Proper study should be done for controlling of flood, landslides and other natural hazards.
- Government should take long term mitigation measures.

Conclusion:

Climate changes effects on the growth and productivity of citrus varieties. Different environmental factors like high temperature, heatwaves, drought, cool temperature, heavy rainfall and frost, have an impressive effect on the growth and productivity of citrus, when rise the carbon dioxide (Co_2) levels it improves the citrus growth and productivity. The climatic conditions in Coorg mandarin growing areas are characterized by mild temperature and high humidity, which favours the pests to spread disease. Successful orange cultivation requires 25^0 to 30^{0}C temperature. Rainfall is needed from 40" to 50" annually. Rainfall should fall during the months of March-November generally; there are adverse effects of temperature fluctuation on the growth and productivity of citrus orchards. The range of the moisture is needed from85-100% is essential. Any type of well-drained clay soil is good for the crop. The land should be fertile, hard ground, and the earth should be selected for a land where there is no stone. Citrus growers have to take steps to adaptthe expected climate changes in the future, they must decide to invest in the current time to balance negative impacts of climate changes on citrus orchards productivity and to cope with unfavorable conditions in the future and keep high production with proper quality.

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