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Chapter 9

Rubber

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1. Introduction

Natural Rubber (*Hevea brasiliensis*) is a perennial rain fed tree crop that has been cultivated in India since the beginning of the 20th century (Sethuraj and Jacob, 2012). Traditionally this crop has been cultivated along the foothills of the Western Ghats up to an altitude of about 450-500 m above MSL in Kanyakumari district of Tamil Nadu and Kerala. In recent decades its cultivation has expanded to further North along the Western Ghats as well as in parts of North East India and pockets along the Eastern Ghats (Figure 9.1) (Krishan, 2013).

Several studies have shown that climate of the rubber growing regions have undergone major changes in recent years/decades (Jacob, 2013). The changes have been more spectacular in terms of rise in temperature (particularly daily maximum temperature) and alterations in the distribution of rainfall and to some extent a reduction in the amount of annual rainfall (Rajeevan *et al.*, 2008; Jacob, 2013.).

A number of studies have shown a clearly changing pattern of rainfall over different Indian terrains during the recent decades (Lal *et al.*, 2001; Rajeevan, 2001; Goswami *et al.*, 2006). The change in rainfall pattern of the spice and plantation regions of India is characterised by an increasing trend in south west monsoon (SWM) over northeast and south west regions and decreasing trend along other regions (Guhathakurta and Rajeevan, 2006). There was a significant reduction of 232.6 mm rainfall during SWM and an increase of 93.9 mm in northeast monsoon (NEM) during the last 135 years in Kerala. Percentage departure of the decadal mean rainfall from the normal indicated that the excess rainfall years during SWM were frequent in the recent decades when compared to the earlier decades from 1871 to 2005 (Krishnakumar *et al.*, 2009).

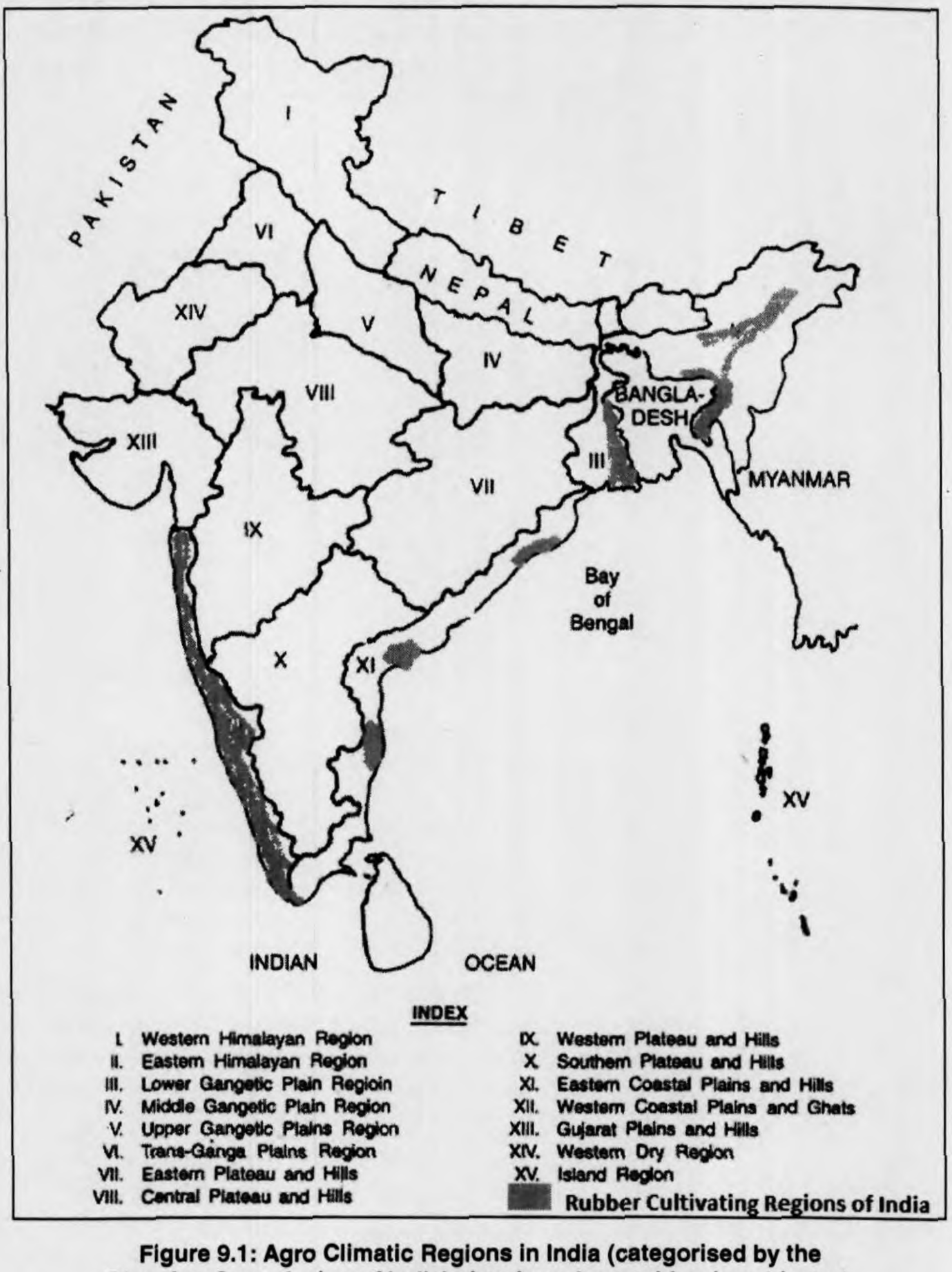

Figure 9.1: Agro Climatic Regions in India (categorised by the Planning Commission of India) showing where rubber is cultivated. Hatched areas only indicative and not drawn to scale.

Guhathakurta and Rajeevan (2006) showed that a significant decreasing trend in the monsoon rainfall for three sub-divisions, Jharkhand, Chhattisgarh and Kerala. Subdivisions like Gangetic West Bengal, Western Uttar Pradesh, Jammu and Kashmir, Konkan and Goa, Madhya Maharashtra, Rayalseema, coastal Andhra Pradesh and north interior Karnataka experienced a significant increasing trend. Goswami *et al.* (2006) showed an increasing trend in extreme rain events over central India during the monsoon season. At the same time, significant decreasing trend in the frequency of moderate events during the same period. But the annual mean rainfall showed no significant trend.

A change in precipitation pattern of Kerala requires special attention while discussing about climate change responses of rubber growing in the traditional area. Regarding the trends of precipitation in Kerala, Krishnakumar *et al.* (2008) have observed that monthly rainfall during June-July was decreasing while the same was increasing during august and September, indicating a shift in the monthly precipitation pattern. Pal and Al-Tabbaa, (2009) have reported an increasing trend in extreme rainfall during winter and autumn in Kerala while the spring seasonal extreme rainfall showed decreasing trend, which may lead to increasing probability of water scarcity in the pre-monsoon time and a delaying monsoon onset.

Studies have shown that even though a warming trend is evident across many regions of the country, it is not uniform and some regions show a cooling trend also (Kumar and Hingane, 1998; Kumar and Parikh, 1998; Singh and Sontakke. 2002; Gadgil and Dhorde, 2005). Kerala being the largest rubber cultivating region in the country, India Meteorological Department (IMD) has reported an increase of 0.8°C, 0.2°C and 0.5°C increases in maximum, minimum and mean temperatures respectively over Kerala. It is also reported that the maximum temperature of Kerala increased by 0.64°C while the minimum temperature rose 0.23°C during the period of 1956 to 2004 (Rao *et al.*, 2009). Jayasooryan *et al.* (2015) reported an increasing trend with respect to the indices of extreme temperature events in a rubber growing region in Kerala.

The long term climatic events in the traditional rubber growing regions in India showed a difference of approximately 2°C in maximum and minimum temperatures between two decades (Raj *et al.*, 2011; Satheesh, 2014). This is a good indicator of local climate variability in the traditional rubber growing regions. Decrease in the number of rainy days during the monsoon season with no change over the annual period in the traditional region suggests that the spread of rain fall is becoming more skewed in nature. Impacts of climate change are felt more strongly through changes in climate extremes. Temperatures are rising, rainfall is becoming more skewed and bright sunshine hour per day is decreasing.

2. Climate Change and Growth and Establishment of Rubber in the Field

Throughout the world, natural rubber is cultivated as a rain fed crop and irrigation is limited only to the nursery. However, in recent years many growers in Kerala had to provide life saving irrigation to young rubber plants during the first summer after field planting (RRII, 2015). Normally young plants are planted in the field in Kerala during the month of June-July when sufficient soil moisture is assured and sunshine intensity is usually low. In recent years there has been considerable rise in the day temperature, number of active sunshine hours and a reduction in the amount of rainfall received during June – July (Krishnakumar *et al.*, 2008). These changes can have an adverse effect on the initial survival and establishment of young rubber plants in the field. Due to these adverse changes in the recent years, an increasing proportion of growers are forced to give at least one irrigation during peak summer time in order to stop young plants from drying up.

Casualties posed by uncertain weather pattern on young plants and different mitigation measures adopted by farmers along the traditional rubber growing regions were studied by RRII. The study revealed that 16 per cent of farmers in Kerala are providing irrigation to young plants during the early stages of establishment. In Southern Kerala only 3 per cent of the farmers practising irrigation, while in Central Kerala 30 per cent farmers providing irrigation, which keeps the casualty below 1 per cent. Along the North-Central Kerala and Northern Kerala 19 and 20 per cent of farmers provide irrigation respectively. Visual drought symptoms due to soil moisture stress was manifested as yellowing in the early stages, which was seen in almost all the regions studied. Severe cases of yellowing, leaf tip dryness and leaf shedding were seen in North-Central Kerala, indicating low water availability during summer period (RRII, 2015).

3. Climate Change and Diseases of Rubber

There are a few important fungal diseases affecting natural rubber. Young rubber plants are affected by fungi such as *Colletotrichum, Phytophthora, Oidium, etc.* (Liyange and Jacob., 1992 Manju *et al.*, 2001 Gogoi and Dey., 2012). The most important disease affecting mature rubber tree is Abnormal Leaf Fall disease caused by *Phytophthora* spp. All these fungal diseases have a direct association with weather parameters such as rainfall, relative humidity and temperature. These important weather parameters have undergone significant changes in the rubber growing regions of India in the recent times.

Most parts of the traditional natural rubber growing regions of India, extending from Kanyakumari district in the South to Kasaragod district in the North received excess and prolonged rains during 2013. This led to severe incidence of Abnormal Leaf Fall (ALF) disease caused by the fungus, *Phytophthora* sp. A comparison of LAI during 2012 and 2013 (as studied using satellite images) showed that as the monsoon advanced, LAI decreased substantially in both years, but the reduction was much more substantial and prolonged in many districts during 2013 than 2012 reflecting increased leaf fall due to ALF disease in 2013 (Pradeep *et al.*, 2014). The decline was more pronounced in Central and Northern Kerala than in the South. Kanyakumari district is generally known to be free from ALF disease, but there was considerable leaf loss due to ALF in June 2012 and June and July 2013 even as the monsoon was unusually severe in 2013 (Pradeep *et al.*, 2014).

In the recent years, a new fungal disease become quite prevalent in parts of Karnataka namely *Corynespora*. Similarly *Colletotrichum* has become a major concern in parts of the most traditional rubber growing regions in Central Kerala (Manju *et al.*, 2014). It cannot be ascertained whether climate change has been responsible for the emergence of the new diseases, even as one would suspect that to be the case. There have been sporadic incidences of mealy bug infestation becoming a significant pest in rubber. These are thermophilic insects and it is likely that warming conditions will result in more incidences of this pest in coming years also.

4. Climate Warming and Rubber Yield

Among various parameters that can influence latex flow and thereby rubber yield, ambient temperature is perhaps the most important one. The cooler the ambient temperature, the longer the duration of latex flow and thus the higher the rubber yield. Thus yield is relatively poor during the summer months. It has been shown that summer season yield is only 60- 80 per cent of the winter yield (Rajagopal *et al.*, 2013; Reju *et al.*, 2014). According to Satheesh and Jacob, (2011), if both Tmax and Tmin rose by 1°C, NR productivity will reduce by 9-16 per cent in the agro-climatic conditions of Kerala and by 11 per cent in the hot and drought-prone North Konkan region. On the other hand, in the cold prone North Eastern India, there is hardly any reduction in NR productivity if both Tmax and Tmin went up by 1°C (Figure 9.2). The study also indicates that a persistent warming trend reported from Kerala could be reduce the NR productivity by 4-7 per cent and in North East India it may go up by as much as 11 per cent in the next decade.

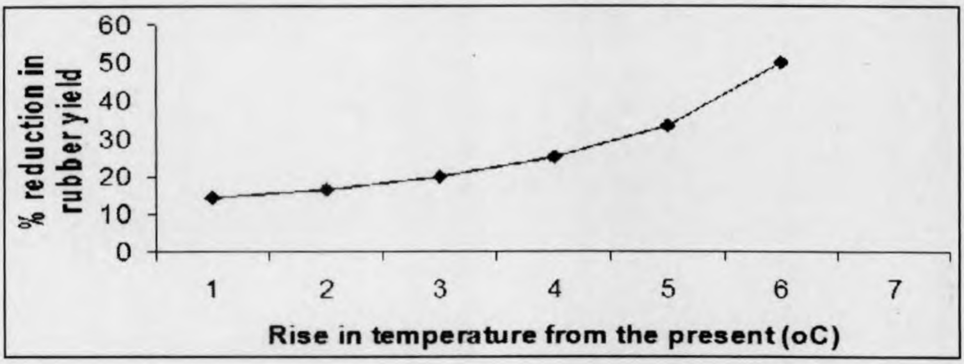

Figure 9.2: Estimated Per cent Reduction in Rubber Yield for Every Degree Rise in Temperature from the Present (Direct effect only) after Satheesh and Jacob, (2011).

Studies shown that as climate warms, rubber yield will decline in the traditional rubber growing regions because T max and T min had a negative impact on rubber yield (Jacob *et al.*, 2012). In Kerala and the Konkan regions, the prevailing temperatures are already at the higher side of the temperature threshold for rubber cultivation (Jacob *et al.*, 1999) and therefore any further warming can become harmful in these regions. However in the Northeast, climate warming can improve rubber yield, because T max had a positive impact on rubber yield. Therefore climate warming has different effects in different agro climatic regions (Satheesh and Jacob, 2011; Rey *et al.*, 2014). It is generally considered that severe winter condition is a limiting factor for growth and productivity of rubber in NE India (Jacob *et al.*, 1999) and therefore a warming trend in this region may improve the rubber yield.

Satheesh and Jacob (2011) made the attempt to assess the direct impact of climate warming on NR productivity. This study clearly indicate how Tmax and Tmin have been increasing in the past, how it has adversely affected the NR productivity in the past and what would be the raising temperatures might do to NR productivity in future in the different agro-climatic regions in India where the rubber is cultivated today.Climate change is obviously much more complex than daily variations in weather parameters such as daily maximum or minimum temperatures (Figure 9.3). Changes in cloud formation, wind, rainfall pattern, occurrence of extreme weather events, unexpected breaks in monsoon, spread of new pest and diseases *etc.* are important factors that can seriously influence rubber yield. Commercial productivity of natural rubber from growers' fields registered a steady increase over the years even as the local climate continued to warm, apparently contradicting the predictions. Increase in the area under the high yielding clone, RRII 105 that came into tapping over the years was responsible for masking the adverse impact of climate warming on productivity of rubber until recently (Satheesh and Jacob, 2015).

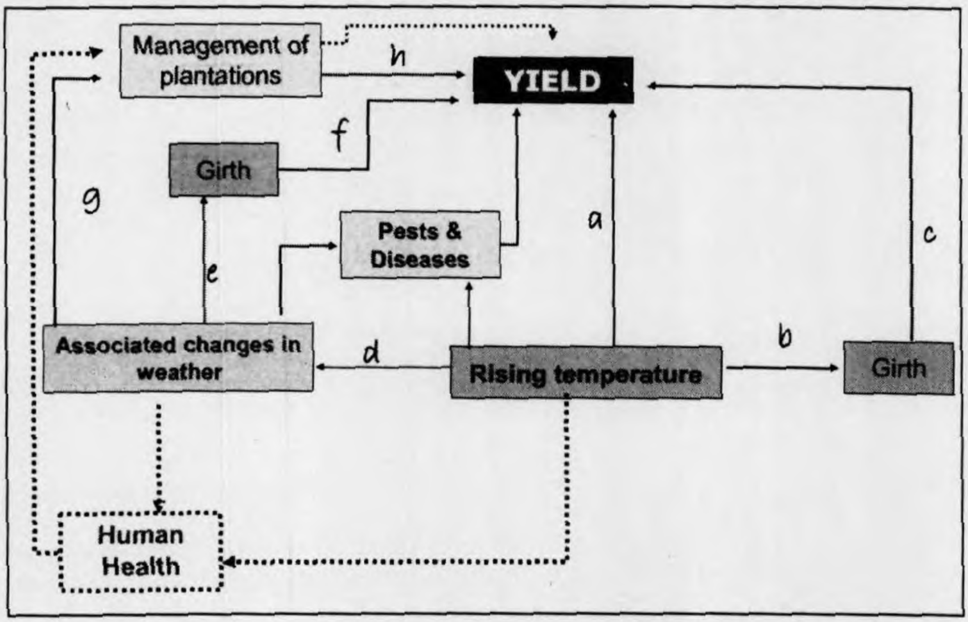

Figure 9.3: Schematic Chart Showing the Direct and Indirect Effects of Climate Warming on Growth and Yield of Rubber (after Satheesh and Jacob, 2011).

Using a different approach namely Ecological Niche Modelling, Ray *et al.* (2015) also found that in the coming years, if the present warming trend continues, more area will become stressful for rubber cultivation along the Western Ghats. More areas in North East India (where low temperature is presently a limiting factor for rubber cultivation) will become better suited for rubber cultivation if the warming trend continues (Ray, 2015; Satheesh, 2015).The two high altitude districts of Kerala namely Idukki and Wynad traditionally did not have much rubber cultivation in the past. In recent years, these two districts witnessed considerable warming (Rao *et al.*, 2009) which may be one reason why rubber cultivation is expanding to these districts now.

Extreme weather events have been on the rise in recent years (Guhathakurta *et al.*, 2011; Jain and Kumar, 2012). Tmax mean, hot day frequency, temperature of hottest day *etc.* shows a steady increase during the last 40 years. The magnitude of increase in maximum temperature is greater than that of minimum temperature (Jayasooryan *et al.*, 2015). It is almost impossible to categorically state if any single extreme weather event is the result of climate change, either global or regional. However, there is a clear rising trend in the number of occurrence of such events in recent years, particularly number of hot days and number of days with extremely high intensity rainfall.

5. Climate Change, Soil Organic Matter Content and Floral Diversity

Rising temperature can cause increased loss of organic matter from the soil due to oxidation (Yang *et al.*, 2005; Li *et al.*, 2013). In the past five to six decades, organic carbon content of the rubber soils of Kerala has declined (Saha *et al.*, 2009) and warming conditions may be one main reason for this. Such a decline has been generally noticed in other crops as well (Ray and Thomas, 2012). RRII has recently come out with a few recommendations that will help improve soil organic carbon levels. Minimum disturbing of the soil (zero tillage) is the key. There is no need to make large pits to plant a young rubber. It is enough to make a small pit just sufficiently large enough to contain the soil bole (zero pitting). Leguminous cover crops or commercial intercrops may be planted in young rubber holdings following principles of zero tillage.

Another important finding has been that allowing natural flora to grow inside a mature rubber holding will help improve soil organic carbon status as well as reduce soil acidity (Nath and Chaudhuri, 2010). This will improve the floral biodiversity status of rubber holdings which can have positive impacts on the populations of butterflies, honey bees *etc.* which are generally on the decline of several reasons including climate change. Several studies have demonstrated the significant ecological services provided by natural rubber plantations which include restoration of denuded ecosystems high rates of CO_2 sequestration (Annamalainathan *et al*,. 2011; Ambily *et al.*, 2012), improvement to the physical, chemical and biological properties of soil *etc.* (Wauters *et al.*, 2008).

6. Carbon Sequestration by Rubber Plantations

Carbon dioxide accumulation in the atmosphere has contributed the maximum to global warming compared to the other greenhouse gases. A mature rubber plantation can sequester as much as 35 to 45 ton CO_2/ha/yr (Annamalainathan *et al.*, 2011). It is estimated that entire rubber plantation in India can fix as much as 4-5 per cent of the CO_2 emitted by the automobiles in the country every year. Fast growing tree species like natural rubber are efficient in sequestering atmospheric CO_2. However, trees alone will not be able to off set the current rate of accumulation of this gas in the atmosphere even as the world emits increasing quantities of greenhouse gases into the atmosphere year after year.

7. Natural Rubber and Synthetic Rubbers

Adopting a low carbon growth trajectory is crucial to reducing emissions without compromising economic growth. Rubber is a key industrial raw material essentially needed to drive the economy. While natural rubber is a renewable raw material that is produced from rubber plantations in an eco-friendly manner, synthetic rubbers (SR) are produced from petroleum stocks. Therefore, when SRs are manufactured, huge quantities of CO_2 and other greenhouse gases are emitted into the atmosphere unlike natural rubber production (George *et al.*, 2006). Thus natural rubber is the obvious choice over SRs when it comes to low carbon growth. A fast growing economy like India requires increasing quantities of rubber – either natural or synthetic or both - and climate change puts a major obstacle in increasing domestic supply of natural rubber. Therefore, developing climate resilient smart clones of natural rubber is a top priority of research.

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