Journal of Agricultural Development and Policy, 2022
Volume 32, No. 1, 30-35

Adaptation Strategies of Paddy for Change in Climate in Thamirabarani River Basin of Tamil Nadu

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Abstract

An assessment of impact of climate change on rice in Thamirabarani basin will definitely help to take adaptation options to maximize production in the state. It is selected as a study area as it is one of the major rice growing regions of southern Tamil Nadu. From the river basin 60 farmers were selected at random to study the impact of climate change on rice production in the basin. The study found that reduction in number of irrigation, change in cropping pattern and delaying of cropping seasons are the strategies followed by majority of farmers who perceive that climate change is caused by change in rainfall pattern and availability of irrigation water in the Thamirabarani river basin. The crop cultivation depends on the rainfall and farmers' perception on climate change exists which may require to design the weather based crop insurance scheme to cope with the climate change impact.

Keywords: Climate change**,** Aquifers, Evaporation, Drought, Erratic

JEL Classification: Q1, Q54, Q56, Q34, Q25

Introduction

India has experienced 23 large scale droughts starting from 1891 to 2009 and the frequency of droughts is increasing. Climate change is posing a great threat to agriculture and food security. Water is the most critical agricultural input in India, but 55% of the total cultivated area is without sufficient irrigation facilities (Kumar, 2014)

A warmer climate will accelerate the hydrologic cycle, altering rainfall, magnitude and timing. Climate change has about 4-9 per cent impact on agriculture each year. As agriculture contributes 15 per cent to India's GDP, climate change presumably causes about 1.5 per cent loss in GDP. (Subhojit Goswami, 2017; Rao *et al*, 2008)

The Tamil Nadu State Action Plan on Climate Change (TNSAPCC) predicts that the state could have climate-related events of higher intensity in the coming years. Quoting studies carried out by the Centre for Climate Change and Adaptation Research (CCCAR) of Anna University and TNSAPCC states that the average annual maximum temperature for Tamil Nadu could increase by 3.1°C in the year 2100 from the baseline of 1970-2000. Similarly, the average annual minimum temperature could increase by 3.5°C. Average annual rainfall, on the other hand, could reduce by up to 9%. The rainfall pattern could shift more towards the northeast monsoon, which could bring more intense cyclones and floods. (Warrier, 2017).

The Tamiraparani flows through Tirunelveli and Tuticorin districts of the Tamil Nadu state. The climate of Tirunelveli is generally hot and humid. The average annual rainfall is 680 mm, most of which occurs during the northeast monsoon which runs through October to December. The average temperature during summer (March to June) ranges from 23 to 36°C and 18 to 30°C during the rest of the year. Since the economy of the district is primarily based on agriculture, fluctuations in the monsoon rains or flooding of the Thamirabarani river has an immediate impact on livelihood in the region of Thamirabarani river basin.

The total paddy area cultivated in Tirunelveli and Thoothukudi districts is about 113721 ha which is entirely fed by the Tamirabarani river; out of which 86 per cent is area under paddy.

Hence an assessment of impact of climate change on rice in Tamirabarani basin will definitely help to take adaptation

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options to maximize production in Tirunelveli district (Shukla, 2005). Therefore, the present study was undertaken with the objectives of studying the trend in area under paddy, to know the relationship between area under paddy and rainfall and to identify the adaptation strategies followed by farmers to cope up climate change in Thamirabarani basin in the study area.

Data Sources and Methodology

Tamirabarani basin is selected as a study area as it is one of the major rice growing regions of southern district in Tamil Nadu. The study was based on primary information collected by the personal interview method using a pre – structured interview schedule from the farmers of Tirunelveli district. From the river basin area 60 farmers were selected at random to study the impact of climate change on rice production. The necessary information was collected and analysed using the following tools of analysis.

i) Percentage analysis was used for making simple comparisons.

ii) Growth rate was calculated for area under paddy, rainfall, irrigation source of Tirunelveli district in the present study. Compound growth rate was estimated with the help of following exponential model.

$$Y = a\, b^t e$$

Where, Y = Dependent variable for which growth rate was estimated.

a = Intercept.
b = Regression coefficient.
t = Time variable.
e = Error term.

The logarithmic form of the above equation was

$$\log Y = \log a + t \log b$$

The compound growth rate (g) was estimated by using

$$g = [\text{Anti log of } (b) - 1] * 100$$

iii) Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables. This analysis attempts to establish the nature of the relationship between the variables and thereby provides a mechanism for prediction of forecasting. In this study, the relationship between groundwater level and rainfall was determined by calculating correlation using the formula as given below;

$$r = \frac{n\sum(X_i Y_i) - \sum(X_i)\,(Y_i)}{\sqrt{[n\sum X_i^2 - \sum(X_i)^2]\,[n\sum Y_i^2 - \sum(Y_i)^2]}}$$

Where,

X = Rainfall in Cuddalore district
Y = Groundwater level at two different periods
n = Number of observation.

Results and Discussion

The results of the study was presented and discussed in seven sections viz., area under paddy cultivation, trend in rainfall, area under irrigation, adoption strategies, problems faced by the sample respondents, crop management practices and crop insurance.

Area under paddy cultivation in Tirunelveli district

The annual compound growth rate was estimated for area under paddy cultivation in Tirunelveli district and it is presented in table- 1. The trend line was drawn and it is given in figure 1.

Table 1. Area under paddy cultivation in Tirunelveli district

Year	Area (ha)
2005-06	86397
2006-07	91884
2007-08	83711
2008-09	91320
2009-10	85994
2010-11	79765
2011-12	84725
2012-13	45402
2013-14	62280
2014-15	84825
2015-16	98506
2016-17	84824
2017-18	98506
2018-19	29881
2019-20	39805
CGR	-3.99

Source- Statistical Hand Book, Tirunelveli

It could be inferred from the table -1 that the paddy area in 2005-06 was 86397 hectares. In the year 2015-16 it was 98506 hectares. The area under paddy cultivation was increased in the year 2015-16 due to increase in rainfall. Besides, the total rainfall was high in the year 2015-16. Therefore, the crop cultivation was dependent on the rainfall. After that the year 2019-20 the area under cultivation was declined compared to the year 2017-18.

During the period of 2009-10 to 2012-13and 2018-19 to 2019-20 the harvest was low in Tirunelveli district. Hence, the area in the same year was declined. The compound growth rate was negative (-3.99 per cent) during the period of 2005-06 to 2019-20.

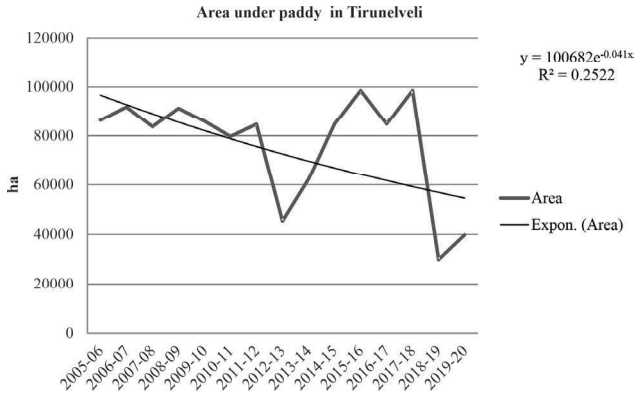

Fig 1. Area under paddy in Tirunelveli District

Rainfall by season in Tirunelveli district

The total rainfall ranged between the minimum of 821.3 mm in the year 2012-13 and the maximum of 1332.6 mm in the year 2015-16. It showed that there is wide variation in rainfall during the period of 15 years. Also it would be seen that there is a wide difference in receipt of rainfall within same seasons. The co-efficient of variation also indicated that the rainfall in winter and hot weather seasons had high fluctuation in the study area. The uncertainty of rainfall creates difficulties to the farmers in making decision about their cropping scheme. The season wise rainfall in Tirunelveli district from 2005-06 to 2019-20 is given in table 2.

Area under Irrigation

The major source of irrigation for this region is Tamirabarani river. The state government used to release Manimuthar canal water if the water level crosses the limit of 80 feet which benefits farmers in Naguneri, Seranmagadevi, Sathankulam and Tiruchandur taluk, otherwise the water is sent only to Tamirabarani basin. The traditional date of releasing water on December 15 and it extends upto end of February for 'kuruvai' cultivation. The area irrigated is presented in table 3 and Figure 2.

It could be seen from the table that the net irrigated area was 118171 hectares in the year 2006-07 and 57192 hectares in the year 2019-20. In the year 2012-13, 2013-14 and 2019-20 net area irrigated and gross irrigated area were low compared to other years. The compound growth rate was negative for both net and gross area irrigated. In the year 2019-20, 2782 ha of area was irrigated more than once and this might be due to the reason that the shortage of rainfall water.

Table 2. Rainfall by seasons in Tirunelveli district (2005 to 2020)

(in mm)

Year	South west monsoon		North East monsoon		Winter season		Hot weather season		Total	
	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual	Normal	Actual
2005-06	92.6	147.8	429.8	548.7	72.6	72.4	141.9	184.2	736.9	953.1
2006-07	92.6	115.6	429.8	784.7	72.6	19.9	141.9	136.3	736.9	1056.5
2007-08	92.6	257.6	429.8	426.5	72.6	67.6	141.9	509.8	736.9	1261.5
2008-09	92.6	145.2	429.8	564.1	72.6	8.2	141.9	123.9	736.9	841.4
2009-10	92.6	127.3	429.8	653.4	72.6	3.6	141.9	84.4	736.9	901.1
2010-11	92.6	189.6	429.8	555.8	69.3	74.5	166.2	127.7	757.9	947.6
2011-12	142.4	107.7	467.2	639.9	69.3	70.7	166.2	100.7	845.1	919
2012-13	142.4	36.9	467.2	575.8	69.3	98.9	166.2	169.7	844.9	821.3
2013-14	142.4	23.7	467.2	412.8	69.3	70.4	166.2	314.9	845.1	1034.3
2014-15	142.4	118.8	467.2	847.5	69.3	19.5	166.2	317.9	845.1	1303.7
2015-16	142.4	158.8	467.2	1050.6	69.3	6.8	166.2	111.9	845.1	1332.6
2016-17	142.4	77.32	467.2	178.83	69.3	42	166.2	84.96	845.1	383.11
2017-18	142.4	272.6	467.2	665.5	69.3	25.8	166.2	84.96	845.1	988.86
2018-19	142.4	344.5	467.2	519.8	69.3	23	166.2	81.6	845.1	968.9
2019-20	128.4	269	473	684	64.2	17.9	153.9	122.7	819.5	1093.6
Mean	121.54	159.49	452.62	607.1953	70.06	41.41333	157.28	170.3747	801.5	987.10
SD	24.717	91.57	19.34	201.57	2.26	31.114	11.68	120.59	52.29	230.20
CV	0.203	0.5741	0.042	0.33	0.032	0.751	0.074	0.707	0.065	0.233

Source: District Statistical Department

Table 3. Actual area irrigated in Tirunelveli district

Year	Net irrigated area (ha)	Gross irrigated area (ha)
2006-07	118171	145474
2007-08	111854	138434
2008-09	118171	145474
2009-10	116900	141855
2010-11	109449	132606
2011-12	117486	141154
2012-13	87888	96192
2013-14	85533	64881
2014-15	116576	140236
2015-16	124940	154246
2016-17	76258	81671
2017-18	99753	105455
2018-19	110270	135182
2019-20	57192	59974
CGR	-2.955	-3.921

Source- Statistical Hand Book, Tirnelveli

Correlation analysis

The correlation co-efficient (r) measure the strength of the liner relationship between two variables the correlation analysis. Direct correlation means positive correlation (i.e) increase together and decreases together. The relationship between rainfall areas under paddy was identified correction analysis. The co-efficient of correlation calculated and results are given table 4.

Table 4. Results of the correlation analysis

Particulars	Rainfall	Area under paddy
Rainfall	1	
Area	0.081	1

The correlation matrix was prepared with rainfall and area under paddy. Rainfall was positively correlated with area under paddy cultivation. Besides, it could be inferred from the table that the area under paddy increased by 0.081 ha when rainfall increased.

Adoption Strategies of Sample Respondents

Adoption to climate change by the farmers in Tamirabarani basin of Tamil Nadu

The adoption framework by famers to climate change has several actions. The one important factor is change in cropping pattern.

Cropping pattern

The cropping pattern of Tirunelveli district was collected and results are presented in table 5.

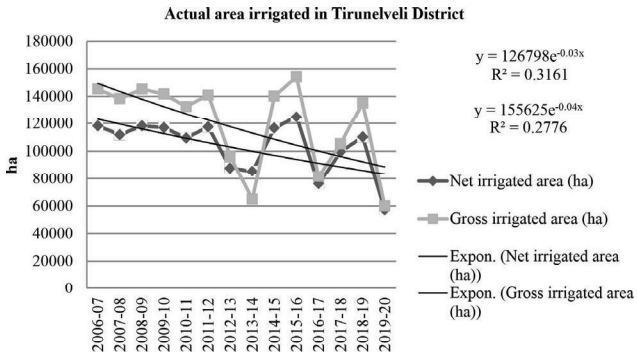

Fig. 2. Actual Irrigated in Tirunelveli district

Table 5. Cropping pattern adopted by sample respondents

Crop	Average Area (ac)	Minimum area (ac)	Maximum area (ac)
Paddy	4.23	0.50	13.00
Pulses	4.19	0.02	13.00

From the table 4, it could be revealed that most of the farmers were cultivating paddy followed by pulses. Also, few farmers expressed the difficulty in cultivating black gram due to lack of water availability and the crop is susceptible to yellow mosaic virus due to late season.

Adaptation strategy at farm level

The strategy adoption for climate change impact was collected and results are furnished in the table 6.

The information collected from the survey indicates that all farmers aware about the change or shift in rainfall pattern and rise in temperature. It was observed from the table 5, all the farmers are delayed their sowing time and reduced the number of irrigations due to delaying of water availability from the canal. Also about 98 per cent of the farmers keeping livestock as additional source of income to cope with the adverse effect of climate change.

Problems faced by the sample farmers

The problems of sample respondents in different categories are furnished in the table 7.

The details of the problems faced by the sample famers indicated that 98 per cent of the farmers want to quit the agriculture due to labour problem. Due to crop failure and yield declining 48 and 53 per cent of the farmers respectively go for borrowing of money either from bank or the available local money lender. The remaining farmers depend on livestock as additional source of income for the same problem.

Shift in Cropping Pattern and Crop Management Practices

The shift in cropping pattern and crop management practices were collected and the results are presented in table 8

Table 6. Adoption strategies for climate change by sample farmers

Particulars	Adoption (No. of Farmers)	Percentage	Non-adoption (No. of Farmers)	Percentage
Conventional water saving irrigation methods	0.00	0.00	60.00	100.00
Growing rain-fed crops	0.00	0.00	60.00	100.00
Change to livestock rearing	59.00	98.33	1.00	2.00
Cultivating perennial crops	0.00	0.00	60.00	100.00
Advancement / Delaying of cropping season	60.00	100.00	0.00	0.00
Reducing the no of irrigation	60.00	100.00	0.00	0.00
Technology Adoption (SRI)	50	83.33	10	16.66

Table 7. Problems faced by the respondents

Problems	Quit Agriculture	Borrowing money	Expecting compensation from Govt	Depending on livestock, poultry and allied activities	Others
Crop failure	-	32 (53.33)	-	32 (53.33)	1 (2)
Poor germination	-	30 (50.00)	-	-	29 (48.33)
Yield declining	-	29 (48.33)	-	29 (48.33)	1 (2)
Labour problem	58 (97.00)	-	-	-	1 (2)
Pest and disease out break	-	-	38 (63.33)	-	18 (38)

Figures in parentheses indicate percentage to total respondents

It could be observed from the table 8, that all the farmers who raised paddy five years ago continue to raise the same crop. But nowadays the impact of climate change variables such as rainfall and temperature changes the seasonal availability of water and hence the cropping season is reduced from two seasons to one. Besides, only 17 per cent of the famers are going for System of Rice Intensification (SRI) to manage with available water and remaining farmers still continue to follow the conventional methods of cultivation. All the farmers are delaying the cropping season by a month September-October-November to manage the climatic issue such as delaying of North East Monsoon. Currently famers are irrigating the crops once in 5 days due to limited water availability rather than used to irrigate the crop frequently when field dries.

Table 8. Shift in cropping pattern and crop management practices followed by respondents

Crop	Number of farmers	
	Current year	5 years ago
Paddy	60	60
Particulars	Current year	5 years ago
Sowing Season	November	Sep – Oct
Variety	ASD 36, ASD 16 and IR 20	ASD 41 and IR 20
Planting	Delayed planting	Normal
Irrigation	Once in 7 days	Once when field dries
Fertilizer	more fertilizer	Less
Harvesting	Delayed harvesting	Normal
Number of crop/year	One Season	Two season

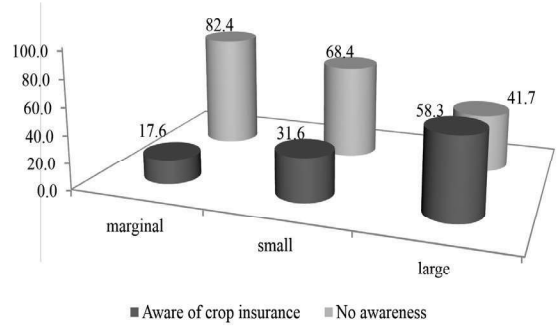

Fig. 3. Popularity of crop insurance among sample farmers

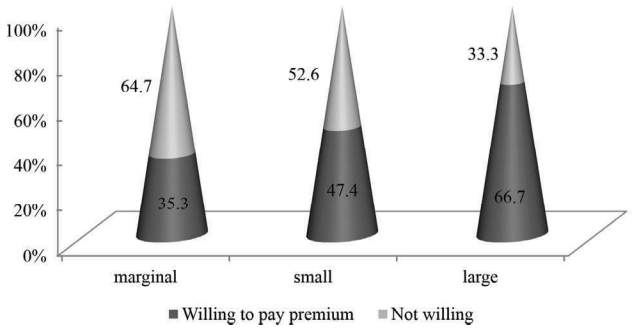

Fig. 4. Willingness to pay premium among sample farmers

Crop Insurance

The popularity of crop insurance scheme among sample farmers and their willingness to pay premium are presented in figures 3 and 4 respectively.

Crop insurance is a risk management mechanism to tide over failure of the crops. The graph above showed that 58.3 per cent of the farmers belonging to the large category are aware about crop insurance plans. The corresponding percentages for small and marginal were 31.6 and 17.6 percent respectively. Mere awareness is not useful for the farmers to join in the crop insurance schemes. So the farmers who were aware of the insurance plans were questioned about their willingness to pay the premium and join in the insurance plans.

Among large farmers who have knowledge in insurance policy programs, 66.7 percent were willing to join in the plans and 47.4 per cent of the small farmers with knowledge on crop insurance were willing to pay premium but only 35.3 per cent of the marginal farmers who knew crop insurance plans were ready to join in the crop insurance plans.

Conclusion and Policy Implications

Climate is the least manageable of all resources. Hence, to avert the ill effects of climate change, more attention has to be paid to other resources and technologies viz. soil, irrigation water, nutrients, crops and their management practices, to sustain the productivity and to ensure food and environmental security to the country. The study found that reduction in number of irrigation, change in cropping pattern and delaying of cropping season are the strategies followed by majority of farmers who perceive that climate change is caused by change in rainfall pattern and availability of irrigation water in the Tamirabrarani river basin.

The study revealed that farmers' perception on climate change exists which may require to design the weather based crop insurance scheme to cope with the climate change impact. The impact of climate change is expected to be negative overall, threatening global food security. For a state like Tamil Nadu, rainfall decides the food grains production and productivity in the significant area in both rainfed and irrigation agriculture. It is identified that the monsoon rainfall are very useful to agriculture production. Predicting the monsoon and deciding the crops as per the monsoon will increase the production of food grains.

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Received: February 1, 2022 Accepted: May 11, 2022