Effect of climate change on Eri and Muga cultivation and the resultant impact on rural income and employment in Assam

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Abstract

India has been the land of the 'Queen of Textiles', that is, silk, from a very old time. At present, India occupies the second position in the production of silk in the world, only next to China while occupying the first position in the consumption of the same. Mulberry silk accounts for 69.16% of the total silk production in India and eri comprises of 20.87%. However, in the state of Assam, non-Mulberry silk (eri and muga) occupies the lion's share (around 99%) in the total silk production, thereby making the sericulture sector of Assam different from the rest of India. The IPCC (2007) has projected that the global temperature would most likely rise by 4.3 to 11.5 degrees Fahrenheit in the next century and silk being an agro-industrial product will be deeply affected. With muga being more susceptible to climate change, the muga cultivators would be more severely affected than the eri cultivators. In light of the above situation, this paper would attempt to analyse two issues. Firstly, it would try to see the differentiated impact of climate change on eri and muga cultivation of Assam and secondly, it would try to understand the resultant impact on rural income and employment.

Key words: Sericulture; Rural income; Employment; Climate change.

Introduction

With about 95% of the total global silk output, Asia stands as the top producer of silk (Dewangan, 2013). India has been the land of the 'Queen of Textiles', that is, silk, from a very old time. At present, out of 58 silk-producing countries of the world, India occupies the second position in the production of silk in the world, next only to China, while occupying the first position in the consumption of the same(Nagaraju, 2008; FAO, 2019). Mulberry silk accounts for 69.16% of the total silk production in India and eri comprises of 20.87%.

Fig 1 Source: FAO, 2019.

Though Assam contributes about one-tenth of India's overall silk production, it contributes about 97 per cent of eri silk and 100 per cent of muga silk production in the country. Temperature between 24°C and 28°C, humidity within 85 to 90 percent and wildly growing host plants are some of the favourable factors for sericulture in Assam (De and Das, 2010).There are four varieties of silk; mulberry, eri, muga and tasar and though eri, muga and mulberry culture have been practised by the rural Assamese people for a long period, tasar culture is a recent addition in the silk culture of Assam.

Ericulture is practiced in almost all the districts of Assam, but it is highly concentrated in the districts of KarbiAnglong, North Cachar Hills, Dhemaji, Lakhimpur, Barpeta, Kokrajhar, Sibsagar and Darrangetc. Among all the districts of Assam, top five districts where number of families engaged in ericulture is the highest are KarbiAnglong, Jorhat, Sibsagar, Lakhimpur and Dibrugarh (Kakoti, 2012). Thousands of families in Assam have been engaged directly or indirectly in various ericulture activities like sowing of seeds, plantation of host plants, maintenance of plants, plucking of leaves from the planted and wildly grown trees, feeding and rearing of silkworm up to cocoon stage, spinning of yarn, weaving of fabrics, marketing of cocoons and cloth etc. Largely, the Kachari, the Bodo, the arbi and the Garo tribes practise this during their leisure time. It helps to improve their economic condition a lot, especially of women.

As muga is an outdoor sericulture activity, it is often influenced by changes in weather, specifically rainfall, and therefore, the resultant outcome has been heavily dependent on the climatic condition. On the one hand, it is a costly venture and, on the other hand, it involves more risk than the other sericulture activities like eri. Net profit per unit of investment is, however, the highest in case of muga, followed by eri. Initial investment required for the operation and risk involved in such activities (especially of pest attack, disease, etc.) are considerably higher in case of muga and that make ericulture more popular among the rural poor people of Assam.

Though both male and female folks of all sections of rural population have been engaged in different sericulture activities, tribal women have been predominant in the rearing and weaving of eri raw silk and endi textiles, who in addition to their daily household activities, use their leisure time and with the help of their traditionally inherited knowledge produce useful but comparatively cheaper endi clothes (De and Das, 2007). Eri and mulberry variety (also tasar) are indoor-rearing activities, while muga is an outdoor-rearing activity. Hence,

the participation of women in eri and mulberry rearing is very high, whereas participation of males is comparatively higher in case of muga.

There is ample literature on the sericulture sector in India and Assam. However, there is a dearth of literature on the impact of climate change on the sector. More particularly, an analysis of muga is hardly found as it is specific mostly to Assam. Therefore, on the basis of the background discussed, this paper aims on achieving the following two objectives.

Firstly, it aims to analyse the differentiated impact of climate change on eri and muga cultivation in Assam. Secondly, to analyse the extent of impact on livelihood of eri and muga cultivators due to the aforementioned effect.

Sericulture, rural livelihood and Assam: Background

For a very long period of time, people's affection towards silk and silk fabrics have been able to secure an important place among the most elegant and valued fabrics (Patil et al, 2009). According to the Food and Agriculture Organization (1990), evidences are found regarding the starting of sericulture about 5000 years ago. As a multidisciplinary programme, the word 'sericulture' is developed from the combination of the Greek word '*Sericos'* and the English word 'culture'; where *'Sericos'* means 'silk' and 'culture' indicates the process of 'rearing' (Kaur and Pabba, 2021). An eco-friendly enterprise, sericulture has a high potential in reducing poverty in the rural economies and preventing rural-urban migration by providing scope for improvement of people's quality of life, generation of employment and economic development (Kaur and Pabba, 2021). Through an effective utilization of natural resources, sericulture has a great scope of raising the status of the farming community (Thapa and Shrestha, 1999; Dewangan, 2013). The quick and high return through low level of investment and shorter gestation period makes this industry an ideal one to fit well in the socio-economic structure of a country like India (Brahma et al, 2019). Including both agricultural as well as industrial activities, sericulture is known as an agro-based industry; involving the activities such as raising the food plants for silkworm, rearing the silkworms and cocoon production from them, spinning or reeling cocoons and the production of silk at the final stage (Shrivastav, 2005; Ahmed and Rajan, 2011; Brahma et al, 2019).

Fig 2: Silkworm rearing process

Source: Patil et al, 2009

According to Brahma et al, (2019), sericulture can be classified into two broad sectors, namely, mulberry and non-mulberry. Mulberry sector is linked with mulberry silk and the non-mulberry sector is linked with the rearing and production of other varieties of wild silk such as Muga *(Antherae aassama)*, Eri *(Samia ricini)* and Oak-tasar *(Antherae aproylei)*. Amongst these, ericulture, that is, rearing and production of the eri silk, has a leading position among the poor rural population of Assam (De and Das, 2009). The art or the process of rearing, spinning and weaving of Eri silk was introduced by the *Bodos*, an indigenous community of India (Sharma, 1983).

The Ericlture in the state of Assam is mainly practised by the women of tribal communities such as *Bodos, Garos, Mishings, Karbis* and *Kacharis*and also by the *Ahoms*, helps to support the livelihood of their families and is also associated with their socio-cultural and economic values (Brahma et al, 2019). In the environment of rural economy of Assam, sericulture stands as one of the agro-based age-old activities providing wide scope for income and employment generation (De and Das, 2010). In astudy in Assam, De and Das (2007) finds that the total employment generated by the sericulture sector is almost three times larger than that of the quantity of people involved in the rearing of the same.

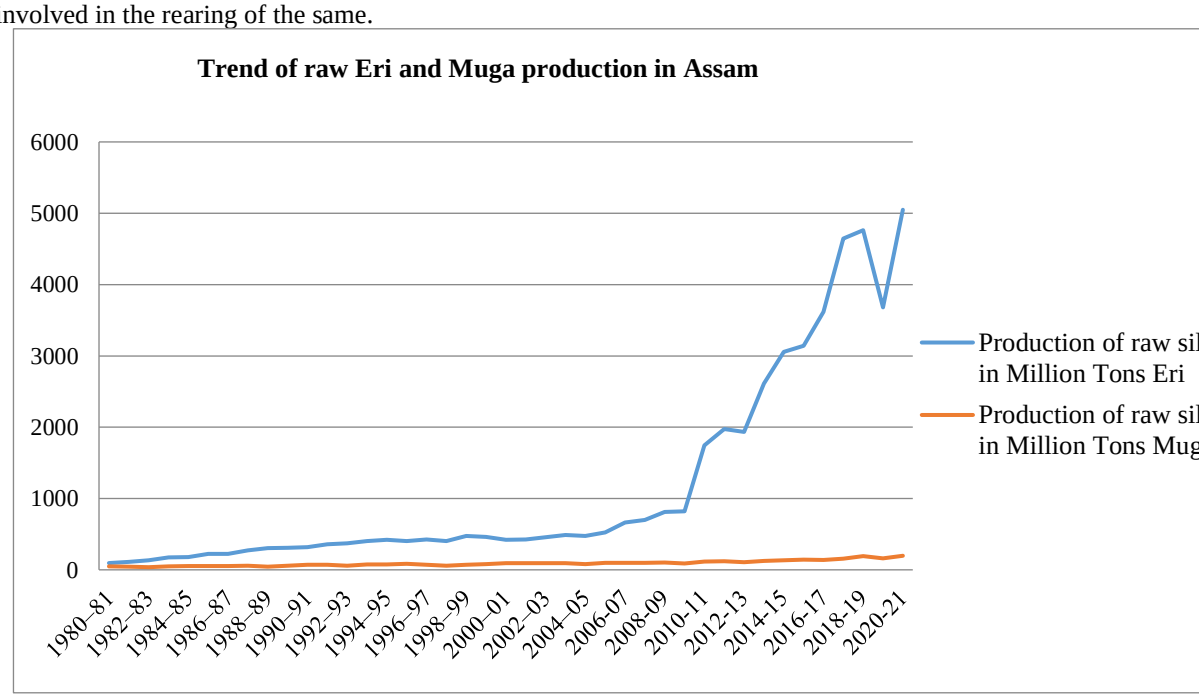

Fig 3: Trend of raw Eri and Muga silk production in Assam
Source: Authors' own finding from the statistical hand books of Assam.

The trend of growth of silk production shown in Figure 3, specially the Eri silk production, indicates the widening of the popularity for silk for commercial purpose as well as for people's regular day to day uses. Even after 2010, the growth in eri and muga production has taken a sharp rise, reflecting a huge potentiality of this sector in supporting people's livelihood and the generation of income in the state. Though in a steady rate, the production of raw Muga silk is also increasing in Assam. Hence, it is expected that in the coming future the silk producing sector will be able to generate huge amount of employment and can support a large number of families of Assam.

Materials and Methods

As the production of Eri and Muga is widely practiced in Assam, therefore, this paper aims to capture two leading Eri silk producing and two leading Muga silk producing districts of Assam to achieve the desired comparative analysis. Therefore, the two leading Eri silk producing districts viz. Karbi-Anglong and Golaghat are considered and similarly Lakhimpur and Sivsagar districts are considered,which are the leading producers of Muga silk in Assam.

Data sources are secondary and the data are collected from the reports published by the Indian Meteorological Department (GOI), Statistical Hand Books of Assam and different authentic reports. For the first objective, this paper has taken average annual temperature and rainfall to be proxies for climate change. And for the second objective, income and employment of the cultivators have been analysed to understand their economic condition. Results are discussed and presented with the help of tables, and diagrams.

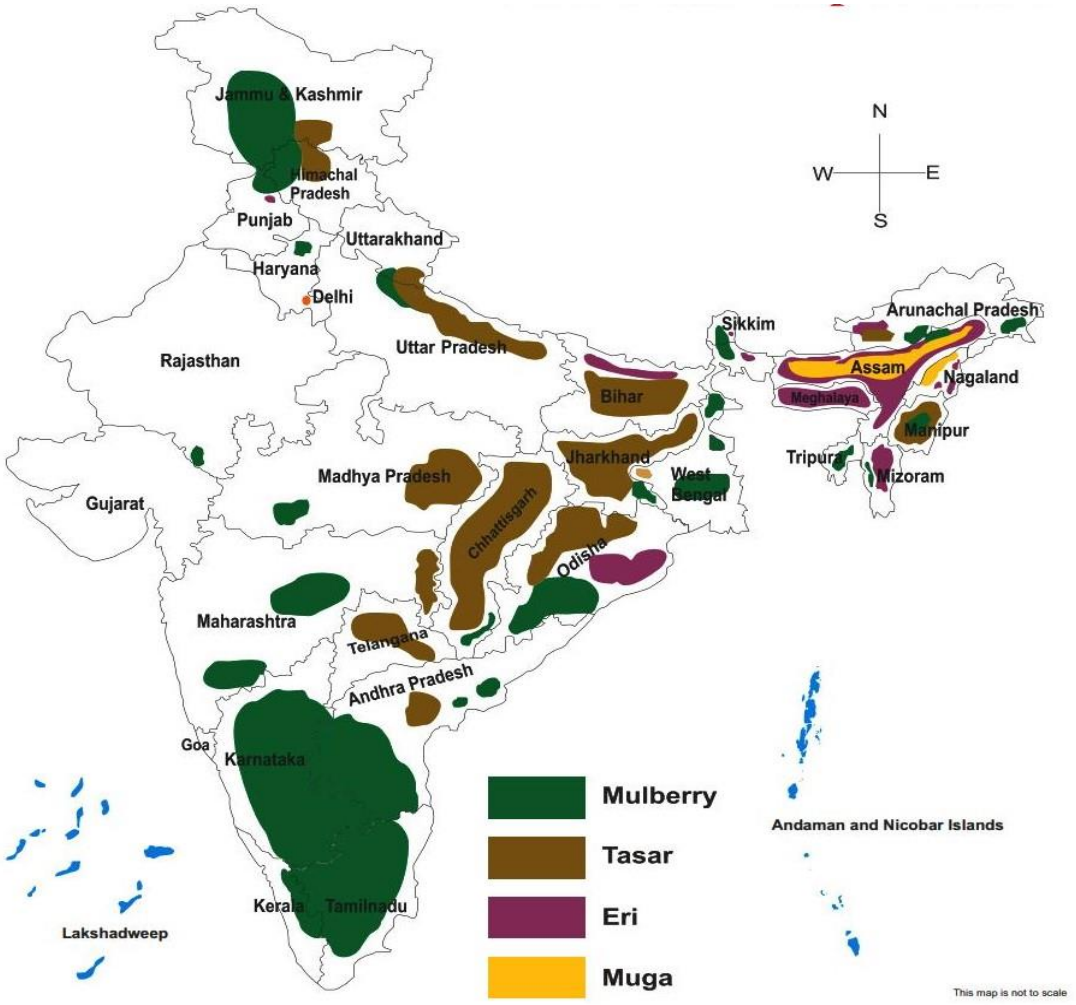

Fig 4: Distribution of sericulture across the states of India
Source: https://twitter.com/csbmot/status/1101343087475867648/photo/1, accessed on 2/2/2023

Fig 5: Golaghat

Fig 6: Karbi-Anglong

Fig 7: North Lakhimpur

Fig 8: Sivsagar

Source: https://www.mapsofindia.com. Accessed on 2/02/2023.

Discussion

It has been accepted worldwide that the globe is facing a climate crisis. Two important features of a climate crisis are the rise in the global temperature and irregularity of rainfall. The Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report observed that, "warming of climate system is now unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global sea level" (Solomon et al, 2007). However, there is a matter

of bigger concern. The brunt of environmental degradation will be felt in a disproportionate manner by different people. Rich countries will be able to mitigate the crisis in a better manner than the poor countries. Even within a country, sectors such as agriculture, fishery, horticulture, sericulture, floriculture, etc., which are intimately related to the environment, would be severely affected. And given that in developing countries like India, a huge chunk of the total population is dependent on such activities for their livelihood, therefore, these already poor people aregoing to be the ones to face the crisis first and foremost.According to FAO, in 2017, about 70 percent of the rural Indian population depended primarily on agriculture and among them 82 percent of the farmers are small and marginal.

In Assam, the total rural population has increased from 23216288 to 26807034 between 2001 and 2011. In percentage terms, it has decreased marginally from 87.09 percent to 85.90 percent. Moreover, the number of rural populations under the poverty line has not decreased much over time. The rural poverty headcount ratio was 36.4 in 2004-05, which came down to 33.89 in 2011-12. Of the total area of the state, which is 78438 sq. km, the total cropped area is 40874.49 sq. km (which comprises of 52.11 percent) in 2016-17.

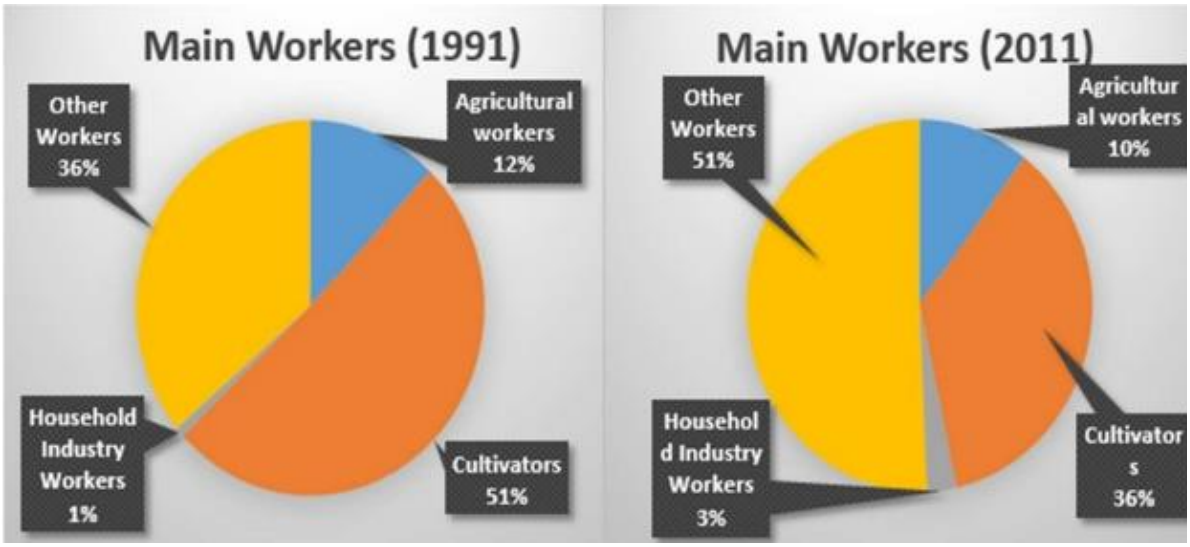

Fig 9: Distribution of Workers in Assam
Source: Census 1991, 2011.

In figure 9, it can be seen that, within twenty years, that is, between 1991 and 2011, the share of cultivators and agricultural workers has declined in the state. While the shares of cultivators have shrunk from 51 percent to 36 percent, the shares of agricultural workers have come down from 12 percent to 10 percent.

Rainfall

The rainfall trend in the state of Assam from 1989 to 2017 is given below in Fig 10

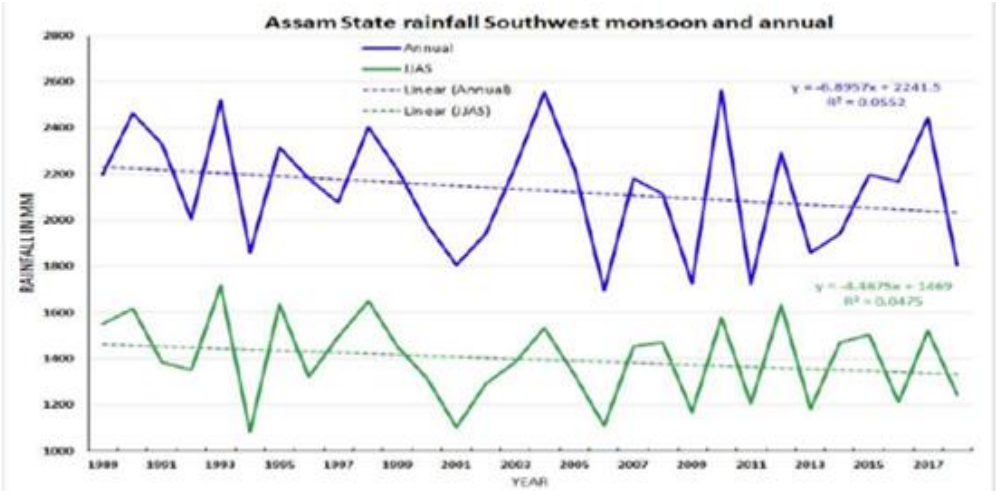

Fig 10: Trend of Rainfall in Assam
Source: : GOI (2020)

The Indian Meteorological Department, GOI, in their report issued in January 2020, has shown the annual rainfall trend (the blue line) of Assam from 1989 to 2017 (Figure 10). The equation of the trend line is y = -6.8957x + 2241.5, with which it can be assumed that, by 2040, the amount of rainfall can be assumed to come down to 1889.81mm.

However, the decrease in rainfall is not uniform all throughout the state.

KarbiAnglong and Golaghat are the leading producers of eri cocoon. It is evident that the annual rainfall trend in both the district shows a gloomy future with annual rainfall decreasing significantly (Figure 11).

On the other hand, Lakhimpur and Sivasagar are two districts that are leading producers of muga cocoon. From the above figure it can be seen that the annual rainfall trend in both the districts shows an increasing trend, though not significant. The table 1 depicts the trend of annual rainfall between 1989 and 2017 in the four districts. The amount of average annual rainfall in these four districts areused in the paper to understand which crops are suitable to be cultivated in these regions.

Temperature

The temperature records of the months of April, May, October and November from 1901 to 2002 were taken for all the four districts. It is because in Assam, kotia and jethua are the main commercial crops which contribute to more than 90 percent of the mugacocoon production in the state annually. Kotia is grown in the months of October and November, while Jethua is grown in the months of April and May (Padkai, V. N. et al., 2014).

From the four panels in Figure 12, it can be seen that, over the last century, the average annual temperatures of the four months (April, May, October and November) in the four districts have been rising. However, the temperature is increasing at an increasing rate in the district of Golaghat.

Now, from the analysis of the rainfall and temperature conditions of the four districts, itcanbe inferred that Golaghat, if the current trend continues, is going to face the brunt of climate change very soon. This will especially be felt by the sericulture sector.

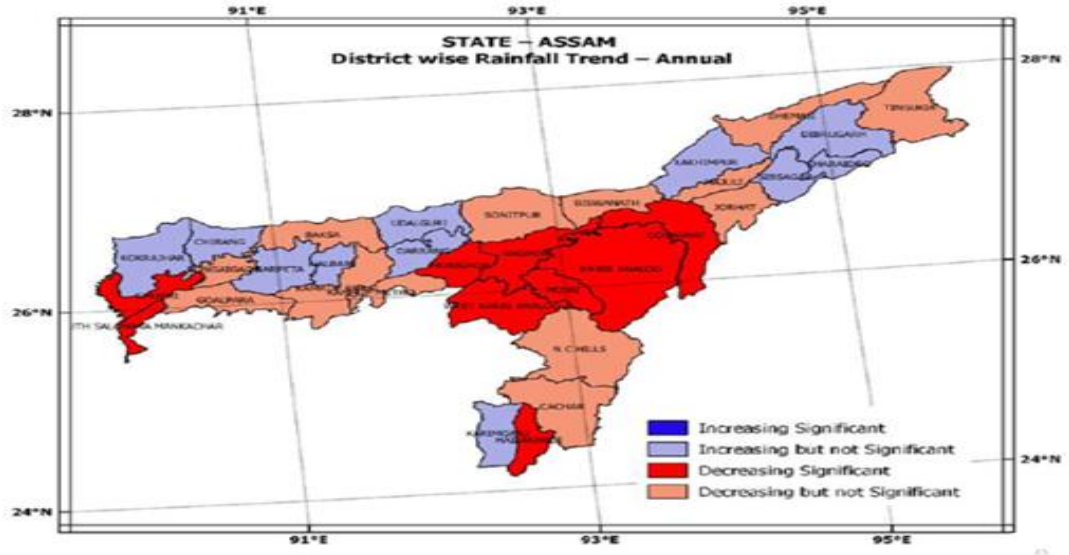

Fig 11: District Wise Annual Rainfall Trend Source: : GOI (2020)

Table 1: Average annual Rainfall

Districts	Average Annual Rainfall (mm)
KarbiAnglong	1356.1
Golaghat	1624.1
Lakhimpur	2721
Sivsagar	1824.2

Source: GOI (2020)

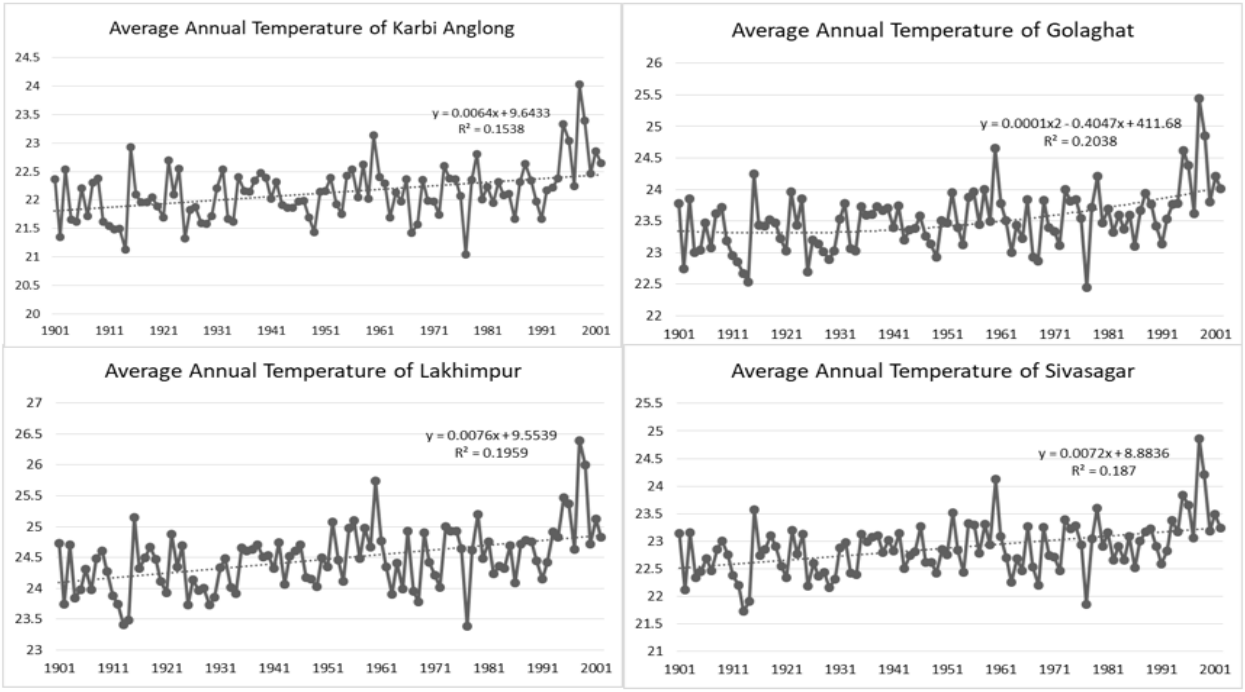

Fig12: Average annual temperature
(Source: Authors' analysis using the data from : GOI (2020))

Impact of climate change on host plant

The silk producing insects live on host plants. In the sericulture industry, the host plant plays a major role in rearing of silkworms. The quality of host plant leaves is influencedby a number of factors like the total number of cycles of silkworms to be reared in a year, number of disease-free layings (dfls) (Das et. al, 2020),effects on survival rate of the silkworms, amount of food intake, digestion, reproductive potential of the worms, growth rate and survival duration etc. (Das K, et al, 2003).

Som (PerseabombycinaKost.), and Soalu (LitseapolyanthaJuss) are the primary host plants of muga silkworm (AntheraeaAssamensis), (Thangavelu et al., 1988). These plants are infected by various diseases and insects which affects the rate of cocoon yield by affecting the quality and quantity of leaves of the plants (Daset al., 2003). Grey blight is a foliar disease (that impact leaves) in som which is caused by Pestalotiopsisdisseminata (Thum) Stey (Bharali, 1969). In this case the leaves have discolour lesions with irregular spots of grey or brown, and with time as the disease develops the leaves of the plant dries (Keith et al., 2006). The numberoflesions on the leaves depends upon the environment, mostly its humidity and temperature (Mathieu and Kushalappa, 1993). In autumn months (August and September) the infection (grey blight) in som increases to 40.43% (Das et al.,2003). Small leaves are mostly affected by this disease than the matured one (Marthe et al., 1996). Therefore, temperature manipulation is a significant tool for managing this disease (Das et al., 2010). Gall insects feed on the leaves of som and soalu. They secret a toxic saliva which results into occurrence of a malignant tumour like substance in the leaves.These are generally caused by insects, mites, nematodes, virus or fungus. Normally galls are available in the entire year but its affect is more significant from June to November (Borgohain, 2015). Som and Soalu trees are mostly affected by three types of gall insects; they are Apantelessp, AsphondyliaspandPauropsyllabeesoni(Singh et al., 2013).This type of gall is seen mostly in the time of June to November (Das, 2014) and mostly attack young plants of som (Singh et al., 2013).Pauropsyllabeesonis an insect that mostly attackssoalu plants. Its peak period is from July to October i.e.summer season, where relative humidity is about 80 to 85% and temperature is in between 25 to 30 degree Celsius. The hot climate creates a suitable environment for expanding the population of these insects (Singh et al., 2013).

Eri cocoons are mostly reared in castor plants. Seedling Blight in castor plant is a disease where stems and young plants are affected with both side of the leaf turning brown or yellow in colour. It occurs mostly in rainy season with temperature in between 20 to 25 degree Celsius (NAIP, 2023).Red Hairy Caterpillar in castor plant mostly attacks during summers (June to August). Semi looperinand tobacco caterpillar in castor plant results in defoliation and mostly occursfromJuly to September and the latter occurs in between august to October. (SILKS, 2023)

According to the analysis of Indian Meteorological Department, each year the mean temperature of Assam is increasing by 0.01 degree Celsius and it may continue to increase by 1.7 to 2.0 degree Celsius till 2050.

Also, the seasonal temperature along with winter temperatures and post monsoon temperatures are also rising. (ASAPCC, 2015). The temperature of the four districts namely; (for the months of April, May, October and November) KarbiAnglong, Golaghat, (for eri cultivation) and Lakhimpur, Sivsagar (for muga cultivation) during 1991 to 2002 is rising. The cultivation of muga will be affected a lot as host plants will suffer from diseases like grey blight and gall insects, as both expand in a favorable way in hot temperature. The temperature of Golaghat is increasing at an increasing rate (figure 12) which may lead to rise in some insects like red hairy caterpillar and semi looperin and tobacco caterpillar (in castor plants) as they occur mostly in hot temperature (as June, July and August has very hot temperature in Assam) which will affect the eri cultivation resulting in fall in eri production.

Impact of changing trend of rainfall and temperature on sericulture

Muga silk is produced by the muga silkworms, scientifically known as *Antheraeaassamensis*, which are fed on som (*Machilusbombycina*) and sualu (*Litsaea polyantha*) leaves, whereas, eri silk, also known as Errandi or Endi, is derived from the silkworm *Philosamiaricini*and*Samiaricini*. *Philosamiaricini*feeds on castor oil plant (*Ricinuscommunis*) leaves and hence known as castor silk (International Sericulture Commission, 2016).Therefore, the growth and development of som, sualu and castor is of vital importance for the rearing of eri and muga silkworm.

The temperature and rainfall requirement of castor, sualu and som are given in the Table 1. Nowcomparing Figures10, 11 and 12 above and Table2, it can be seen that the growth of castor and som are not going to be affected by the rising temperature in the immediate future. But we can also see that the growth and development of sualu is bound to be hampered in all the fourdistricts due to the rising global temperature. And since eri worm is dependent on castor trees, so the growth and development of eri is not going to get affected due to the rising temperature. However, muga worms are fed on both sualu and som tree leaves and since sualu cultivation is likely to get affected due to the rising temperature, therefore, cultivators need to reconsider their production inputs.

Again, Table 1 and Table 2 suggest that castor plantation might get affected in Lakhimpur district, which again means that eri cultivation is likely to be affected in that particular district due to the changing rainfall pattern. However, rainfall pattern is going to affect muga cultivation in the districts of KarbiAnglong, Golaghat and Sivasagar.

Likely impact on cultivators' income and employment

Climatic conditions like annual temperature and rainfall are likely to affect the plantation of castor, sualu and som trees, which are the primary sources of feed for eri and muga worms. This sectionlooks into the trend of eri and muga cultivation and production in the state, and thereby try to see if the predictions that were made in the context of the climatic conditions have actually materialised. The figures were constructed by the authors using data from Economic Survey of Assam (2011-12, 2014-15 and 2016-17).

In Figure 13, against the climatic odds, between the period of 2005 and 2017, the production of eri cocoon has increased at an exponential rate and the rate of increase in muga cocoon is also high (even if not exponential).

From the two panels given in Figure 14, it can be seen that the growth in the number of sericulture villages has increased only marginally over the period 2005-2018 (except for the sudden spike in 2014-15). However, the other graph shows a dismal picture as the number of families engaged in sericulture shows a drastic downward trend from 2013-14, before which the number was increasing at a satisfactory rate. Lastly, the trend in the average prices of raw eri and muga silk in the state is looked into.

Table 2: Characteristics of Castor, Sualu and Som

Scientific name	Common name	Temperature required (^{0}C)	Rainfall required (mm)
RicinusCommunis	Castor	15-38	700-2300
Litsea Polyantha	Sualu	0-20	2800-3200
Litsea Polyantha	Som	23-25	2400-2800

Source: indiabiodiversity.org

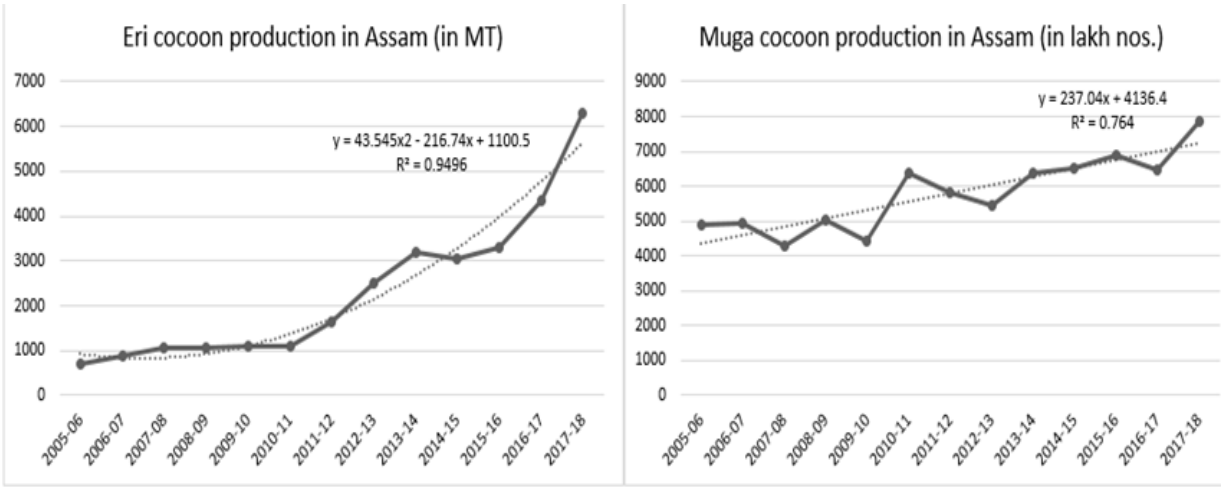

Fig 13: Eri and Muga Cocoon Production in Assam
Source: Authors' analysis using the data from Economic Survey of Assam.

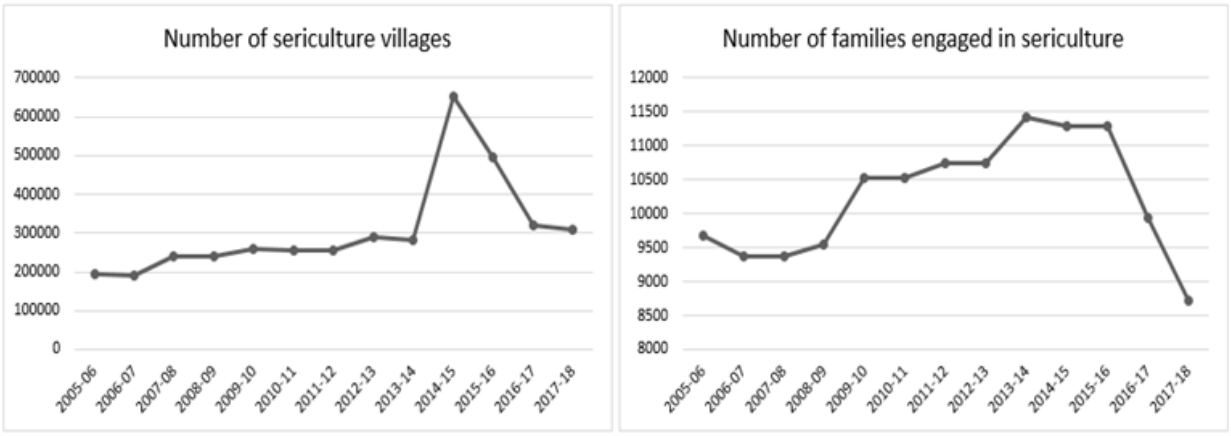

Fig 14: Number of Sericulture villages and family engaged
Source: Authors' analysis using the data from Economic Survey of Assam

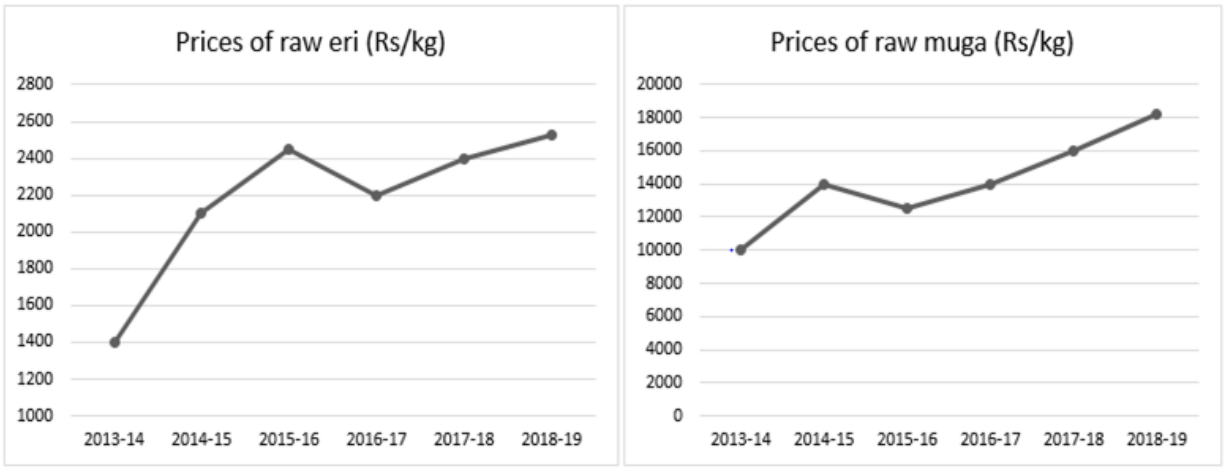

Fig 15: Prices of Eri and Muga
Source: Authors' analysis using the data from Economic Survey of Assam

In the two panels in Figure 15, it is seen that, over the period 2013-2019, the prices of both raw eri and raw muga have been rising at almost a steady rate. However, it should be noted that the price of per kg of eri is way less than the price of per kg of muga. During this time period, while the highest price of eri was Rs. 2525/kg, the lowest price of muga was Rs. 10000/kg.

Thus, from the above discussion, the following points are highlightedregarding the status of eri and muga cultivation in Assam.

- The rainfall pattern of India is deeply affected by the subdivisional monsoon rainfall, the El-Nino Southern Oscillation and the Indian Ocen sea-surface temperature (Krishna Kumar et al, 2004). Moreover, rainfall intensity reduction and prolonged rainfall breaks can also have a severe adverse effect on crop production of India (Prasanna V, 2014). Rainfall trend shows a problematic future for Golaghat and KarbiAnglong districts, both of which are leading producers of eri. Sivasagar, a leading producer of muga, is likely to face threat from rainfall pattern.
- The effect of a rise in temperature on agricultural production is reflected in numerous studies (Ortiz et al., 2008). Consequently, temperature increase may affect castor tree cultivation in Golaghat district, thereby affecting eri cultivation. Muga cultivation in KarbiAnglong, Lakhimpur and Sivasagar would be affected by rising temperature because, one of the plants on which muga worm feeds on (sualu) may get affected.
- Sericulture is a labour-intensive industry and thus this sector has huge potential to generate income and employment (Chantotra et al., 2019). Moreover, in India, almost half of the people working in this sector are women. Therefore, this sector can also play a role in the upliftment of the condition of women (Rama Lakshmi C.S. 2007). However, as we saw, the number of families dependent on sericulture is coming down. On the contrary, there has been a considerable rise in the production of eri and muga cocoon over the years. This means that labour from the sericulture industry is moving on to other areas.
- It should be noted that the price of eri is way below the price of muga (Figure 15). However, both are showing steady increase. This shows that muga and eri are fast becoming high valued products and their international demand is also high. Both these factors together point towards sericulture becoming a profitable area.

Conclusion

The total production of eri and muga is increasing at a steady rate, even though rainfall and temperature is becoming uncongenial for cultivation of the primary plants (castor, som and sualu) on which eri and muga worms survive. Therefore, it is very likely that there are other forces at play like advanced technologies, intensive cultivation, better pest control measures, etc. However, it shown be made clear that the price of eri is well below the price of muga and since a large share of the workforce is engaged in eri, therefore, the total revenue generated from the sale of eri would be distributed among a larger population, thereby making the economic gap between eri and muga cultivators sharper.

Conflict of interest: The authors confirm that there is no conflict of interest.

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