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Perception of Tasar Silkworm Rearers about the Climate Change Impact on the Tasar Silk Production of Maharashtra

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Tasar sericulture is one of the allied sectors of agriculture which is a climate sensitive sector. Understanding farmer's perception about the climate change impact on the rearing performance tasar silkworm is a key to the development of new climate tolerant technologies so as to encourage the other farmers for adopting sericulture eventually to boost the production of the tasar silk

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production in the state. Thus, the study was designed to establish farmer's perception on climate change and its impacts on tasar silkworm rearing performance. The study was conducted in all four tasar silkworm rearing districts of Maharashtra namely Bhandara, Gondia, Gadchiroli and Chandrapur. A total 160 tasar silkworm rearers were selected randomly from all the four districts. Information was collected from each tasar silkworm rearers through Rapid Rural Appraisal (RRA) and focus group discussions (FGD). Climate Change Perception Index (CCPI) and Climate Change Impact Perception Index (CCIPI) were used to assess the perception about the impact of climate change on tasar silk production. Weighted Average Index (WAI) was used to analysis the impact. Results showed that majority of the respondents perceived that the yield and production of tasar cocoons production has reduced compared to last ten years. Moreover, frequent loss of the crop is noticed due to sudden change in the climatic conditions during the rearing of silkworm. Similarly, the high incidence of diseases and pest is also noticed thereby affecting the income generation of the tribal tasar farmers of the state. The results of the study will be useful for formulating appropriate policy against the ill-effects of the climate change. The results will also give impetus to the researcher to develop the thermo tolerant and climate change tolerant or resistant varieties or races of tasar silkworm so as to boost the tasar silk production of the state.

Keywords: Climate change; perception; tasar; silkworm; sericulture.

1. INTRODUCTION

Climate change has been recognized as a major threat to the survival of species and integrity of ecosystems worldwide [1]. It is recognized globally as the most impending and pressing critical issue affecting mankind's survival in the 21st century. The global temperature is rising every year and a series of record-breaking weather events are causing havoc the world over [2]. According to the recent reports of the Intergovernmental Panel on Climate Change, the global average surface temperature over the 20th century has increased by around 0.60°C [3]. The Intergovernmental Panel on Climate Change [4] suggested that if temperatures rise by about 2.0^{o}C over the next 100 years, negative effects of global warming would begin to extend to most regions of the world; it is believed likely that approximately 20-30 percent of plant and animal species will be at an increased risk of extinction. It has also been reported that the average temperature in India has risen by about 0.5°C from the accumulation of anthropogenic greenhouse gases in the atmosphere during the past century or so [5,6]. The effect of recent emissions will be manifested over several decades and given current trends, the temperature rise will likely exceed 2.0°C. [7]. Climate variability and change is one of the major sources of risk for farmers in farming [8,9]. Based on the prediction of several researchers from various Indian institutions, the temperature may rise from 0.5 to 4.0°C in the various parts of the country in the next few decades from the accumulation of anthropogenic greenhouse gases in the atmosphere, which may change practices and economy of Indian agriculture or sericulture drastically [10].

Silk, the queen of textile industry, has achieved remarkable growth in production in recent times. Silk production has increased from 21,005 MT in 2010-11 to 33,770 MT in 2020-21 at a compound growth rate of 4.6% per annum [11]. The possible effects of a changing climate on Lepidoptera and other insects have already started receiving some attention [12,13]. Anthropogenic climate change is an important issue which needs to be taken seriously in the context of Lepidoptera conservation and pest research [14-16]. Silkworms, being exothermic insects, are being exposed to the environmental factors such as temperature; humidity, rainfall etc. and plays important role in their growth and development in every stage [17]. The tasar silkworm, as a lepidopteron insect, is also exposing to the vagaries of climate since it is being reared outside in the open forest and it is sensitive to the changing climatic condition [18-20]. The environmental factors like temperature and humidity determines the success of rearing of the tasar silkworm and the production of the final outcome of this industry, the silk. During silkworm rearing, high temperature adversely affects nearly all biological processes including the rates of biochemical and physiological reactions [21] and the silkworms were more sensitive in fourth and fifth instars stages [22,23]. Thiagarajan et al. [24] and Ramesh et al. [25] reported that the phenotypic expression is greatly influenced by environmental factors such as temperature, relative humidity, light, and nutrition.

The tasar culture provides livelihood to 1.65 lakh tribals in Jharkhand, Chhattisgarh, Odisha, Madhya Pradesh, West Bengal, Uttar Pradesh, Maharashtra, Bihar, and Andhra Pradesh states [26]. Creation of rural employment, alleviation of poverty and elevation of socio-economic status of tribals are the unique feature of Indian tropical tasar culture [27,28].

The tasar sericulture industry is very age old in Maharashtra state since it is a traditional tasar silk producing state. The tasar silk production is mainly carried out in 4 districts of Vidharbha region i.e. Gadchiroli, Bhandara, Chandrapur and Gondia. Nearly 2757 families mainly belong to Dheewar community are practicing Tasar sericulture since last 200 years [23,29].

The climate of Maharashtra state is generally characterized by hot summers, monsoon and then mild winters. The western and central parts of Maharashtra fall in the Hot Semi-Arid Eco-Region and have hot and humid summers, mild and dry winters and mean annual rainfall of 600-1000 mm. Most of eastern Maharashtra lies in the Hot Sub-Humid (Dry) Eco-Region and has hot summers, mild winters and mean annual rainfall of 1000-1500 mm, with an increasing trend towards the east [30]. The regions focused in Tasar sericulture practicing areas fall in the Hot Semi-Arid and Hot Sub-Humid regions [31].

It has become common knowledge that the poor are likely to be hit hardest by climate change and the capacity to respond to climate change is the lowest in developing countries. It seems clear that vulnerability to climate change is closely related to poverty, as the poor are least able to respond to climatic stimuli. The tasar silkworm rearers of the Maharashtra are the tribal people who does not even owned the land/forest for the rearing of tasar silkworms. The land allotted by the forest department of Maharashtra is being utilized by those tribal people for earning their bread and butter and sustenance of life. It has been noticed that the interest farmers gradually declining towards tasar sericulture activities due to continuous failure of their crop and low crop yield. Thus, it is pertinent to study their perception about the impact of climate change on their sustenance and livelihood for better understanding of tasar farmers' concerns and the approach in which they perceive climate change is crucial to design effective policies for supporting successful adaptation measures for sericulture sector. Moreover, understanding how tasar farmers perceive changes in climate and what factors shape their adaptive behavior is useful for adaptation research [32,33]. The knowledge about the climate change impact on tasar silk production will ultimately enhance the credibility of policies and their strength to tackle the challenges being imposed by climate change on farmers [34]. Farmers' perceptions about climate change, therefore, strongly affects how they understand and deal with climate induced risks and uncertainties, and undertake specific traditional or innovative measures to mitigate the adverse impact of climate change on rearing performance. With this background the study was conducted with the objective of knowing the general perception of climate change and impact of climate change on tasar silkworm rearing perceived by the tasar silkworm rearers of Maharashtra.

2. MATERIALS AND METHODS

The "Ex post facto" research design was used for the present investigation along with cross sectional survey for data primary data collection (Fig. 1). The present study was conducted in Bhandara, Gondia, Gadchiroli and Chandrapur districts of Maharashtra state. From each district one tensil was purposively selected for the study where tasar silkworm rearings are extensively taken by the Tasar silkworm rearers. Four tehsils selected were Bhandara, Arjuni and Armori, Bramhapuri from Bhandara, Gondia, Gadchiroli and Chandrapur districts, respectively. From Each tensile two villages were selected randomly and from each village 20 tasar silkworm rearing farmers were selected randomly to make a total sample size of 160 respondents. Pre testing of the questionnaire was made on pilot basis and suitable changes were incorporated within the formation of things, questions and their sequences.

For studying the general perception of tasar silkworm rearers about the climate change, Climate Change Perception Index (CCPI) was developed. The index contained 10 statements on 3 point continuum Likert Scale i.e. Agree, Undecided and Disagree. Similarly, Climate Change Impact Perception Index (CCIPI) was used to assess the perception about the impact of climate change on tasar silkworm rearing performance. Respondents were asked to score the Climate Change Impact Perception Index based on 3 point continuum Likert Scale. The scale contained 10 (positive and negative) statements. For positive statements scoring was done Increased-03, Unchanged-2, and

Decreased-01 and for negative statement the scoring was Decreased-03, Unchanged-02 and Increased-01. Weighted Average Index (WAI) was used to analysis the impact with the following formula;

$$WAI = \frac{(f_3w_3+f_2w_2+f_1w_{1)}}{(f_1 + f_2 + f_3)}$$

Where, f- is frequency,
w- Corresponding weight

Suitable descriptive statistics such as mean, mode, median, standard deviation, variance etc. were used to analyze the data. SPSS software was also used for the analysis.

Fig. 1. Interviewing the tasar silkworm rearers

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Status of Tasar Silkworm Rearers

The socio-economic characteristics of the Tasar silkworm rearers are depicted in the Table 1 which reveals that most of the Tasar silkworm rearers fell in middle to old age category with average age of 42 years. Most of them were educated from primary to middle school level with the average education up to 8th class/standard. Tasar silkworm rearers were found to have small to medium family size with average 6 family members. As far as the experience in Tasar silkworm rearing was concerned, more than half of the rearers (55.00%) were having 11-20 years experience in rearing followed by more than 20 years of experience (33.75%) and slightly more than one tenth of the rearers (11.25%) had up 10 years of rearing experience. The average experience in tasar silkworm rearing was about 18 years. It is also evident from the table that majority of the Tasar sericulturist (36.25%) possessed the rearing capacity of 501Dfls to 750 Dfls in a single crop in the jungles/forest allotted by the state forest departments to them. The average rearing capacity possessed by the tasar silkworm rearers was 603.34dfls per crop. The average rearing capacity was found high in Gadchiroli district with 611 dfls per crop. As far as the annual income from the Tasar Sericulture is concerned, for the majority of the Tasar silkworm rearers the annual income purely from the tasar silkworm rearing was ranging from Rs.40,000/- to Rs.80,000/- with the average income of Rs.56,975/-. The highest total average annual income from the tasar sericulture was reported in the Gadchiroli district of Rs.58,800/- followed Chandrapur, Gondia and Bhandara district with Rs.56,950/-, Rs. 56,750/- and Rs. 55,400/-, respectively. The results of the study are in line with study conducted by Jalba [35], BAIF [36] and Haribaruah et al. [37]

3.2 General Perception About the Climate Change of Tasar Silkworm Rearers of Maharashtra

General perception of the tasar silkworm rearers about the climate change is depicted in the Table 2. From the perusal of the data presented in Table 2, it can be inferred that more than 88 per cent tasar silkworm rearers had agreed that the heat waves during day hours in summer have increased with the WAI 2.81. Increased in temperature and sunny dayswas expressed by around 85 per cent with WAI 2.74. Similarly, more than 80 per cent tasar silkworm rearers had revealed that the total rainy days have decreased over the period. It has got 2.69 WAI. Around 79 per cent rearers perceived that the winter is shortened, followed by drought conditions have increased over the period (74.37%) and rainfall has become more erratic (75.62%) with the WAI of 2.60 and 2.58, respectively. Long dry spells during the rainy season and rains don't come when it normally used to have received WAI of 2.56. Moreover, too much/heavy rainfall has got the WAI of 2.34. Overall, more than 75 per cent tasar silkworm rearers have agreed that there is a climate change happening over the period while 15.62 per cent tasar silkworm rearers were disagreed with the fact and 9.38 per cent respondents remained neutral. Finding of the study are consonant with Rupa Kumar et al., [38], Loria and Bhardwaj, [39] and Kawadia and Tiwari [40].

Table 1. Socio-Economic status of the tasar silkworm rearers of Maharashtra (n=160)

Characteristics	Category	Bhandara (n=40)		Gondia (n=40)		Gadchiroli (n=40)		Chandrapur (n=40)		Overall (N=160)	
		f	%	*f*	%	*f*	%	*f*	%	*f*	%
Age (Yrs)	Young (<30)	7	17.5	8	20.0	7	17.5	8	20.0	30	18.75
	Middle (31 to 50)	23	57.5	21	52.5	24	60.0	22	55.0	90	56.25
	Old (>51)	10	25.0	11	57.5	9	22.5	10	25.0	40	25.00
	Mean/Average	42.06		43.03		41.08		42.08		42.06	
	S.D.	8.52		8.89		8.48		8.58		8.62	
Education	Illiterate	2	5.0	5	12.5	4	10.0	4	10.0	15	09.38
	Primary	14	35.0	12	30.0	13	32.5	13	32.5	52	32.50
	Middle School	15	37.5	16	40.0	16	40.0	15	37.5	62	38.75
	High School	7	17.5	7	17.5	5	12.5	6	15.0	25	15.62
	Graduate	2	5.0	0	0.0	2	5.0	2	05.0	6	03.75
	Mean/Average	7.63		7.39		7.79		7.61		7.60	
	Std. Deviation	3.13		3.18		3.05		3.13		3.12	
Family size (In Nos. of Members)	Small (2- 4 Members)	13	32.5	10	25	13	32.5	12	30.00	48	30.00
	Medium (5-7 Members)	19	47.5	21	52.5	18	45.0	21	52.50	79	49.38
	Big (8 &above)	8	20	9	22.5	9	22.5	7	17.50	33	20.62
	Mean/Average	5.60		5.85		5.77		5.74		5.73	
	Std. Deviation	1.89		1.82		1.94		1.88		1.89	
Tasar Silkworm rearing experience (In No. of years)	Up to 10 years	3	7.5	5	12.5	6	15.0	4	10.00	18	11.25
	11 to 20 years	22	55.0	24	60.0	19	47.5	23	57.50	88	55.00
	More than 20 years	15	37.5	11	27.5	15	35.5	13	32.50	54	33.75
	Mean/Average	18.07		17.30		18.10		17.80		17.82	
	Std. Deviation	4.23		5.54		4.91		4.44		4.78	
Rearing capacity of allotted forest (In Nos. of Dfls/Crop)	Up to 300 Dfls	3	7.5	5	12.5	3	7.5	5	12.50	16	10.00
	301-500 Dfls	15	37.5	12	30	14	35	13	32.50	54	33.75
	501-750 Dfls	12	30.0	16	40	16	40	14	35.00	58	36.25
	More than 750 Dfls	10	25.0	7	17.5	7	17.5	8	20.00	32	20.00
	Mean/Average	600.625		596.25		611.25		605.25		603.34	
	Std. Deviation	193.87		202.27		194.88		195.38		196.61	

Characteristics	Category	Bhandara (n=40)		Gondia (n=40)		Gadchiroli (n=40)		Chandrapur (n=40)		Overall (N=160)	
		f	**%**	***f***	**%**	***f***	**%**	***f***	**%**	***f***	**%**
Annual Income from Tasar Silkworm Rearing (Rs.)	Less than Rs.20000/-	03	7.5	03	7.5	02	5.0	02	05.0	10	6.25
	Rs.20000/- to Rs.40000/-	06	15.0	05	12.5	05	12.5	08	20.0	24	15.00
	Rs.40000/- to Rs.60000/-	15	37.5	14	35.0	13	32.5	12	30.0	54	33.75
	Rs. 60000/- to Rs.80000/-	12	30.0	14	35.0	15	37.5	11	27.5	52	32.50
	More than Rs.80000/-	04	10.0	04	10.0	05	12.5	07	17.5	20	12.50
	Mean/Average	Rs.55400/-		Rs.56750/-		Rs.58800/-		Rs.56950/-		Rs.56975/-	
	Std. Deviation	Rs.18660/-		Rs.18390/-		Rs.18160/-		Rs.18450/-		Rs.18415/-	

Source: Author's calculation

Table 2. General perception about the climate change of tasar silkworm rearers of Maharashtra

Sl. No.	Climate change parameters	Tasar silkworm rearers' perception (n=160)			WAI
		Agree	Undecided	Disagree	
01	Rainfall has become more erratic	121 (75.62%)	11 (6.88%)	28 (17.50%)	2.58
02	Rain start early and ends early	113 (70.62%)	09 (5.63%)	38 (23.75%)	2.47
03	Increased in Temperature and sunny days	135 (84.38%)	08 (5.0%)	17 (10.62%)	2.74
04	Heat waves during day hours in summer	141 (88.12%)	07 (4.37%)	12 (7.50%)	2.81
05	Long dry spells during the rainy season	111 (69.37%)	27 (16.88%)	22 (13.75%)	2.56
06	Rains don't come when it normally used to	109 (68.12%)	32 (20.00%)	19 (11.88%)	2.56
07	Total rainy days have decreased	129 (80.62%)	13 (08.12%)	18 (11.25%)	2.69
08	Short winter season	126 (78.75%)	09 (05.62)	2515.63%)	2.63
09	Too much/heavy rainfall	98 (61.25%)	19 (11.88%)	43 (26.87%)	2.34
10	Drought conditions have increased	119 (74.37%)	18 (11.25%)	23 (14.38%)	2.60
	Average	**120 (75.15%)**	**15 (9.38%)**	**25 (15.62%)**	**2.60**

Author's calculation

3.3 Impact of Climate Change on Tasar Silkworm Rearing Perceived by the Tasar Silkworm Rearers of Maharashtra

The data presented in the Table 3 and Fig. 3 reveals that majority of the tasar silkworm rearers perceived that the cocoon production & yield in last ten years has been decreases and ranked first with the WAI of 2.81. They also agreed with the fact that the frequency of loss of tasar rearing due to climate change has been increased over the period. It has got WAI of 2.76. They also revealed that the frequency of disease incidence is increased and ranked it as 3rd major factors in the impact of climate change on the rearing rearing. It has received the WAI of 2.71. Further, the income from tasar silkworm rearing has perceived to be decreased, while mortality of final stage larvae of silkworm, frequency of pests and predators incidence, hatching problem in dfls during first crop have perceived to be increased by the majority of the tasar silkworm reares and they have received the rank of 4th, 5th, 6th and 7th respectively with the WAI of 2.70, 2.67, 2.61 and 2.55 respectively. New pests and diseases incidence has received 8th rank while Labour cost for tasar silkworm rearing has received 9th rank with the WAI of 2.51 and 2.50 respectively. Lastly, the quality of tasar cocoons has reported to be decreasing and received last rank i.e.10th with 2.44 WAI. The findings of the study are in

Fig. 2. Disease and pests outbreaks due to climate change

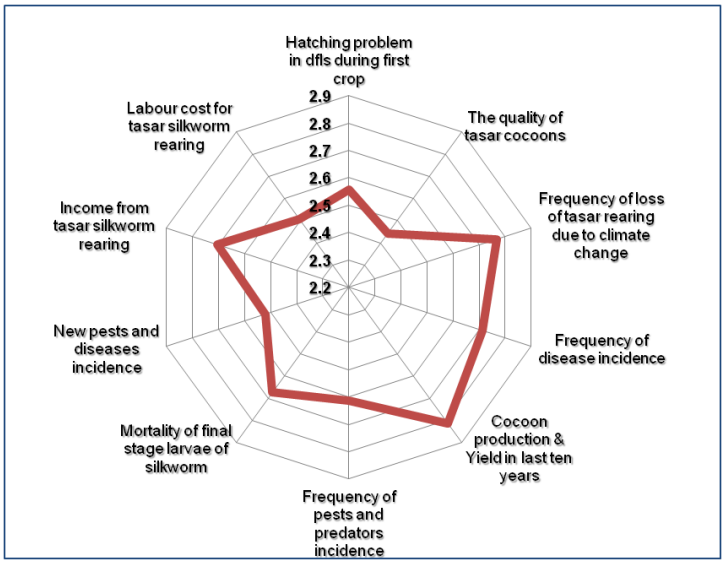

Fig. 3. Impact of climate change on tasar silkworms rearing perceived by the tasar silkworm rearers of Maharashtra

Table 3. Impact of climate change on tasar silkworm rearing perceived by the tasar silkworm rearers of Maharashtra

Sl. No.	Impact parameters	Statement type	Frequency of Perception (n=160)			WAI	Rank
			Increased	No Change	Decreased		
01	Cocoon production & Yield in last ten years	Negative (-)	05 (03.12%)	20 (12.50%)	135 (84.38%)	2.81	I
02	Frequency of loss of tasar rearing due to climate change	Positive (+)	133 (%)	17 (%)	10 (%)	2.76	II
03	Frequency of disease incidence	Positive (+)	123 (76.87%)	28 (17.50%)	09 (5.63%)	2.71	III
04	Income from tasar silkworm rearing	Negative (-)	10 (6.25%)	27 (16.87%)	123 (76.87%)	2.70	IV
05	Mortality of final stage larvae of silkworm	Positive (+)	123 (76.87%)	22 (13.75%)	15 (09.38%)	2.67	V
06	Frequency of pests and predators incidence	Positive (+)	117 (73.12%)	24 (15.0%)	19 (11.88%)	2.61	VI
07	Hatching problem in disease free laying during first crop	Positive (+)	104 (65.0%)	41 (25.62%)	15 (09.38%)	2.55	VII
08	New pests and diseases incidence	Positive (+)	101 (63.12%)	48 (30.00%)	11 (06.88%)	2.51	VIII
09	Labour cost for tasar silkworm rearing	Positive (+)	99 (61.87%)	43 (26.88%)	18 (11.25%)	2.50	IX
10	The quality of tasar cocoons	Negative (-)	22 (13.75%)	45 (28.13%)	93 (58.12%)	2.44	X

Author's calculation

conformity with the study of Zamal T. et al [41] and Chand and Kumar [42]. Sharma et al. [43] in their study reported that a positive correlation was observed between temperature and diseases viz. grasserie (0.74) and flacherie (0.80) and high viral and bacterial infection was recorded in autumn season due to the high temperature and humidity. Weather is one of the important factors that influences disease incidence in silkworm. Several researchers working either in the field of agriculture or sericulture predicted the significant effect of climate change on silkworms' host plants, silkworm rearing and post cocoon technology which directly affects the Indian economy [10]. Rising temperature and day-to-day changing weather patterns linked to global warming which becomes a threat to the sericulture industry not only for India but for the other countries which are associated with this industry. The effect of climate change on silkworms and other beneficial insects is of greater significance because they are involved in many biotic interactions which play a major role in the ecological functioning as well as they use to contribute a significant amount to the GDP of the country [44].

4. CONCLUSION

From the findings of the study it can be concluded that the majority of the tasar silkworm rearers have perceived that the climate change is happening over the period of time and climatic factors such as temperature, rainfall have been showing the deviation from the normal. Moreover, they also perceived that the climate change has the significant impact on the rearing performance and affecting the cocoon production and yield in the state. The results of the study will be useful for formulating appropriate policy against the adverse effects of the climate change on tasar sericulture. The results will also give impetus to the researcher to develop the thermo tolerant and climate tolerant or resistant varieties or races of tasar silkworm so as to boost the tasar silk production of the state. It will also provide valuable information to the technology developers who are engaged in the improvement of quality and quantity of tasar silk acceptable to the international standard.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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