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An Analysis of Crop Insurance as an Adaptation Tool of Climate Vulnerability in Cauvery Delta Zone

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Abstract:

Using the Climate Vulnerability Index (CVI), this study investigates the efficacy of crop insurance as an adaptation strategy for reducing climate vulnerability in the Cauvery Delta Zone. The effects of climate change, such as increased temperatures, changed precipitation patterns, and extreme weather events, are particularly vulnerable to the region's agriculture. In order to create a composite Climate Vulnerability Index (CVI) score, indicators such as Rainfall, Paddy Production, Cultivated Land, and Insured Land are normalised. Our assessment of crop insurance concentrated on how it can improve adaptive capacity by offering monetary protection against crop failures are induced by climate change. The findings demonstrate crop insurance's important role in boosting resilience by showing a considerable reduction in the CVI. In order to reduce climate risks and promote sustainable agriculture in the Cauvery Delta Zone (CDZ), this study emphasises the significance of incorporating crop insurance into more comprehensive adaption measures. A five-year data collection covering the fiscal years 2018–2019 through 2022–2023 was considered for this study from the Government of India's Directorate of Economics & Statistics.

Keywords: Climate Vulnerability Index, Climate Vulnerability, crop insurance, Cauvery Delta Zone.

1. Introduction:

The most vital agricultural area CDZ is situated in southern India and is distinguished by its rich soil and sophisticated irrigation systems. With its production of staples like rice, sugarcane, and cotton, the area is crucial to Tamil Nadu's agricultural economy. But the effects of climate change, such as rising temperatures, altered precipitation, and extreme weather patterns like floods and droughts are making the CDZ more and more susceptible. Patil, S., & Deepa, S. [1] explores the broad impacts of climate change on Indian agriculture, including changes in temperature and rainfall. It provides context for how these changes specifically affect the CDZ’s agricultural output and farmer livelihoods.

The livelihoods and agricultural output are seriously threatened by climate change of farmers belonging to CDZ. Raising temperatures can cause heat stress in crops, which lowers yields and degrades the quality of the crop. The region's overall water balance and irrigation are impacted by altered precipitation patterns, which include irregular rainfall and protracted dry spells that worsen the problem of water scarcity. Furthermore, agriculture, infrastructure, and rural communities are susceptible to immediate and serious damage from extreme weather events like floods and cyclones. Mall, R. K., et.al [2] examines the relationship between climate change and water resources in India, with a focus on the impacts on agriculture. It provides valuable data on precipitation patterns and water availability in the CDZ, essential for understanding the region's climate vulnerability.

Effective adaptation measures are desperately needed in light of these difficulties in order to lessen the negative consequences of climate change on agriculture. Using crop insurance is one such tactics that helps to shield farmers financially from crop losses brought on by natural disasters. By guaranteeing economic stability and allowing farmers to invest in climate-resilient agricultural practices, crop insurance helps to stabilise farmers' incomes. Kumar, R. et.al , Mahul, O et.al [3,8] provides comprehensive insights into the impact of climate change on agriculture across various river basins in India, including detailed studies on the Cauvery basin. It discusses how climate variability affects agricultural productivity and offers adaptation strategies, making it a relevant source for understanding climate vulnerability in the Cauvery Delta Zone.

The purpose of this study is to assess crop insurance's efficacy in the CDZ as an adaptation tool using the Climate Vulnerability Index (CVI). The CVI is a composite metric that evaluates a region's susceptibility to climate change by considering many factors such as exposure to climatic risks, the sensitivity of socio-economic and environmental systems, and the capacity for adaptation. The CVI offers a thorough assessment of climate vulnerability by combining indices including temperature rise, precipitation changes, agricultural productivity, water availability, and infrastructural resilience. Hahn, M. B., Riederer, A. M., & Foster, S. O.[4] introduces the Livelihood Vulnerability Index, a methodology that can be adapted to create the CVI used in this study. It offers a framework for assessing vulnerability based on exposure, sensitivity, and adaptive capacity, which can be applied to the Cauvery Delta context. Parthasarathy, R., & Natesan, U.[5] offers a detailed examination of how climate change is affecting the hydrology and water resources in the Cauvery River Basin. It is essential for understanding the broader environmental changes impacting agriculture in the delta region.

This study aims to, assess the climate vulnerability of the CDZ using the CVI through an in-depth examination of climate vulnerability and the function of crop insurance in the Cauvery Delta Zone, this research adds to the growing body of knowledge regarding the adaptation tactics required to maintain rural livelihoods and agricultural productivity over the long term. Roxy, M. K., Ritika, et., al [6] focuses on the warming of the Indian Ocean and its implications for regional climate patterns, including the monsoon system that is crucial for agriculture in the Cauvery Delta. Understanding these climatic changes is vital for assessing climate vulnerability in the CDZ. Das, P., & Ghosh, S.[7], specifically focuses on the impact of climate change on crop yields in the CDZ. It provides empirical data and analysis that are critical for understanding the region's vulnerability and the effectiveness of adaptation strategies like crop insurance.

The purpose of this study is to examine the impact of vulnerability of the climate change in the CDZ, and how the crop insurance schemes acting as the most effective adaptation strategy to shield farmers from climate-related risks.

Methodology:

Globally, climate change is becoming more widely felt as a serious threat to social, economic, and environmental systems. Tripathi, A., & Mishra, A. K. [9], examines the ways in which Indian farmers are adjusting to climate change and offers information on the efficacy of several adaptation tactics, such as crop insurance. It talks about how knowledge and perception play a part in implementing such policies.

In this research, the researcher used the Climate Vulnerability Index methodology to analyse the vulnerability of climatic changes. An extensive instrument for evaluating a region's susceptibility to climate change is the CVI. The CVI assists in identifying regions that are most vulnerable to climate impacts by combining many indicators, assisting stakeholders and policymakers in developing efficient adaptation plans.

Climate vulnerability is a function, which is determined by three factors:
Exposure: The degree to which a system is subjected to notable fluctuations in the weather. Eg: Rain Fall

Sensitivity: The extent to which stimuli connected to the climate have an impact on a system.

Eg: Crop Productivity

Adaptive capacity: The ability of a system to adapt to climate change, mitigate possible harm, seize opportunities, or deal with the fallout is known as adaptive capacity. Eg: Cultivated Land Size. According to Yohe, G., & Tol, R. S. J. [10], Indicators of adaptive capacity are covered in this work since they are important for determining the possible efficacy of adaptation strategies such as crop insurance. It aids in comprehending how these indicators can be used to assess the Cauvery Delta Zone's ability to adapt to the effects of climate change.

In this research, the researcher chooses three different factors for five financial years 2018 - 2023 like Rain fall, Paddy production, cultivated land & Insured land districts of CDZ: Ariyalur, Cuddalore, Nagapattinam, Perambalur, Pudukkottai, Thanjavur, Thiruvarur and Tiruchirappalli.

For calculating CVI, first data is normalized and then climate vulnerability Index or score is calculated. Here, the mini max criterion methodology is used for normalising the collected data and assigned weightage to every factor based on the importance of it, then calculate CVI. In this CVI calculation, assigned weightage values are, for rain fall 03, for paddy production 0.3, for cultivated land 02 and for insured land 0.2

Climate Vulnerability Index:

Minimax Methodology:

$$Normalaisation\ of\ X_y = \frac{X_y - \min(X_y)}{max X_y - \min(X_y)}$$

Were,

X= Value of the Selected factor

Y =Year

Climate Vulnerability Index (CVI) = $\sum_{i=1}^{n}(X_i * WV_i)$

Were,

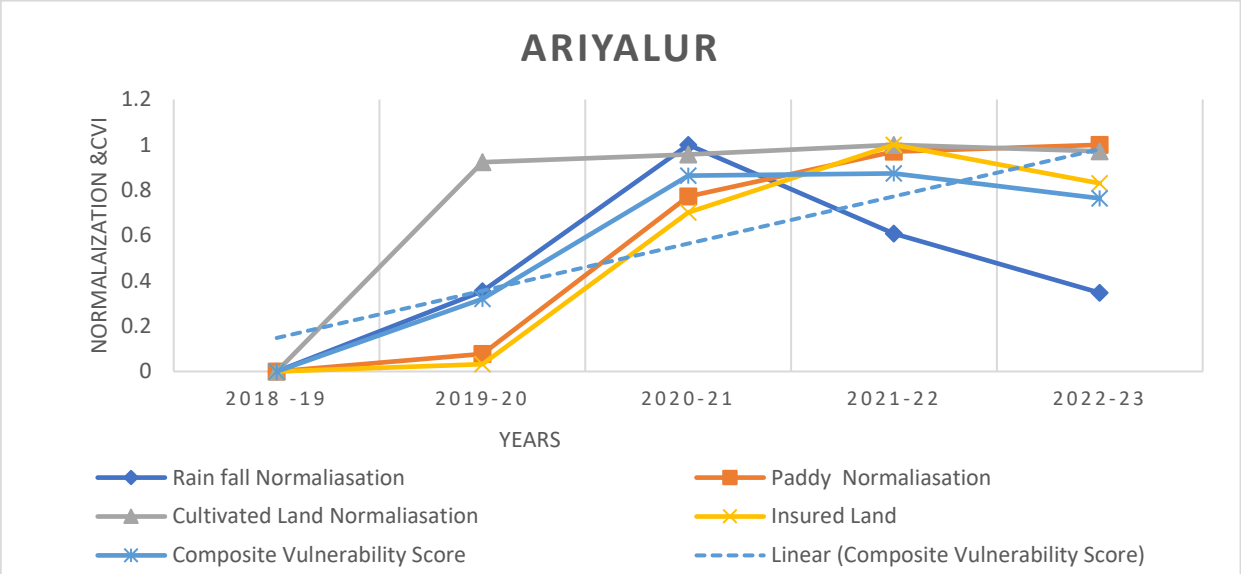
X_i= Normalised Value of the indicator (i=1,2, 3……n)

WV_i = Weighed value of indicator, (i = 1,2,3…n)

Normalization value & CVI for Ariyalur districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Climate Vulnerability Index
2018-19	Ariyalur	0	0	0	0.01997	0.003994
2019-20		1	0.007284	0.886361	0	0.479457
2020-21		0.716066	0.666945	0.916606	0.508926	0.70001
2021-22		0.933311	1	0.999193	1	0.979832
2022-23		0.022903	0.960368	1	0.50711	0.596404

The aforementioned findings show that the climate vulnerability index has grown from 0.3% to 97%. due to the fact that various indicators have caused the overall CVI. The Ariyalur areas saw a wide range of precipitation from 2018 to 23. The productivity of the crops had been significantly impacted by that level of rainfall. In 2023, the amount of precipitation decreased, which had an effect on Ariyalur's crop productivity. Crop production has increased, although at a very slow rate.

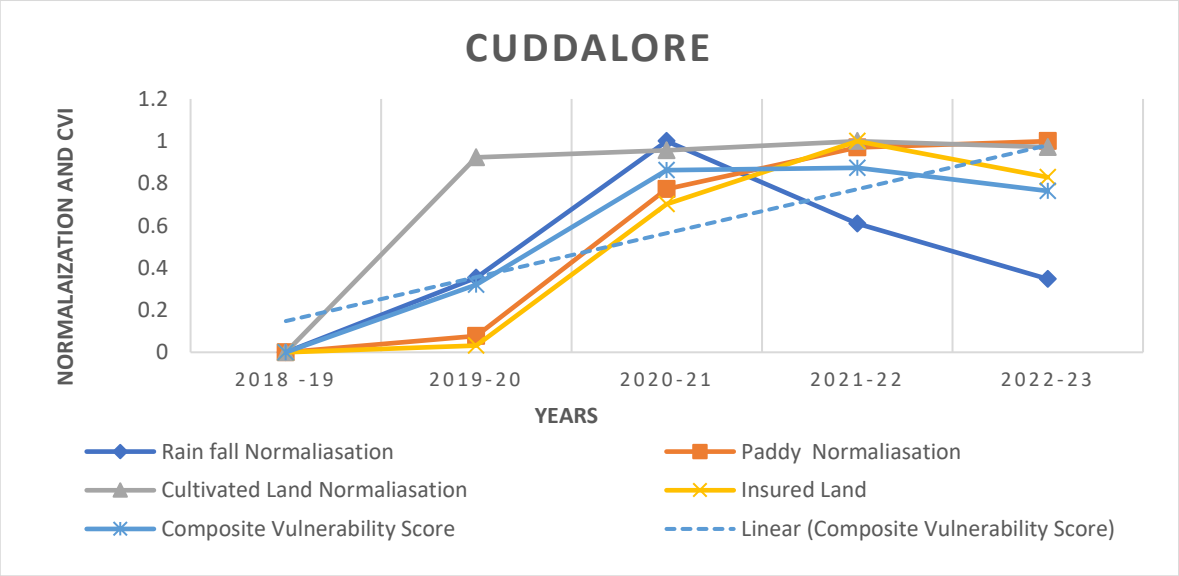


The computed CVI graph clearly displays an increased trend when viewed graphically. As a result, the susceptibility to climate change has grown annually. Furthermore, based on the normalised value, the insured land size value has increased annually. Based on this scenario, we may conclude that the most effective way to shield farmers from the effects of climate change is through crop insurance.

Normalization value & CVI for Cuddalore districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Composite Vulnerability Index
2018-19	**Cuddalore**	0	0	0	0	0
2019-20		0.353795	0.076951	0.923064	0.031852	0.320207
2020-21		1	0.772681	0.957086	0.701318	0.863485
2021-22		0.608817	0.970558	1	1	0.873813
2022-23		0.34654	1	0.971637	0.829738	0.764237

According to the above cited research, the climate vulnerability index increased from 0% to 87%. because a number of metrics have contributed to the overall CVI. From 2018 to 23, there was a significant variation of precipitation in the Cuddalore districts. That changes of rainfall had taken a big toll on the crops' yield. Cuddalore's crop productivity suffered in 2023 as a result of a drop in precipitation. The crop production has increased with low percentage. Also, due to the poor climatic condition the size of cultivated land has reduced drastically.

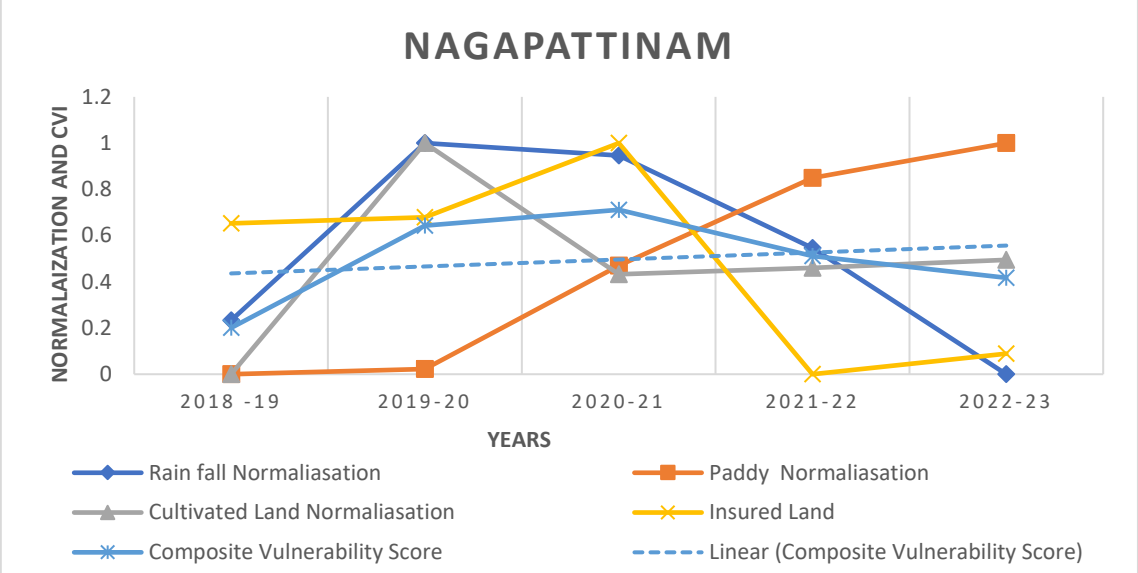


When examined graphically, the computed CVI graph clearly shows an increasing tendency. The vulnerability to climate change has increased yearly as a result. Moreover, the insured land size value has grown yearly depending on the normalised value. This scenario leads us to the conclusion that crop insurance is the best means of protecting farmers from the effects of climate change.

Normalization value & CVI for Nagapattinam districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Composite Vulnerability Index
2018-19	Nagapattinam	0.233306	0	0	0.652316	0.200455
2019-20		1	0.022052	1	0.678642	0.642344
2020-21		0.946458	0.469572	0.432936	1	0.711396
2021-22		0.545806	0.849703	0.460397	0	0.510732
2022-23		0	1	0.494996	0.089173	0.416834

The analysis mentioned above indicates that the range of the climate vulnerability index was 20% to 71%. due to the fact that several measurements have influenced the CVI as a whole. The Nagapattinam areas had a notable fluctuation in precipitation from 2018 and 23. The crops' output had suffered greatly as a result of the variations in rainfall. In 2023, Nagapattinam's crop productivity declined due to a decrease in precipitation. Crop productivity has increased, but not significantly. Furthermore, the area of land under cultivation has severely decreased as a result of the unfavourable climate.



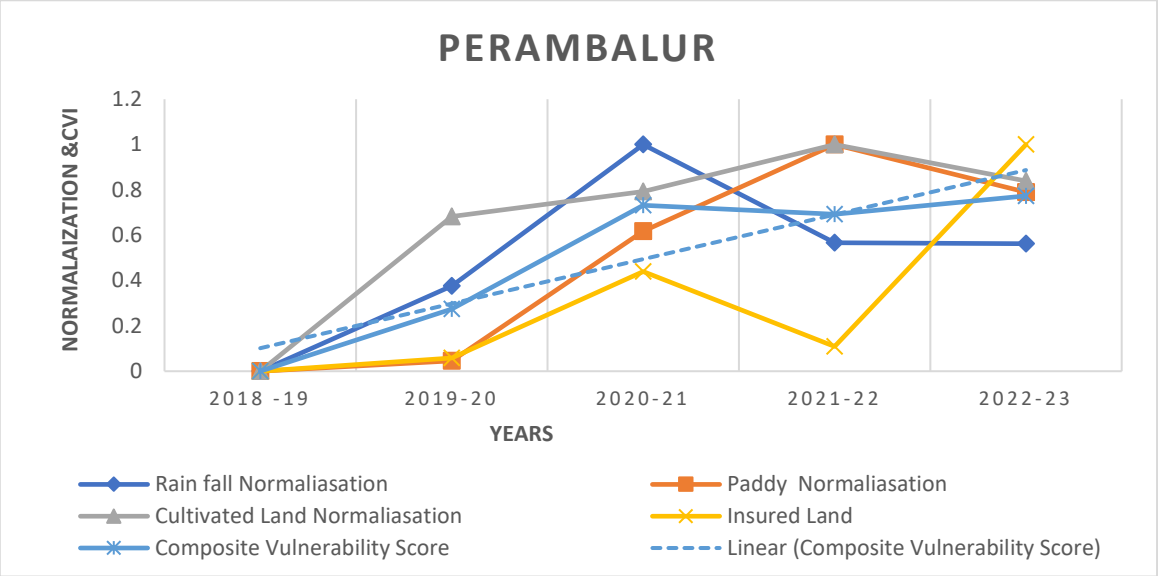
The computed CVI graph clearly demonstrates a tendency towards progressive increase when seen graphically. As a result, the susceptibility to climate change has grown yearly. Furthermore, based on the normalised value, the insured land size value has increased annually. We conclude from this scenario that the most effective way to shield farmers from the effects of climate change is through crop insurance.

Normalization value & CVI for Perambalur districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Composite Vulnerability Index
2018-19	**Perambalur**	0	0	0	0	0
2019-20		0.376032	0.045024	0.682633	0.058539	0.274551
2020-21		1	0.617752	0.792672	0.440316	0.731923
2021-22		0.56686	1	1	0.109188	0.691896
2022-23		0.562291	0.789788	0.838847	1	0.773393

According to the abovementioned investigation, the climate vulnerability index ranged from 0% to 77%. because the CVI as a whole has been impacted by many readings. There was a significant variation in precipitation in the Preambular districts from 2018 and 23. The fluctuations in rainfall have had a detrimental effect on the crops' yield. Perambalur's agriculture productivity decreased in 2023 as a result of less precipitation. Productivity in crops has gone up, but not

dramatically. In addition, the poor environment has led to a significant reduction in the area of land under cultivation.

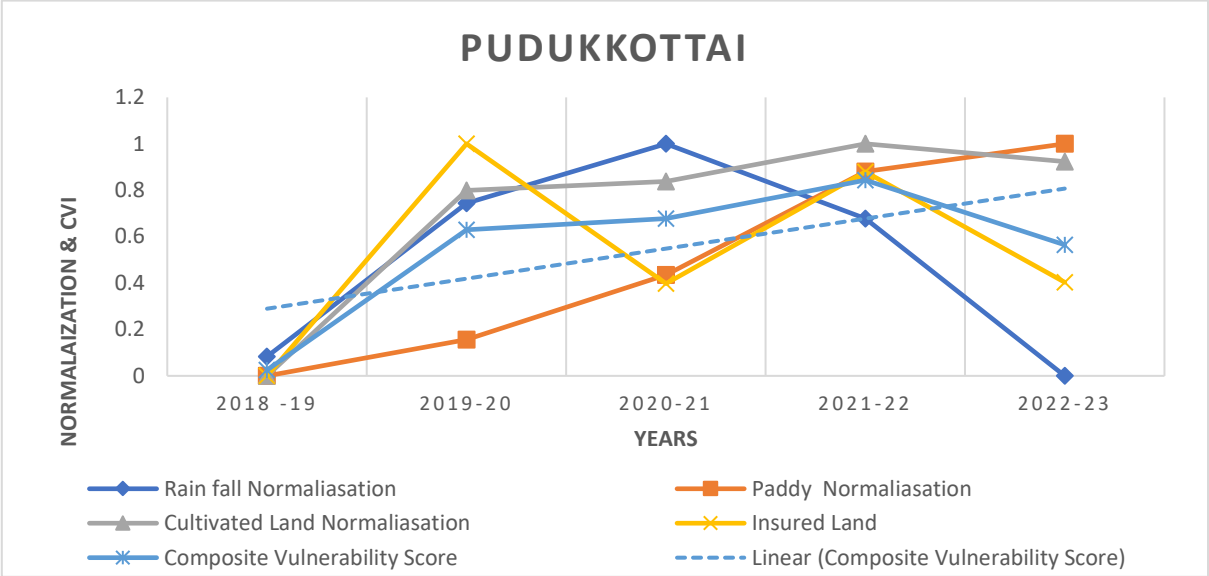


When seen visually, the calculated CVI graph amply illustrates a tendency towards progressive rise. The yearly susceptibility to climate change has increased as a result. Moreover, the insured land size value has grown yearly depending on the normalised value. This scenario leads us to the conclusion that crop insurance is the best means of protecting farmers from the effects of climate change.

Normalization value & CVI for Pudukkottai districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Composite Vulnerability Index
2018-19	Pudukkottai	0.083572	0	0	0	0.025072
2019-20		0.743902	0.156517	0.798896	1	0.629905
2020-21		1	0.434905	0.837563	0.397236	0.677431
2021-22		0.677905	0.880006	1	0.879808	0.843335
2022-23		0	1	0.922703	0.403846	0.56531

The previously mentioned research found that the range of the climate vulnerability score was 2% to 84%. because numerous readings have had an impact on the CVI overall. Precipitation in the Pudukkottai regions varied significantly from 2018 and 23. The crops' yield has suffered as a result of the variations in rainfall. Due to reduced precipitation in 2023, Pudukkottai's agricultural productivity fell. Crop productivity has increased, but not significantly. Furthermore, the area of land under agriculture has significantly decreased as a result of the unfavourable environment.

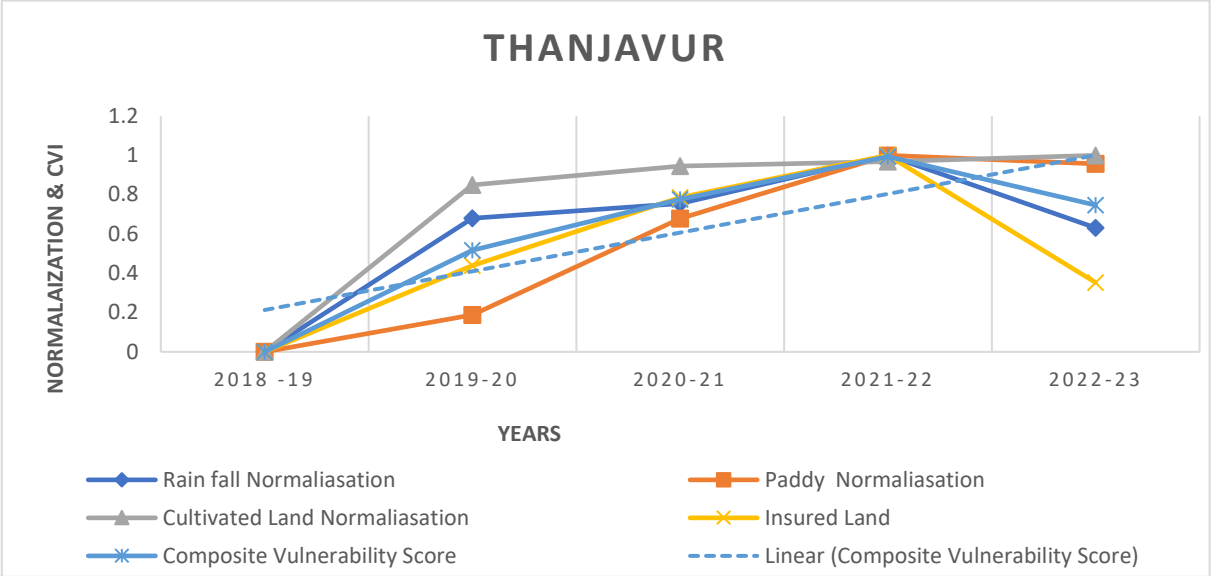


Graphically, the computed CVI graph clearly shows a tendency towards progressive rise. The vulnerability to climate change has increased yearly as a result. Additionally, the insured land size value has increased annually depending on the normalised value. Based on this hypothetical situation, we may infer that crop insurance is the best means of protecting farmers from the effects of climate change.

Normalization value & CVI for Thanjavur districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Composite Vulnerability Index
2018-19	Thanjavur	0	0	0	0	0
2019-20		0.680456	0.187355	0.848566	0.438515	0.51776
2020-21		0.754066	0.678512	0.945741	0.786543	0.77623
2021-22		1	1	0.967939	1	0.993588
2022-23		0.631098	0.956462	1	0.351895	0.746647

The study mentioned above indicated that the range of the climate vulnerability index was 0% to 99%. because numerous readings have had an impact on the CVI overall. Precipitation in the Thanjavur regions varied significantly from 2018 and 23. The crops' yield has suffered as a result of the variations in rainfall. Due to reduced precipitation in 2023, Thanjavur's agricultural productivity fell. Crop productivity has increased, but not significantly. Furthermore, the area of land under agriculture has significantly decreased as a result of the unfavourable environment.

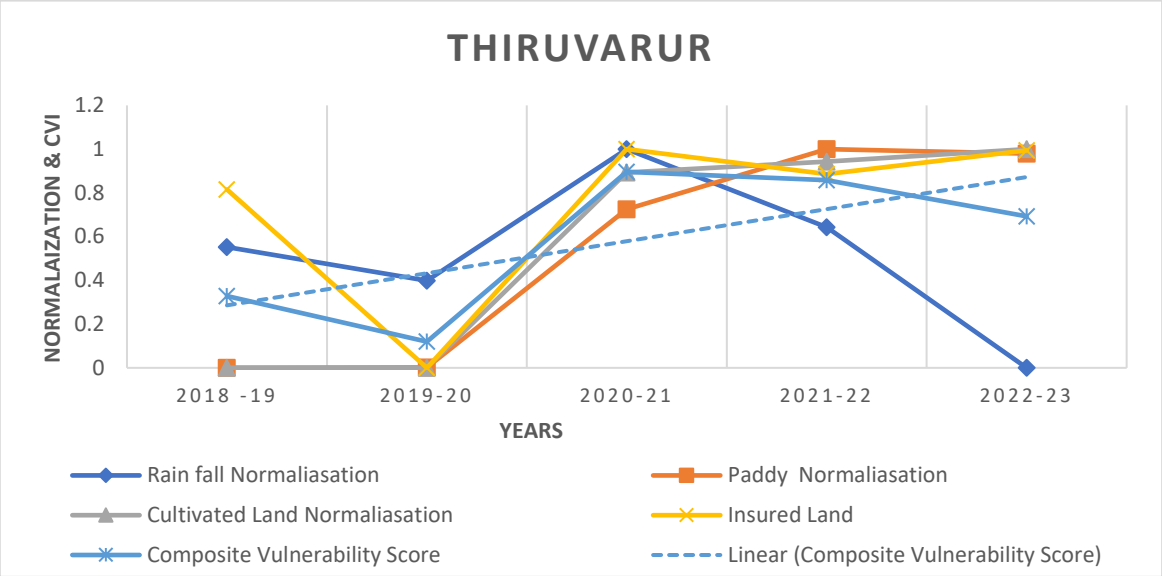


The computed CVI graph clearly illustrates a tendency towards progressive rise in terms of graphics. As a result, the susceptibility to climate change has grown yearly. Furthermore, based on the normalised value, the insured land size value has increased yearly. We may conclude that crop insurance is the most effective way to shield farmers from the effects of climate change based on this hypothetical scenario.

Normalization value & CVI for Thiruvarur districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Composite Vulnerability Index
2018-19	Thiruvarur	0.551736	0	0.000165	0.816191	0.328792
2019-20		0.398075	0.001387	0	0	0.119839
2020-21		1	0.724545	0.893217	1	0.896007
2021-22		0.642489	1	0.943444	0.885655	0.858567
2022-23		0	0.978893	1	0.993654	0.692399

According to the above study, the climate vulnerability score ranged from 11% to 89%. because the CVI as a whole has been impacted by many readings. The Thiruvarur regions experienced notable variations in precipitation between 2018 and 23. The fluctuating rainfall has negatively impacted the crops' output. Thiruvarur's agricultural productivity decreased in 2023 as a result of less precipitation. Productivity in crops has gone up, but not dramatically. Furthermore, because of the hostile environment, the area of land used for agricultural has drastically decreased.

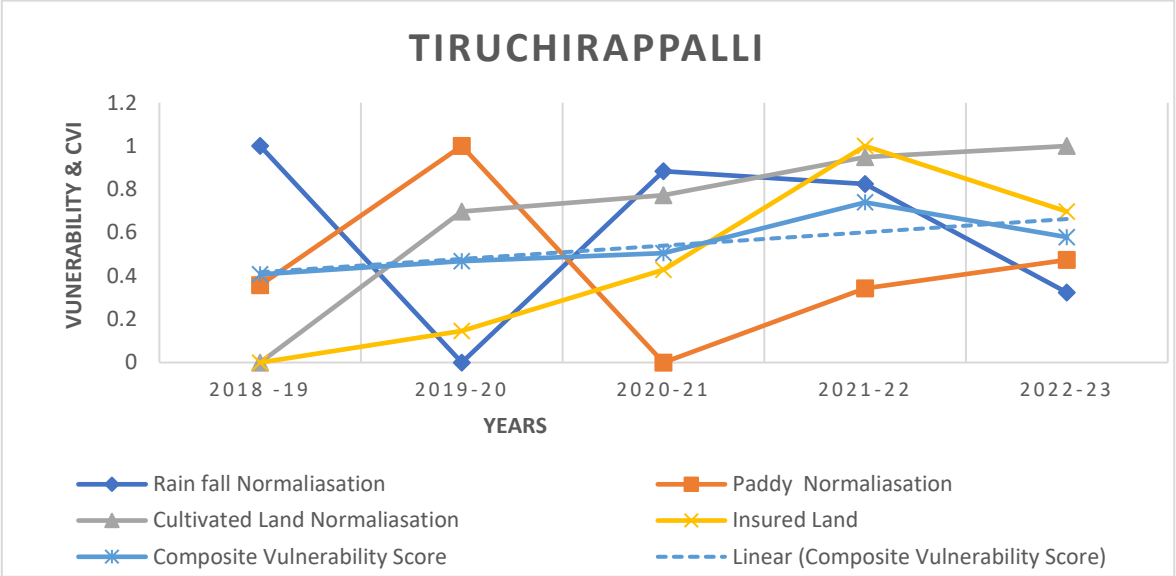


Visually, there is an obvious tendency towards a progressive climb in the computed CVI graph. As a result, there has been an annual rise in vulnerability to climate change. Furthermore, the insured land size value has grown yearly in accordance with the normalised value. We may conclude from this hypothetical scenario that the most effective way to shield farmers from the effects of climate change is through crop insurance.

Normalization value & CVI for Tiruchirappalli districts: (2018-2023)

Years	District	Rain Fall(mm)	Paddy Production	Cultivated Land	Insured land	Composite Vulnerability Index
2018-19	Tiruchirappalli	1	0.357602	0	0	0.407281
2019-20		0	1	0.697856	0.146229	0.468817
2020-21		0.88306	0	0.773417	0.428425	0.505286
2021-22		0.824044	0.342103	0.949188	1	0.739682
2022-23		0.322951	0.474532	1	0.69805	0.578855

According to the mentioned study, the climate vulnerability score ranged from 40% to 73%. because the CVI as a whole has been impacted by many readings. Compare with other regions Tiruchirappalli's CVI varying with a limit of small boundary. The Tiruchirappalli regions experienced notable variations in precipitation between 2018 and 23. The fluctuating rainfall has negatively impacted the crops' output. Tiruchirappalli's agricultural productivity decreased in 2023 as a result of less precipitation. Productivity in crops has gone up, but not dramatically. Furthermore, because of the hostile environment, the area of land used for agricultural has drastically decreased.



A tendency towards progressive growth is plainly shown graphically in the computed CVI graph. It has led to an annual increase in the vulnerability to climate change. Furthermore, the normalised value has been the yearly basis for the insured land size value rise. The best way to shield farmers from the effects of climate change is probably through crop insurance, based on this fictitious scenario.

Conclusion:

Climate change affects considerably the agriculture of Tamil Nadu. The region's susceptibility has increased due to rising temperature unpredictability, unpredictable rainfall patterns, and an increase in the frequency of extreme weather events, which has a specific effect on the agrarian economy. This study investigated crop insurance as a potential adaptation strategy and used the Climate Vulnerability Index (CVI) to evaluate the region's sensitivity to climate threats.

Thanjavur is identified as the district most badly affected by climate vulnerability based on the analysis conducted using the Climate Vulnerability Index (CVI). Not only does this district have the highest level of climate risk, but its insured land area has increased significantly as well, suggesting that crop insurance is becoming a more popular mitigation tactic. With significant climate issues threatening its agricultural yield, Ariyalur is the second most affected district. Commensurately, Pudukkottai, which comes in third, is confronted with significant climate-related problems that affect its agricultural income. The increasing trend in covered land sizes in these regions highlights how important crop insurance is for protecting farmers' livelihoods against climate uncertainty and rising hazards associated with it.

In this critical situation, as a vital instrument for adaptation, crop insurance offers farmers a safety net against crop losses brought on by climatic unpredictability, thereby reducing financial risk. This maintains agricultural output and aids in revenue stabilisation for farmers. However, the breadth of coverage, prompt claim resolution, and the incorporation of meteorological data to precisely identify and manage risks are what determine how effective crop insurance is.

For further research, adaptation plans can be more effectively tailored for changing climatic conditions with the support of ongoing monitoring of climate patterns and updating the CVI with the most recent data. Long-term sustainability depends on supporting community-based adaption strategies, strengthening the resilience of agricultural infrastructure, and investing in climate-smart agriculture.

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