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STATUS AND SCOPE OF CROP DIVERSIFICATION AS A TOOL FOR RISK MITIGATION IN THE CYCLONE PRONE CUDDALORE DISTRICT OF TAMIL NADU, INDIA

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Abstract

The study was carried out with an overall objective of analysing the status and scope of crop diversification in the cyclone prone Cuddalore district of Tamil Nadu. The specific objectives were to assess the existing degree of farm level crop diversification, to assess and analyse the shift in cropping pattern in the last two decades and to rank the reasons for the non-adoption of crop diversification in Cuddalore district of Tamil Nadu. With regard to selection of district, Cuddalore was purposively selected, since it was worst affected by cyclones and floods in the past decade. The analyses revealed that the concept of crop diversification is less pronounced in Cuddalore district and also there is no remarkable shift in cropping pattern in the past decade, even though the region encountered with severe havocs due to repeated cyclones. Strong attachment to the conventional farming system is found to be the reason for non-adoption of crop diversification.

Key Words: Risk, crop diversification, shift in cropping pattern, Markov Chain analysis

Introduction

The history of coastal disasters around the globe due to nature's fury has provided powerful reminders of the vulnerability of coastal regions. The recent decade has witnessed not only an increase in the frequency but also an increase in the intensity and duration of cyclones. Therefore, it is time to generate various means and methods to map the vulnerability of cyclones, so that the impact of the disaster can be minimized (Saravanan S, 2018). The coast of Tamil Nadu has been hit by cyclonic storms with disastrous effects, almost once in two years. In some years, the coast has been hit more than once. The districts often affected by cyclones in the state are, Kanyakumari, Thirunelveli, Ramanathapuram, Thanjavur, South Arcot (now bifurcated as Cuddalore and Villupuram districts) and Chengalpattu (Directorate of Water Management, Bhubaneswar, 2014).

Cyclones like Thane and Nilam in the recent past caused very severe irreparable damages to Cuddalore district of Tamil Nadu. The havoc was unbearable affecting agriculture, livestock and fisheries sectors. During Thane, 3170 hectares of crop, 822 numbers of boats and nets were damaged. 1214 numbers of livestock lost their lives in Cuddalore district. Similarly, during Nilam, around 81,500 hectares of agriculture and horticultural crops got damaged (IMD, 2012).

During such havocs the livelihood security of the farmers of the region has met with a severe and very serious blow which needs to be certainly addressed with. Eventually it is also a fact that the damage became intolerable since majority of the farmers were adopting a monocropping system of farming. In the districts prone to cyclone, annual-perennial crop mix in a farm is the ideal form of crop diversification. During milder havocs, the damage with tree crops would be less than field crops. Hence tree crops could support the farmer for survival even though field crops may let the farmer down. At times of heavier havocs tree crops as well as field crops would get damaged but field crops would add much to the resilience of farmers since he can regain his position at least in the next season, with some external aid. Crop diversification almost remains as a forgotten concept in the region, and farmers are unaware of the alternative crops which could be cultivated in their land, since the present system has been followed for decades/ centuries together.

In general, existing statistics reveal that in the

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Cuddalore district, crop diversification seems to be very much limited. If the district as the whole is concerned, cultivation is undertaken with a wide spectrum of crops esp. Paddy, Cashew and Jack in large stretches. But the micro level details on village specific and farm specific scenarios, explicitly reveal only a very negligible level of crop diversification. The reason for which has to be explored and set right, since in such areas which are prone to cyclone, crop diversification could serve as an effective remedy.

Under this perception the following study was conceived with the following objectives:

· To assess the existing degree of farm level crop diversification in the cyclone prone Cuddalore district of Tamil Nadu.

· To access and analyse the shift in cropping pattern in the last two decades in Cuddalore district.

To rank the reasons for the non-adoption of crop diversification in Cuddalore district.

Materials and Methods

Study Area and Selection of Farmers

Cuddalore district formed the universe of study. With regard to selection of blocks, four coastal blocks *viz.,* Cuddalore, Kurinjipadi, Parangipettai and Panruti were selected purposively since they are more prone to cyclones. From each of the selected blocks, 30 farmers were selected at random. The primary data on crop wise area allocation at farm level and reasons for non-adoption of crop diversification were collected from the selected farmers. With regard to the secondary data the district level data on crop coverage for the past twenty two years was collected from Department of Economics and Statistics, Cuddalore, Tamil Nadu.

Tools of analysis

Herfindahl Index (HI)

The Herfindahl index is a measure of concentration. The degree of crop diversification in a region could be assessed using the Herfindahl index. It is an economic concept widely applied in competition law in USA (Brown Donald *et al.,* 1988).

Index was computed by taking the sum of square of area proportion of each crop in the gross cropped area of the farm. This index was worked out by the following formula.

$$HI = \sum_{i=1}^{N} Pi^2$$

Where, N = Total number of crops

P_i = Average proportion of the i^{th} crop in gross cropped area

With increase in diversification, the index decreases. The index takes a value of one when there is a complete specialization and approach to zero as N is large, i.e. diversification is perfect. The Herfindahl index was estimated separately for each farm and the average value of the farm level indices was considered for district level interpretation.

Simpson Index (SI)

The Simpson Index (SI) is also a suitable index of measuring diversification in a particular geographical region. Mathematically, SI is defined as

$$SI = 1 - \sum_{i=1}^{N} Pi^2$$

Where,

$P_i = A_i / \Sigma A_i$ is the proportion of the i^{th} activity in acreage.

If Simpson Index is nearer to zero, it indicates that the zone or region is near to the specialization in growing of a particular crop and if it is close to one, then the zone is fully diversified in terms of crops. The Simpson index was estimated separately for each farm and the average value of the farm level indices was considered for district level interpretation.

Markov Chain Analysis

The direction of shift in cropping pattern of area under major crops was analyzed using the first order Markov chain approach using LINGO software. Central to Markov chain analysis is the estimation of the transitional probability matrix 'P' whose elements, P_{ij} indicate the probability (share) of crop categories switching from i^{th} crop category to j^{th} crop category over time. The diagonal element P_{ij}, where i=j, represents the retention share of respective crop category in terms of area under crops.

This can be denoted algebraically as

$$E_{jt} = \sum_{i=1}^{n} (E_{it-1}) P_{ij} = e_{jt}$$

Where,

E_{jt} = Area under major crops to the j^{th} crop in the year t

E_{it-1} = Area under i^{th} crop during the year t-1

P_{ij} = The probability of shift in area under i^{th} crop to j^{th} crop

e_{jt} = The error term which is statistically independent of E_{it-1}

n = The number of major crops

The transitional probabilities P_{ij}, which can be arranged in a (m x n) matrix, have the following properties:

$$\sum_{i=1}^{n} P_{ij} = 1 \text{ and } 0 \leq P_{ij} \leq 1$$

Thus, the expected share of each crop during period 't' is obtained by multiplying the share of these crops in the previous period (t-1) with the transitional probability matrix.

The transitional probability matrix is estimated using linear programming (LP) framework by a method referred to as minimization of Mean Absolute Deviation (MAD), the formulation is stated as

Min, OP* + Ie

Subject to,

X P* + V = Y

GP* = 1

P* ≥ 0

Where,

P* is a vector of the transitional probabilities P_{ij} to be estimated

O is the vector of zeros

I is an appropriately dimensional vector of areas

e is the vector of absolute errors

Y is the proportion of area to each crop category.

X is a block diagonal matrix of lagged values of Y

V is the vector of errors

G is a grouping matrix to add the row elements of P arranged in P* to unity.

This Markov Probability model was also used to study the changes in the cropping pattern in the study area.

Garrett's Ranking Technique

To study the reasons for non-adoption of crop diversification, Garrett's ranking technique was employed (Garette, 1969). The order of merit assigned by the respondents were converted in to ranks using the formula,

$$\text{Percent position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where,

R_{ij} = rank given for i^{th} factor by j^{th} individual

N_j = number of factors ranked by j^{th} individual

By referring to Garrett's table, the percentage positions estimated were converted in to scores and then for each factor the scores of various respondents were added and mean value was arrived at. These means were arranged in descending order. The problem having the highest mean value was considered as the most important and was given the highest rank and vice versa.

Results and Discussion

Crop Diversification

The degree of farm level crop diversification in Cuddalore, Kurinjipadi, parangipettai and Panruti blocks were assessed and quantified using Herfindahl Index and Simpson Index for the three recent years *viz.,* 2017, 2018 and 2019. The indices were estimated for each farm separately and the average value of these farm level indices is presented in table 1.

The Herfindahl index would decrease with increase in diversification. It could be observed that the calculated values of Herfindahl index were relatively high and almost equal in all the four selected blocks *viz.,* Cuddalore, Kurinjipadi, Panrangipettai and Panruti. The value of indices ranged between 0.656 to 0.763 for all the recent three years referred. The indices vividly conveys the fact that crop diversification is much limited in Cuddalore district.

With regard to Simpson index, the lower values indicate a decreased level of diversification and the higher values indicate an increased level of crop diversification. As per table 1, the Simpson indices ranged between 0.2375 and 0.3434. The values indicate that crop diversification is not upto the needed level in Cuddalore district.

From the above results, it is evident that, the farmers of Cuddalore district does not consider the concept of crop diversification even though, they have encountered with several cyclonic havocs.

Shift in Cropping Pattern

Markov Chain Analysis was used to study the shift in cropping pattern in Cuddalore district over the last two decades. The probability of retaining the particular crop and the shift was interpreted by studying the diagonal and off diagonal elements of transitional matrix. The transitional probability matrix and steady state probabilities

Table 1: Farm level Crop Diversification Indices for Coastal Blocks of Cuddalore District.

S. No.	Name of the Block	Herfindahl Index			Simpson Index		
		2017	2018	2019	2017	2018	2019
1.	Cuddalore	0.7625	0.6891	0.7712	0.2375	0.3109	0.2288
2.	Kurinjipadi	0.6986	0.7018	0.7097	0.3014	0.2982	0.2903
3.	Parangipettai	0.6566	0.7079	0.6711	0.3434	0.2922	0.3289
4.	Panruti	0.7112	0.7291	0.6926	0.2888	0.2709	0.3074

pertaining to shift in cropping pattern in the study area were computed using the data on area under major crops and presented in table 2.

Shift in the Area under Major Crops in Cuddalore District

Markov chain analysis is the way of analyzing current movement of variables in an effort to predict future movement. In the transitional probability matrix, the rows identify the current state of cropping pattern in major crops and the columns identify the alternatives to which the cropping pattern could move. The diagonal elements represent probability of retaining the same level of area with a specific crop.

The transitional and steady state probabilities for the shift in cropping pattern was computed based on the area under major crops between 1996-97 and 2017-18. Out of this twenty two years of temporal data available on cropping pattern, only the intermittent values with an interval of two years *i.e.,* every third year was only considered for the analysis. The results reveal the following inferences,

1. The probability of retention of existing area under Groundnut was estimated at 50.65 percent, Paddy at 47 percent and maize at 35.77 percent.

2. The analysis revealed that the shift in area from Groundnut to Paddy was 18.19 percent, Maize to Paddy was 29.12 percent and Cashew to Paddy was 63.68 Percent.

3. Gingelly and Tapioca crops were found to be less stable and could retain only 1.75 and 6.35 percent. The possible shift in area from Gingelly was estimated at 32.87 percent to Paddy and 20.99 percent to Black gram and 14.10 percent to Cashew. Subsequently, the possible shift in the area from Tapioca was estimated at 40.05 percent to Groundnut, 28.07 percent to Paddy and 9.23 percent to Sugarcane respectively. But a parallel observation which needs to be considered is that the cumulative current area under Gingelly and Tapioca accounts to only 2.34 percent. And hence this may not have a significant impact on the larger cropping scenario of the district.

The steady state probabilities showed that if the trend continues like this, in future 41.24 percent of area would be under Paddy, 17.14 percent would be under Black gram, 10.28 percent would be under Sugarcane and 10.27 percent of area would allocated to Cashew.

The future forecasted share of area under different crops vide steady state probabilities were not very much deviating from the current share of area under the respective crops. Hence it could be concluded that the cropping pattern of Cuddalore district remains almost same over years and the trend would be continued.

This trend again reiterates the fact that the expected

Table 3: Major Reasons for Non-adoption of Crop Diversification by Farmers.

S.No.	Particulars	Rank
1.	Attachment to the conventional cropping pattern	I
2.	Resistance in adoption due to fear of failure	II
3.	Lack of technical knowledge	III
4.	Lack of training facilities to promote crop diversification	IV
5.	Unable to get involved in related training	V
6.	Lack of awareness on government schemes and policies	VI

Table 2: Transitional Probability Matrix for Area under Major Crops in Cuddalore District between 1996-97 and 2017-18.

Major Crops	Paddy	Maize	Black Gram	Tapioca	Sugar cane	Cas-hew	Grou-ndnut	Ging -elly	Cot-ton	Other Annual Crops	Other Perennial Crops
Paddy	0.4700	0.0236	0.1659	0.0039	0.1205	0.0914	0.0000	0.0164	0.0168	0.0634	0.0280
Maize	0.2912	0.3577	0.2314	0.0000	0.0000	0.0115	0.0000	0.0000	0.0816	0.0263	0.0000
Black Gram	0.3389	0.1040	0.2270	0.0000	0.0908	0.1200	0.0000	0.0017	0.0157	0.0967	0.0049
Tapioca	0.2807	0.0000	0.0000	0.0635	0.0923	0.0158	0.4005	0.0789	0.0000	0.0562	0.0118
Sugarcane	0.3006	0.0026	0.2464	0.0000	0.1677	0.1289	0.0202	0.0061	0.0000	0.0982	0.0289
Cashew	0.6368	0.0279	0.0291	0.0288	0.0302	0.1494	0.0000	0.0000	0.0222	0.0000	0.0751
Groundnut	0.1819	0.0000	0.0000	0.0700	0.1091	0.0325	0.5065	0.0543	0.0000	0.0232	0.0222
Gingelly	0.3287	0.0029	0.2099	0.0000	0.0918	0.1410	0.0749	0.0175	0.0000	0.1329	0.0000
Cotton	0.1442	0.3726	0.3054	0.0000	0.0000	0.0131	0.0000	0.0331	0.0846	0.0465	0.0000
Other Annual Crops	0.4706	0.0020	0.1642	0.0177	0.0916	0.1090	0.0000	0.0289	0.0000	0.1059	0.0096
Other Perennial Crops	0.1392	.0000	0.1056	0.0352	0.2382	0.1698	0.0399	0.0082	0.0000	0.0193	0.2441
Steady State Probability	0.4124	0.0587	0.1714	0.0085	0.1028	0.1027	0.0155	0.0121	0.0182	0.0652	0.0320
Current year share of Major Crops (%)	43.7	6.76	16.76	1.04	7.11	9.63	2.82	1.30	1.83	6.60	2.73

dynamism of farmers in accordance with the prevailing risk due to natural calamities is very much lagging. And hence the farm level crop diversification remains a dream yet in Cuddalore district.

Major Reasons for Non-adoption of Crop Diversification by Farmers.

The major reasons for non-adoption of crop diversification are presented in table 3. It could be observed from the table that, 'Attachment to the conventional cropping pattern' ranked first followed by 'Resistance in adoption due to fear of failure' as rank second. 'Lack of technical knowledge' had been reported as the third major reason for non-adoption of crop diversification. Subsequently 'Lack of training facilities to promote crop diversification', 'Unable to get involved in related training' and 'Lack of awareness on government schemes and policies' were ranked fourth, fifth and sixth respectively.

Conclusion

Cuddalore is a district much prone to cyclonic havocs and to mitigate this sort of risk, crop diversification is a time tested and proven tool.

The analyses reveal that in Cuddalore district farm level crop diversification is very much limited and the cropping pattern is also almost stable over two decades. The farmers are hesitant to accept the concept of diversification, because of their blind attachment to the conventional pattern of cropping and less risk absorbing nature.

Policy suggestions

· Awareness needs to be created among farmers on the concept of crop diversification and its role in risk mitigation.

The suitable alternative crops preferably favouring an annual-perennial mix at farm level may be advocated and needed training needs to be imparted on the technical aspects of cultivation.

References

Brown, Donald M., Warren-Boultan and R. Frederick (May 11, 1988). "Testing Structure-Competition Relationship on Cross-Sectional Firm Data", Discussion paper 88-6. Economic Analysis Group, U.S. Department of Justice.

Garrett, Henry E. and R.S. Woodworh (1971). "Statistics in Psychology and Education", (Bombay: Vakils Feffer and Simon, 1971).

Prabakar, C. (2012). "Motorization Technology Delivery in Small Scale Fisheries- Its Impact and Impediments in Adoption", *Agricultural Economics Research Review,* **25(3):** 495-500.

Prabakar, C. (2011). "Labour Scarcity- Its Immensity and Impact on Agriculture", *Agricultural Economics Research Review,* **24(3):** 373-380.

Mahadevaiah, G. Ravi and P.O. Chengappa (2005). "Stability Analysis of Raw Cotton Export Markets of India – Marov Chain Approach", *Agricultural Economic Research Review,* **18(2):** 253-259.

Paramasivam, R., M. Umanathan, V. Kavitha, A. Kuzhandhivel Pillai and R. Vasanthi (2017). " Dynamics of Land Use Pattern and Cropping Pattern in Cuddalore District of Tamil Nadu", *Assam Journal of Agricultural Extension, Economics and Sociology,* **19(3):** 1-10.

Sarvanan, S., Jacinth Jennifer, Leelambar Singh and D. Abijith (2018). "Cyclone Vulnerability Assessment of Cuddalore Coast in Tamil Nadu, India using Remote Sensing and GIS", *MATEC Web of Conferences, ICDM,* **229:** 02022, 2018.

Sita Devi, K. and T. Ponnarasi (2009). "Economics of Rice Production Technology and its Adoption Behaviour in Tamil Nadu", *Agrl. Economics Research Review,* **22(33):** 341-347.

Sita Devi, K., C. Prabakar and T. Ponnarasi (2011). "Impact of Microfinance Innovation in Pushing Back Rural Poverty in Tamil Nadu", *Indian Journal of Agrl. Economics,* **66(3):**.

Websites

www.iiwm.res.in (Directorate of Water Management, Bhubaneswar, 2014), mausam.imd.gov.in (IMD, 2012).