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Strategic preferences towards drought and coping mechanisms in sericulture: A multivariate statistical approach

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Abstract
The mulberry cultivation and silk worm rearing in several sericulture clusters of Southern region of India are severely affected due to drought. The coping mechanisms adopted by the farming community have recently become a subject of increasing importance in climate change research with an objective to reduce the vulnerability of climate sensitive activity. The present study designed to know the technological preferences of farmers towards sericulture, mainly focusing on both mulberry cultivation and silkworm rearing to manage drought in Chikkaballapura district of Karnataka. The practices such as the drip irrigation and micro irrigation techniques, followed by trenching and mulching, formation of runoff collection pits/ponds, green manuring, summer ploughing and sub soiling are major strategies adopted by the farmers in mulberry garden. The practices such as reducing size of rearing, skipping of rearing and providing leaf to animals, shift from BV to CB rearing and early brushing in summer season are major management practices adopted by the sericulture farmers in silkworm rearing. The study also aims to investigate the determinants of adoption of coping mechanisms by the farmers to mitigate the impact of drought on their farming activity. The discriminant analysis was carried out and the result shows that the predictor variables such as education, crop diversity, animal husbandry, non-farming income, liquid assets, Government support, extension activities and information communication sources are relatively more important and positively influencing on adoption of drought coping strategies.

Keywords: Coping strategies, drought, adoption index, discriminant analysis, eigen value

Introduction
The State of Karnataka has 72 per cent of the cultivable area is rainfed and only 28 per cent is under irrigation (GOK News, 2020) [19]. The State is the second largest in terms of arid region, next only to Rajasthan in India. The State faced consecutive droughts during the years 2001-02, 2002-03 and 2003-04 resulted in a sharp decline in agricultural output (Nagaratna and Sridhar, 2004) [9]. Drought stress is the major limiting factor for rice production and yield stability under the rainfed crop ecosystem. Karnataka faces a high risk of moisture stress at maximum tillering and reproductive stages of the crop, which may lead to yield loss of 25 to 100 per cent (Hanamaratti *et al*., 2008) [2].
When drought occurs, the agricultural sector is usually the first to be affected. Even though the meteorological drought is over, the adverse economic impact of drought may persist for several years depending upon the nature of drought (Praveena, *et al*. 2016) [11]. Based on the case studies and focus group discussions with farmers, the most commonly used adjustments in rice production practices during drought years are allocating more area to short-duration varieties, switching from transplanting to direct seeding, switching to traditional varieties which are considered to be more drought-resistant, etc. (Serraj, *et al*, 2008) [14].
The mulberry cultivation and silk worm rearing in several sericulture clusters of southern regions of India are severely affected by drought. Due to drought, there will be reduced mulberry yield and which directly affects the silkworm crop partially or totally. The quality of the silk cocoons will also be affected due to drought. The ill effects of drought, to a considerable extent, can be alleviated by adopting proper management strategies.

Integrated drought management technologies are propagated to farmers to mitigate drought but the extent of adoption of these technologies is very low. (Mahimasanthi *et al*., 2018) [20] had reported very high gap in adoption of technologies. The major problems of drought experienced by the farmers are acute water shortage, dry and desiccating wind, drying of leaves in the shed, disease outbreak, spinning of small size cocoons, higher melting of cocoons and lower silk ratio.

Reason for selection of Chikkaballapura district as a study area

The Chikkaballapura region is one of the drought prone areas in eastern dry zone of Karnataka where most of the farmers were involved in rainfed agriculture (Fig 1). The Chikkaballapura district selected based on important parameters like rainfall distribution, number of rainy days, temperature, relative humidity, dry windy days and hot sunshine hours in a day etc. The analysis of the rainfall distribution showed that there was a 50 per cent probability of occurrence of drought in Chikkaballapura district than in any other districts of Southern Karnataka. The average rainfall of Chikkaballapura district is around 500 mm to 650 mm, which experienced severe drought during the year 2016 and medium drought during the year 2017.

The drought occurs in Chikkaballapura district is majorly contingent drought, which occurs mainly due to, it's located in rain shadow region of monsoon flow and located far away from the coastal zone, hence drought is more prevalent there and precipitation occurrence is less. However the district also stands frontline in dairy farming and live-stock rearing which leads to dairy products. Alternative solutions based on scientific assessment of land and water resources are essential to mitigate the losses from recurrent drought (Nagendra and Hanjagi, 2019) [10].

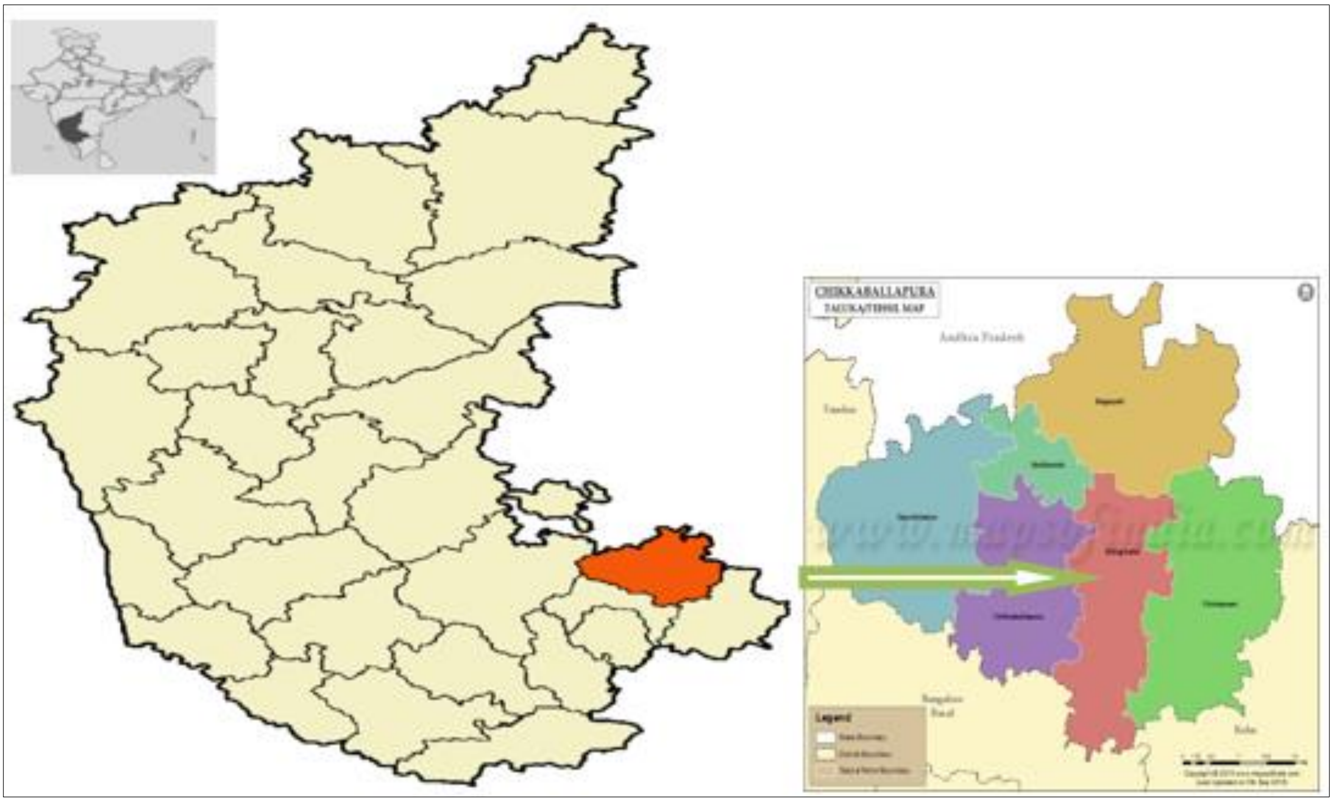

Fig 1: Karnataka map highlighting the Chikkaballapura district and the taluk list

Scope and Objective of the study

The outcome of the study would be useful to the policy makers to implement drought relief programmes during the drought periods depending upon the intensity of drought and its impact on levels of income and productivity. The identification of socio-economic characteristics, agronomical practices, cropping patterns and livestock, income, extension activities and other sources of information, etc. are considered under study. The statistical models are constructed to know the adoption of drought coping strategies and which would be helpful to find the factors affecting the adoption rate.

The main objectives of this research are

a) To study the strategic preferences in mitigating the drought in mulberry cultivation & silkworm rearing in Chikkaballapura district of Karnataka.
b) The study also aims to determine and analyze the factors influencing on adoption of drought coping mechanisms.

Materials and Methods

The primary data recorded on socio-economic characters, agronomical aspect of sericulture, rearing patterns, cropping pattern, livestock details, agro based enterprises, drought management strategies, income details (Farming and non-farming), extension activities and communication and information sources of farmers of Chikkaballapura district of Karnataka (India). The data is mainly related to coping strategies implemented against drought by the sericulture farmers of this region and the information collected by employing the simple random sampling design (Mequannt Marie *et al*., 2020) [7]. The sample size (number of farmers) is 100 and the variable of interest, the unit of measurement are given in the table 1.

Table 1: Variables Encoding Summary

Code	Variables	Measurement
Y	Adoption behavior (Response Variable: Adoption Index)	Y = 1 for Low levelAdoption = 2 for Medium level Adoption = 3 for High level Adoption
X_1	Age of the farmer	Number of years
X_2	Education of the farmer	Formal years of education
X_3	Household size	Number of family members
X_4	Farm size	Number of acre's
X_5	Farming experience	Number of years
X_6	Crop diversity	Number of crops grown in a year
X_7	Animal husbandry	Number of farm animals/livestock's
X_8	Agro based activities	Number of activities
X_9	Farm income	In Rupees (Rs.)
X_{10}	Non Farming income	In Rupees (Rs.)
X_{11}	Information & Communication Sources	Number of sources exposed frequently
X_{12}	Extension Visits	Number of Visits
X_{13}	Worth of Liquid Assets	In Rupees (Rs.)
X_{14}	Crop Insurance & Drought relief found by Government	In Rupees (Rs.)

Intensity of adoption of drought coping strategies by the sericulture farmers

The extent of adoption of any technology has captured by providing adoption score, here the score 3 indicates high level adoption, the score 2 provides medium level of adoption and the score 1 indicates low level of adoption. There are total 16 different drought mitigating parameters related to sericulture are formulated in questionnaire with equal importance and the sericulture farmers are grouped into high level, medium level and low level adopters based on their adoption score. The adoption index was computed for each farmer as below:

$$\text{Adoption index} = \frac{\text{Farmer'stotalscore}}{\text{Totalpossiblescore}} \text{x100}$$

Statistical Analysis

Discriminant Analysis

Discriminant analysis is a multivariate technique concerned with classifying distinct set of objects and allocating new objects or observations to the previously defined groups. It involves deriving variants which are combination of two or more independent variables that will discriminate best between a priori defined groups.

Linear Discriminant Function

If the population covariance matrices are equal then linear discriminant function for classification is very useful, otherwise quadratic discriminant function is used for this purpose. The maximum number of discriminant functions that can be computed is equal to minimum of G-1 and p, where G is the number of groups and p is the number of variables. Suppose the first discriminant function is

$$Z_1=W_{11}X_1+W_{12}X_2+......W_{1p}X_p,$$

Where, the W_{1j} is the weight of the j^{th} variable for the first discriminant function. The weights of the discriminant function are such that the ratio

$$\lambda_1= \frac{\text{Between groups SS of } Z_1 \text{ is Maximized}}{\text{Within groups SS of } Z_1}$$

Suppose the second discriminant function is given by,

$$Z_2=W_{21}X_1+W_{22}X_2+......W_{2p}X_p$$

The weights of above discriminant function are estimated such that the ratio

$$\lambda_2= \frac{\text{Between groups SS of } Z_2}{\text{Within groups SS of } Z_2}$$

Is maximized subject to the constraint that the discriminant scores Z_1 and Z_2 are uncorrelated. The procedure is repeated until all possible discriminant functions are identified. Once the discriminant functions are identified, the next step is to determine a rule for classifying the future observations.

Results and Discussion

Intensity of adoption: In order to stabilize the livelihood and to balance the farm income, the farmer's will adopt certain drought management strategies. Here, around 16 sericulture strategies are enlisted, which are helpful for mitigating drought effect on sericulture farmer's income. The result of adoption index shows that, out of 100 sericulture farmers (Table 2), about 37 farmers were belongs to higher level of adoption (Adoption score > 60%), followed by 35 farmers belongs to medium level of adoption (Adoption score between 30% to 60%) and finally 28 farmers belongs to low level of adoption (adoption score < 30%) (Mahimasanthi and Rajaram 2020) [4].

Table 2: Farmer wise extent of adoption of drought management strategies

Extent of Adoption	Adoption Level (%)	Number	%
Low	< 30	28	28
Medium	30 -60	35	35
High	> 60	37	37

Preferences and expectations of farmers from research and extension personnel to overcome the crisis were collected by personal interviews, compiled and enlisted in Table 3. There are 16 different parameters are enlisted for sericulture farmers to mitigate the effect of drought on their farm income. All the technologies should be followed in an integrated manner to harvest successful silkworm crops (Munikrishnappa *et al.*, 2009) [8].

Table 3: Drought management strategies in sericulture

Mulberry Cultivation	
Variable Name	**%**
Drip Irrigation & micro irrigation techniques	94
Trenching & mulching	83
Formation of runoff collection pits/ponds	81
Green manuring	76

Summer ploughing	59
Sub soiling	53
Bore well Recharging	46
Cover crop/Catch crop as intercrop	35
Planting across the slope	12
Tree plantation instead of bush plantation	7
Drought tolerant variety	5
Silkworm Rearing	
Reduce size of rearing	90
Skipping of rearing & providing leaf to animals	64
Shift from BV to CB rearing	51
Early brushing in summer season	32
Awareness rearing new hybrid suitable for drought	10

Adoption of mulberry cultivation technologies in integrated manner is required to overcome the crisis of drought. There are 11 mulberry cultivation practices and the maximum of 94% of farmers have full adoption of drip irrigation and micro irrigation techniques, followed by trenching and mulching (83%), formation of runoff collection pits/ponds (81%), green manuring (76%), summer ploughing (59%) and sub soiling (53%) are also major strategies in mulberry garden adopted by the farmers and these practices help them to preserve soil moisture. The construction of farm ponds and other rain water harvesting structures should be encouraged in drought prone areas to mitigate water shortage (Krishnamoorthy and Radhakrishnan 2012). Production of quality mulberry leaves with moisture content is essential for successful silkworm rearing during summer months. Adoption of these technologies will increase the moisture holding capacity of the soil; prevent moisture loss and helps in production of quality mulberry leaves.

The following silkworm rearing strategies are majorly adopted by the farmers, reducing size of rearing (90%), Skipping of rearing and providing leaf to animals (64%), Shift from BV to CB rearing (51%) and early brushing in summer season (32%). The silkworms are more prone to diseases during hot and humid weather. Hence in addition to above strategies farmers has to adopt some common techniques to maintain temperature and humidity in the rearing house such as sprinkling the water and cover with wet cloth, providing required aeration in the rearing shed, reduce size of rearing, sprinkle clean water on the floor and walls of the sheds, raising trees around the rearing house, hanging filled earthen pots inside sheds, hanging wet curtains to windows and doors of the shed, covering the roof of the shed and management of pruning schedule (Rajaram *et al*. 2006) [12].

Table 4: Tests of Equality of Group Means

Variables	Wilks' Lambda	F	DF 1	DF 2	Sig.
Age	0.75	1.80	2	97	0.308
Education	0.60	31.51	2	97	0.000
Farm Size	0.96	1.59	2	97	0.209
Farming Experience	0.99	0.09	2	97	0.911
Crop Diversity	0.92	3.74	2	97	0.027
Animal Husbandry	0.47	54.46	2	97	0.000
Agro based activities	0.97	1.36	2	97	0.262
Farm Income	0.64	2.62	2	97	0.096
Non Farming Income	0.58	34.24	2	97	0.000
Liquid Assets	0.35	86.73	2	97	0.000
Government Support	0.06	711.48	2	97	0.000
Extension Activities	0.38	78.63	2	97	0.000
Information Communication Sources	0.90	5.36	2	97	0.006

The result of the test of equality of group means, which explains the strong statistical evidence of significant differences between means of different group of adopters shown in Table 4. Further, the importance of independent variables are assessed based on Wilk's lambda, F statistics and their probability level. The predictors like education, crop diversity, animal husbandry, non-farming income, liquid assets, extension activities and information and communication sources are having high F statistics value and statistically significant at 5% level. These predictors are main contributors for differences in the means of two groups and they are capable enough to discriminate the groups.

Table 5: Canonical Discriminant Coefficient Summary

Function	Eigen Value	% of Variance	Cumulative %	Canonical Correlation
1*	25.77	98.20	98.20	0.98
2	0.47	1.80	100	0.56

***** First Canonical Discriminant functions used in the analysis.

There are many ways to decide the numbers of functions which are sufficient to classify the groups, among them the Eigen value and associated % of variance is major one to decide the number of functions. The Eigen value of each discriminant function reflects the ratio of importance of the dimensions which classify cases of the dependent variable. It means between-groups sums of squares divided by within-groups sums of squares. A large Eigen value is associated with a strong function and considered as potential function for classification.

The Eigen value and corresponding variance explained by the discriminant function from the whole data explained in Table 5. If there is more than one discriminant function only the function with Eigen values greater than 1.0 is retained and other functions which are less than one are discarded out of the model. In the above table Eigen value (25.77) of the first function explains 98.20% of variations in the data, which is potential enough to classify the events.

Table 6: Standardized canonical discriminant function coefficients

Variables	Function
	1
Age	0.017
Education	0.396
Farm Size	0.066
Farming Experience	0.097
Crop Diversity	0.475
Animal Husbandry	0.562
Agro based activities	0.068
Farm Income	0.094
Non Farming Income	0.384

Liquid Assets	0.420
Government Support	0.922
Extension Activities	0.367
Information Communication Sources	0.416

The standardized canonical discriminant coefficients which explain the relative importance of each predictor on discrimination of adopters into three different categories which provided in Table 6. The sign indicates the direction of the relationship and magnitude indicates extent of contribution to the group discrimination. The predictors like education, crop diversity, animal husbandry, non-farming income, liquid assets, Government support, extension activities and information communication sources are relatively more important and positively influencing on adoption of drought coping strategies (Meenakshi *et al*., 2015) [6].

Table7: Classification table

Observed	Predicted			
	1	**2**	**3**	**Percent Correct**
1	25	2	1	89.28%
2	4	29	2	82.85%
3	3	4	30	81.08%
Overall Percentage	25.00%	29.00%	30.00%	84.00%

The classification matrix, which helps to assess the performance of the model by cross tabulating the observed response categories with the predicted response categories presented at Table 7 and it shows how well our full model correctly classifies the cases.

Classification result is summary of number and percent of subjects classified correctly and incorrectly. Out of 28 low level adopters, about 25 cases are correctly categorized as low level adopters and remaining 3 cases are wrongly classified in to other section which yields 89.28% accuracy and in the same way out of 35 medium level adopters, 29 respondents are correctly categorized as medium level adopters and only 6 respondents are mismatched and grouped in to other section, results 81.08% accuracy. The main information is the overall percentage in the lower right corner, which shows our discriminant function is 84% accurate in discriminating the respondents into three categories.

Conclusion

The Chikkaballapura district of Karnataka belongs to the Eastern dry zone (Agro climatic zone) and the sericulture farmers were usually suffers from acute water shortage due to low rainfall, rainfed ecosystem and frequently occurrence of drought. This affected the production and productivity of mulberry cultivation and silkworm rearing. Hence the farmers in drought affected areas followed drought management technologies to cope up drought effect.

The coping mechanisms such as the drip irrigation and micro irrigation techniques, followed by trenching & mulching, formation of runoff collection pits/ponds, green manuring, summer ploughing and sub soiling are also major strategies in mulberry garden adopted by the farmers and these practices help them to preserve soil moisture. The silkworm rearing mechanisms such as reducing size of rearing, skipping of rearing & providing leaf to animals, shift from BV to CB rearing and early brushing in summer season are major management practices adopted by the sericulture farmers of Chikkaballapur district. The majority of farmers in this district gave more importance to only few strategies which gave immediate effect on production and gave less importance to others which was beneficial in long term.

The discriminant analysis was carried out to understand the determinants of adoption and the result of the analysis shows that the variables such as education, crop diversity, animal husbandry, non-farming income, liquid assets, Government support, extension activities and information communication sources are relatively more important and positively influencing on adoption of drought coping strategies.

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